PLUREL

Sustainability
Impact Assessment

Module 4

December 2010

PERI-URBAN LAND USE RELATIONSHIPS –
STRATEGIES AND SUSTAINABILITY ASSESSMENT
TOOLS FOR URBAN-RURAL LINKAGES,
INTEGRATED PROJECT,
CONTRACT NO. 036921

D4.4.3

Cost benefit analysis of peri-urban land use policy

Application to case studies

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Document status:

Draft:	completed
Submitted for internal review:	completed
Revised based on comments given by internal reviewers:	completed
Final, submitted to EC:	completed

SIXTH FRAMEWORK PROGRAMME

Contents

Abstract

This report presents the application of environmental valuation methods and, where possible, cost-benefit analysis to the case of peri-urban land use planning. Benefit transfer methods are used to estimate the value of green space, carbon storage, changes in forest area and other impacts of changing policy in the peri-urban fringe of cities in different case studies around Europe.

Classification of results / outputs:

For the purpose of integrating the results of this deliverable into the PLUREL Explorer dissemination platform as fact sheets and associated documentation please classify the results in relation to spatial scale; DPSIR framework; land use issues; output indicators and knowledge type.

Spatial scale for results: Regional, national, European	Regional – applied to case studies
DPSIR framework: Driver, Pressure, State, Impact, Response	Impact
Land use issues covered: Housing, Traffic, Agriculture, Natural area, Water, Tourism/recreation	All
Scenario sensitivity: Are the products/outputs sensitive to Module 1 scenarios?	Yes
Output indicators: Socio-economic & environmental external constraints; Land Use structure; RUR Metabolism; ECO-system integrity; Ecosystem Services; Socio-economic assessment Criteria; Decisions	Socio-economic assessment criteria
Knowledge type: Narrative storylines; Response functions; GIS-based maps; Tables or charts; Handbooks	Various

How many fact sheets will be derived from this deliverable:	

Introduction

The valuation of the peri-urban environment is crucial for appropriate land use policy development. Increasingly, there is the need for monetising the impacts on the environment to assess the social impacts of policies – e.g. in the development of regulatory impact assessments or cost-benefit analysis of public infrastructure projects.

WP4.4

WP4.4 attempts to apply cost-benefit analysis methods to the case of peri-urban policy and to land use scenarios. The former requires a detailed assessment of a policy or programme at a detailed level. The difficulty is in finding costs of policies – often these are confidential or unknown in the case of some of the scenarios developed. There are clear links to the scenarios developed in M1 and M2 and to the case studies in M3.

This work contributes to both the XPlorer and book end products. An attempt was made to link to the iIAT but due to spatial differences in the level of analysis, this was not possible.

Objectives of the deliverable

This deliverable presents the application of cost-benefit analysis methods to case studies within PLUREL. Full cost-benefit analysis is conducted for 2 case studies (Koper and a non-PLUREL case of Dublin). In the other cases, economic valuation is applied to assess the impacts of policies or scenarios.

Structure of the deliverable

This report is presented as a series of papers focusing on particular topics.

The first chapter focuses on the application of cost-benefit analysis in the case of Koper, Slovenia. A case study is developed of the case of golf course development in the peri-urban fringe. The results suggest that without significant housing development or other ancillary benefits the project would have a significantly negative net present value and would be unlikely to be viable.

The second chapter focuses on the case of a particular project in Manchester, England. The Mosslands project proposes various scenarios for the development of open space – with possible areas for recreation, agriculture and forest in particular. Using environmental valuation techniques, we assess the benefits of different policy scenarios.

The third chapter focuses on the case of transport infrastructure development. An application of cost-benefit analysis is presented to the case of the development of infrasture in the Greater Dublin area.

The fourth chapter focuses on the case of Leipzig and applies economic valuation to assess the impacts of scenarios on carbon storage and green space, comparing these to the GDP scenarios developed in the PLUREL project.

Golf Course Development in the Peri-Urban Fringe: A cost-benefit analysis of the case of Koper, Slovenia

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Abstract

Immense pressure is being placed on the peri-urban fringe from a number of developments. In the case of Koper, a golf course is proposed to be built on land currently occupied by a vineyard and some residential properties. Using cost-benefit analysis methods, we estimate that the golf course would require either significant side development of residential property or stimulate significant tourism revenues to be viable on cost-benefit terms.

Key words: Cost-benefit Analysis, golf course, peri-urban

Introduction

Pressure on the peri-urban fringe is increasing throughout Europe. Demand for residential housing in the suburbs, for recreational sites and for out of town shopping centres is driving the gradual expansion of cities. Agricultural farm land in the urban fringe, with significant multifunctional values for recreation and for ecological sustainability, is under threat from reduced farm incomes as well as increased demand for the land from developers. Tourism development also encourages expansion of development, particularly in coastal areas of cities and towns. Such facilities attract subsidies from local authorities in development – but are the outcomes of development socially sustainable?

Cost-benefit analysis has been around for several decades as a tool to assist planners and policy makers in making decisions. It has been applied in particular for transport policy and, in recent years, for assessing the sustainability of environmental policy – e.g. in the assessment of the Clean Air for Europe programme (ref). We apply the method to assess the viability of a scheme to develop a golf course in the fringe of a town in Slovenia – Koper – on a site that currently is dominated by a vineyard and some housing.

The structure of the paper is as follows. First, we establish the case study in Koper. Then we identify potential costs and benefits of policy measures, and potential techniques to quantify these in monetary terms. We then present background data, which feeds the results of a cost-benefit analysis. Finally, policy conclusions are drawn and areas for further research are identified.

Case study of Koper

This case looks at one potential measure to convert part of the existing vineyards on the peninsula of Debeli rtič to an 18-hole golf course in Koper. That would change part of the existing land from agricultural use to a green space. The size of the total area to be converted accounts for 236 hectares, and this includes 150 hectares of current vineyard, 66 hectares of forestry and 20 hectares of private settlement.

Figure 1: Location of proposed development

Source: Googlemap

Costs and benefits

A scoping of potential costs and benefits of the proposed development is given in Table 1. Some impacts can be valued using market-based methods. For example, the lost grape production can be valued using the market price of grapes (assuming that the impact on yield in the region is marginal – otherwise some adjustment would be needed). For climate regulation, the social cost of carbon can be used (e.g. ref). For recreational values, contingent valuation could be used. For amenity, hedonic pricing methods allow for the estimation of the benefits of living nearer to golf courses – and later we apply benefit transfer to attempt to isolate these values. In what follows, we assume that the golf course management will be to the best environmental standards[1]..

Costs

Physical land cost

The land price for agricultural land ranges at 10-15 €/m² in the selected area, according to the information provided by the stakeholder. Hence the total land cost of claiming the vineyard is estimated at between 15,000,000 and 22,500,000 €. Considering forest land as a type of agricultural land, we estimate the cost of claiming 66 hectares of forest at between 6,600,000 and 9,900,000 €. The cost of claiming private settlement will be discussed later in the section of compensation costs as a result of converting private settlement.

[1] In what follows we have ignored impacts of fertilisers and pesticides. This may be added in a later version. Water use of golf courses can also be significant and we will further examine this.

Table 1: Potential costs and benefits associated with the development of a golf course

Land area	Benefit	Cost
Opportunity costs		
Agricultural land		Grape yields Loss of non-use value, such as landscape, cultural value
Settlement		Compensation costs
Forest		Ecosystem services values: provisional values, climate regulating service values, recreational values and passive value
The cost with golf course development (assumed ecologically sound)	Employment	Design and construction cost Cost of obtaining the agricultural land and private settlement Negative externalities, such as noise, traffic, etc, during construction
The existence of golf course	Amenity (recreational) value, conservation value of green open space (from those who use this golf course)	Operation and maintenance cost
	The increase in the land price Private housing development	Negative externalities, such as noise, traffic
	Revenue of golf course (Green fees, memberships, etc)	
	Increase in employment	
	Ecosystem services values	
	Increase in tourism	
	Aesthetic values of its being green open space (proximity)	
	Fiscal benefits (increase in tax from business; increase in tax from property transactions)	

Compensation costs to the conversion of private settlement

This area of private settlement is assumed to comprise two types of land - residential buildings and vacant urban land. The average price of real estate in this area of private settlement amounts to 2300 €/m^2 for residential building and 80 €/ m^2[2] for vacant urban land. Given that this is a peri-urban area, this study assumes that the residential dwellings are mainly detached houses. According to OECD (2009), the average size of a dwelling in Slovenia is 114 m^2, presumably including usable and non-usable parts; the total number of dwellings on the policy site is estimated at 75 (provided by the stakeholder). Hence, the total area of residential dwellings is 8550 m^2. The size of the vacant urban land area is hence 191450 m^2. By multiplying the sizes of these two types of land area by their corresponding unit compensation costs we obtained the total compensation for private dwellings and the costs of claiming urban vacant land. The total costs associated with converting the private settlement are the sum of compensation and the costs of vacant land.

Loss of benefit from wine production

The annual grape yield of the vineyard is assumed at 7000 kg/hectare (provided by stakeholders). Note that grape yield is subjective to many other factors, such as weather, management methods, etc, whose variations over a period of time however are not able to be considered in this study.

The price of grapes for wine production is obtained by taking the average of the annual prices between from year 2000 to year 2009, with inflation being adjusted. By doing this we control for the annual price fluctuations. The average price is 0.4396 €/kg (2009 €). Multiplying this price by the annual grape yield per hectare and the total hectares of vineyard we obtain the total gross revenue of grape production per year of the 150 ha of vineyard.

[2] Note that the actual price for a unit of vacant land in the policy site can be lower due to its being in peri-urban area.

There is no publicly available information on the gross margin of grape production, in either Slovenia or any country in Europe. According to Deloitte (2007) and Vinpro and Winetech (year unknown), the gross margin of wine production in South Africa and Australia ranges between 27% and 54%, subjective to the size of producers and the period of time. Thus we use 27% as the lower and 50% as the upper bound of the gross margin for our policy site. The loss of the gross margin as a result of converting the 150 ha of vineyard is estimated at 12463 – 23079 €/year (2009€).

Loss of ecosystem services: value of forest

Amongst 66 ha of forest area, around 7 ha is considered as part of the natural heritage area. The other 59 ha is neither protected nor part of the natural heritage area.

At this stage, it is only acknowledged that the 7 ha of forest will be preserved and the trees in the other 59 ha will be cut down only if strictly necessary in the process of conversion. Hence this study assumes the worst-case scenario, i.e. the trees on the 59 ha of woodlands will be all removed. The associated loss of values of ecosystem services of this forest area is taken into account.

In the work of developing economic valuation of forest ecosystem services in the world, Chiabai et al. (2009) identified four types of ecosystem services associated with a given type of forestry: 1) provisional values, including the food, fibre and fuels products, 2) climate regulating services, i.e. carbon storage, 3) recreational services and 4) passive use. Their work provided the estimated economic values for different type of forest biome in different world regions for the year 2007 and the year 2050.

Forest in Slovenia is largely formed by two types of biome – cool coniferous and temperate deciduous and therefore the estimated economic value is considered to be at the range between the two values corresponding to these two types of forest.

We applied the marginal value estimates for the two types of forest in the ECA[3] region in Chiabai et al. (2009) in this study. The original values were in 2007 € and hence were adjusted here to 2009€ based on the inflation index in Slovenia. The marginal values per hectare per year with respect to provisional service, recreational service and passive value are summarised in the table below.

Table 2: Values of Forest Services

	Provisional service (2009€/ha/year)	Recreational service (2009€/ha/year)	Passive value (2009€/ha/year)
Type of biome			
Cool coniferous	96.87	0.21	12.77
Temperate deciduous	12.77	0.21	12.77

Two factors are considered in estimating the value of carbon storage over time. One is the biomass carbon capacity (tC/ha or tCO_2/ha) and this varies by type of biome yet is constant over time. The other is the prices per hectare of carbon stocked and these prices change over time, subjective to the costs of actions being taken to store carbon. The carbon capacity (tC/ha)[4] of different types of biomes in different world region is reported in Chiabai et al. (2009) and the estimated carbon prices are obtained from the EU-funded project CASES (Cost Assessment of Sustainable Energy System) (http://www.feem-project.net/cases/). The first panel in the table below summarises the carbon capacity per hectare of forest types. The second panel includes the carbon prices over three different periods of time relevant to the policy.

Table 3: Carbon storage and Social Costs of Carbon

	Temperate deciduous	Cool Coniferous
Carbon capacity (tCO_2/ha)	217.8	139.26
Carbon value (2009€/tCO_2)	Temperate deciduous	Cool Coniferous
Years 2010-2019	15.63	
Years 2020-2029	20.27	
Years 2030-2039	22.56	

[3] Eastern Europe and Central Asia

[4] tC/ha can be converted to tCO_2/ha by multiplying by the factor of '44/12'.

Finally, the table below summarises the estimated aggregate economic values of the policy site. The values associated cool coniferous forests are the lower bounds whereas those for the temperate deciduous forests are the upper bounds.

Table 4: Economic values of policy site

Aggregate estimated economic value (2009€/year)	Temperate deciduous	Cool Coniferous
Years 2010-2019	202,393	134,919
Years 2020-2029	262,046	173,060
Years 2030-2039	291,395	191,826

The development cost of the golf course

There is no information on the development cost of the particular golf course in the policy site that is available to the researchers. We hence had to rely on some proxy estimates to account for the costs associated with developing an 18-hole golf course.

KPMG (2008) revealed that 11% of the total budget of constructing an 18-hole golf course is spent on pre-construction work and 89% on the actual construction. The average development cost for a new 18-hole golf course is estimated at 1,528,000 (2008€) in Eastern Europe. It usually takes 4-5 years to develop a golf course from concept to realisation. Planning and design is mostly done within one year, and construction work takes around 2-2.5 years. However, the length of permitting procedure can be extremely viable, depending on the country concerned, the nature of the site and the characteristics of the planned environment. Based on the information mentioned above, we assigned 2 years for planning and permitting and 2 years afterwards for the construction stage, amounting to the total development period of 4 years.

Table 5 records the development costs of the golf course of the evaluated policy.

Table 5: Development costs of golf course

Total development costs	€1,541,201 (2009€)
Planning and permitting	€169,532 (equivalent to 11% of the total costs)
Construction	€1,371,669 (equivalent to 89% of the total costs)

Source: authors' own calculation

The loss of cultural heritage

The vineyard is considered locally to be a source of cultural heritage. There is a growing literature on heritage values (see e.g. Navrud and Ready, 2002), and it would be potentially possible to conduct a contingent valuation study on this. However, no funds are available and no existing study investigates the cultural values associated with a vineyard.

Benefits

The revenue of golf course

KPMG (2007) provided valuable information on the average performance of golf courses in Eastern Europe. Amongst the sampled golf courses, the average revenue of an 18-hole golf course in Eastern Europe was around 572,768€ in 2006. The total operating costs of golf courses in Eastern Europe account for about 85-90% of their total revenues, resulting in a gross operating profit of approximately **10-15%** on average. Adjusted to the 2009€ according to the Slovenian Consumer Price Index[5] , the annual gross revenue of the potential golf course in the policy site is estimated at 57,300 – 85,950 €.

[5] Data is available in EUROSTAT http://epp.eurostat.ec.europa.eu/portal/page/portal/hicp/introduction.

Passive values of the golf course: proximity value

We consider the value of a proximity to a golf course (as a type of green open space) as the passive value. This work reviewed several studies that investigated such proximity value of a golf course in the United States[6] by using a hedonic pricing method, and several important studies were identified as follows. Bolitzer and Netusil (2000) estimated that, within 1500 feet of proximity to a golf course, the average house price increased by $3400 - $3940 (1990US$). Shultz and King (2001) found out that the premium of 528 feet (1 mile) of proximity on the average house price was $243-261 (1990US$). More recently, Shultz and Schmitz (2009) discovered that being within 0.5 mile (264 feet) of proximity to a golf course contributed to a 13% - 23% of price increase in the average house price.

We applied a benefit transfer technique to derive estimation for the policy site, based on the estimates in Bolitzer and Netusil (2000), subjective to data availability. The benefit function is demonstrated as follows:

$$P_{policy} = P_{study} * (\frac{HP_{policy}}{HP_{study}}) * (\frac{Population_{policy}}{Population_{study}})\text{, where}$$

P_{policy} : the premium in the policy site in Slovenia

P_{study} : the estimated premium in the study site, i.e. Oregon USA.

HP_{policy}, HP_{study} : the average house prices in the policy site and the study site, respectively.

$Population_{policy}$, $Population_{study}$: the population density in the policy site and the study site, respectively.

We adjusted the estimated premium values from their original price level (1990US$) to current price level (2009US$), by using the housing price index[7] of the state of Oregon in which the study site in Bolitzer and Netusil (2000) was located. These values were then converted from 2009 US$ to their equivalent values in 2009€. The average house price in the study site was $66,000 (1990US$); using the same technique, its equivalent price in 2009€ is 134,896€.

[6] No similar literature in Europe can be found.
[7] http://www.fhfa.gov/Default.aspx?Page=86

The average house price in the policy site was obtained by using the data of actual house transactions, including flats and houses, between year 2007 and year 2009. We firstly adjusted house prices in 2007€ and 2008€ to 2009€ by using the Slovenian housing price indexes. The average sale price of a house between 2007 and 2009 is obtained by taking the weighted average of the annual average sale values by their corresponding annual numbers of transactions. It is the same to derive the average price of a flat. The estimated average sale prices are 119,273 (2009€) for a flat and 211,690 (2009€) for a house.

The population density, population/km², in the study site was obtained for the Multnomah County in Oregon, USA, at the 1990 level, i.e.1406/ km² (USCensus, 1990). The population density for the policy site is 104/km² in the region of Obalno-kraška, at the 2008 level (Statistics office of the Republic of Slovenia, 2010). Obalno-kraška is the region in which the policy site is located.

Using all these values, the proximity premium was estimated at 943,214 – 1,939,845€ (2009€).

Climate regulating service of the golf course

This study considered the carbon capacity of a golf course. Several types of vegetation can be found on a typical golf course and the majority of the area is grasslands.

An 18-hole golf course usually takes up 50-60 hectares of land. In the case of the policy site, the grasslands of the golf course can be converted from any of the three previous land uses – agricultural land, forest and private settlement; however, the researchers do not have detailed information about the exact size to be converted from each of the three types of lands to the course. Hence, we have to make the following assumptions: 1) the grasslands of the golf course are 60 hectares (maximum); 2) these lands will be converted from agricultural land or forest. According to Conant et al. (2001), the capacity of carbon sequestration of temperate grasslands around the world ranges from 0.35 tC/ha/year[8] (if conversation from native vegetation to grassland, hence 'forest' in our policy site) to 1.01 tC/ha/yr[9] (if conversation from arable to permanent grassland, hence 'vineyard' in our policy site). Note these values can vary with climate, grassland management, and other factors which, however, are not accounted for in this study.

[8] 1.25 tCO_2/ha/year
[9] 3.70 tCO_2/ha/year

Using the carbon prices provided in Table 3, we obtained the economic values of climate regulating services of the golf course. See the table below.

Table 6: Carbon sequestration benefits

Aggregate estimated economic value (2009€/year)	Low (0.35 tC/ha/year)	High (1.01 tC/ha/year)
Years 2010-2019	1203.66	3473.42
Years 2020-2029	1561.10	4504.90
Years 2030-2039	1736.97	5012.40

Employment effects

The employment effects of a golf course development can be significant. For example, an 18-hole golf course in Eastern Europe employs 32 people on average, comprising 27 full-time and 5 part-time employees (KPMG, 2007). In addition, there is employment during the stage of course construction. However, if we assume a case of full employment, then the employment effects should not be considered in a cost-benefit framework. The marginal impact on employment between the golf course and vineyard may be significant – and if it could be shown that the employment market was not clearing then these impacts[10] – and associated health benefits or losses in terms of reduced/increased mortality (Markandya, 2000) could be taken into account.

Ancillary housing development

There is often ancillary housing development alongside a golf course of this type. However, we do not have data on the plans for housing development in the Koper case.

[10] Note that in the assumption of market clearing in the employment market we are assuming there is no structural unemployment. This is a common assumption in analysis of this type.

Tourism

Koper is located in the region of Obalno-Kraška, which is the only one amongst the all regions in the country that has an exit to the sea. Natural features facilitate the development of tourism and transport in this region. The shares of hotels and restaurants and of coastal and spa tourism in the total gross value added are higher than in other regions. For example, this region recorded 25% of all tourist overnights in the country in 2008, almost half by domestic tourists (Statistics office of the Republic of Slovenia (2010).

Having a golf course may increase the volume of high quality, high revenue tourism (both domestic and overseas). To our knowledge, little work has been done on the extent to which golf courses act as a draw for these tourists, but it is often cited as a benefit of such developments.

Summary

Table 7 presents a summary of the identified costs and benefits to be used in the cost-benefit analysis. The scale of the construction and land purchasing costs are particularly noteworthy.

Table 7: Summary of costs and benefits used in analysis

Item	Description	Value
Costs		
Physical land cost (land claim)	Vineyards	€15-22.5 million
	Forests	€6.6-9.9 million
	Private land - upper limit	€16.5 million
Development costs of golf course	Predevelopment	€84,700 for each of 2 yrs
	Development	€686,000 for each of 2 yrs
Lost grape yields	Gross margins	€12,500 to €23,100 per year
Lost forest ecosystem benefits		€134,900 to €202,400 per year, rising to €191,800 to €291,400 by end of period
Loss of cultural heritage		Not quantified
Benefits		
Net profit of golf course	Based on KPMG(2007)	€68,300 to €94,900 per year operational
Amenity benefits	Based on transfer from US study	€943,200 to €1,929,800
Carbon sequestration	Based on carbon values from CASES project	€1,200 to €3,500 per year rising to €1,700 to €5,000 per year by end of period
Tourism		Not quantified
Ancillary development		Not quantified

Results

Taking the figures for the quantified costs and benefits shown above, we input them into a cost-benefit analysis framework to estimate the net present value of the proposed scheme. The results are shown in Table 8. There is some sensitivity to the assumptions shown here, but overall the project has a negative net present value whatever the cost/benefit assumption taken. This suggests that in the form presented the golf course would need to yield significant benefits beyond those analysed – either in the form of tourism revenues or in terms of ancillary property development.

The analysis would be further complicated by the potential for development in alternative sites – this may reduce the potential benefit in terms of tourism and golf course revenues. This is often the case with this type of development – with multiple plans for golf courses and other developments on the peri-urban fringe at the same time.

Table 8: Net Present Value of Golf Project (3.5% discount rate)

Cost/Benefit Assumptions	NPV (Euro)
Low Benefit, Low Cost	-38,101,855
Low Benefit, High Cost	-49,786,851
High Benefit, Low Cost	-36,784,439
High Benefit, High Cost	-48,469,436

Conclusions

Golf course development is one of many pressures on the urban fringes of our cities and towns. The benefits in terms of increased revenues from the land are clear and they are likely to yield higher per acre revenues. However, factoring in the costs of purchasing land means that these developments may prove not to be that viable in cost-benefit terms, unless there is significant ancillary property development, and hence more pressure on the urban fringe, or benefits in terms of increased high quality tourism.

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Applying Environmental Valuation Methods to Assess Benefits of Peri-Urban Land Use Policy – The Mosslands Project

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Introduction

This study applies economic analysis tools to quantify the potential economic benefits associated with a case study located in Manchester, UK. Economic valuation and the use of green accounting methods are increasingly being used to assess policies. We draw on the existing literature to value land use change policy in the case of the Mosslands.

A visioning exercise had already been completed in the Mosslands visioning project in 2007 by a team of consultants and the results concluded three possible pictures of land use development of this area in the future.

This study, being complementary to the qualitative outputs of the visioning work, aims to draw economic implications from these three land-use alternatives of the Mosslands area. It provides useful insights into how economic valuation can be used as a tool for policy assessment drawing on further scenarios.

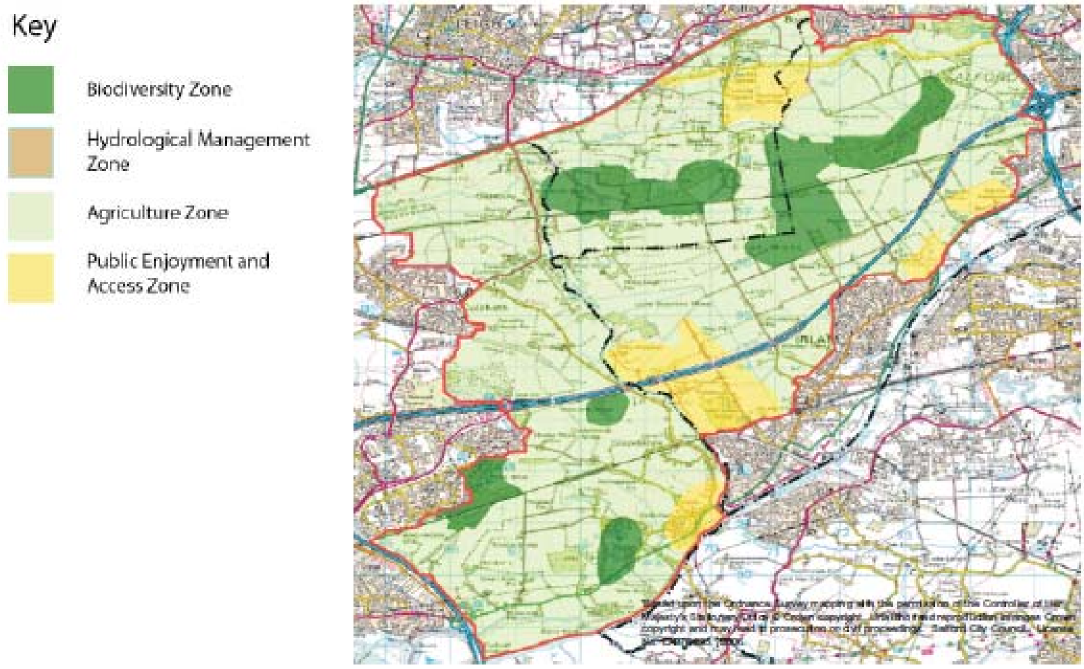
The Mosslands visioning project

The Mosslands project area is approximately 6660 ha in size and is situated across the district of Salford, Warrington and Wigan in North West England. It is generally bounded by the A580 road to the north, the Manchester Ship Canal to the south, the villages of Risley and Culcheth to the west, and the M60 motorway to the east. The area appears isolated from the urban regions that surround it, including Greater Manchester, Salford, Warrington and Leigh. Historically a large part of the area was covered by Chat Moss lowland raised bog. Current land use and land management within the study area varies and includes nationally important nature conservation areas (particularly lowland raised bogs), arable and horticultural production, commercial peat extraction and grass turf production, etc. It is designated as a green belt, with 80% of agricultural land, 5% of the land for public enjoyment and recreation, 8% covered by woodlands, and 5% covered by nature conservation designations and overlaps exist between different types of land uses. The total size of the land is approximately 6660 ha. The area contains the largest single unit of Grade 1 and 2 agricultural lands in Greater Manchester as well as the single block of woodland (Botany Bay Woods). (Malsen Environmental, JBA Consulting and ADAS Consulting, 2007)

The Mosslands Draft Vision was the recommendation of a team of consultants. It is based on the findings of site observations, desk top research including a review of existing documentation, consultation and an analysis into the existing and potential functionality and multi-functionality of the Mosslands landscape. More details are available in Malsen Environmental, JBA Consulting and ADAS Consulting (2007).

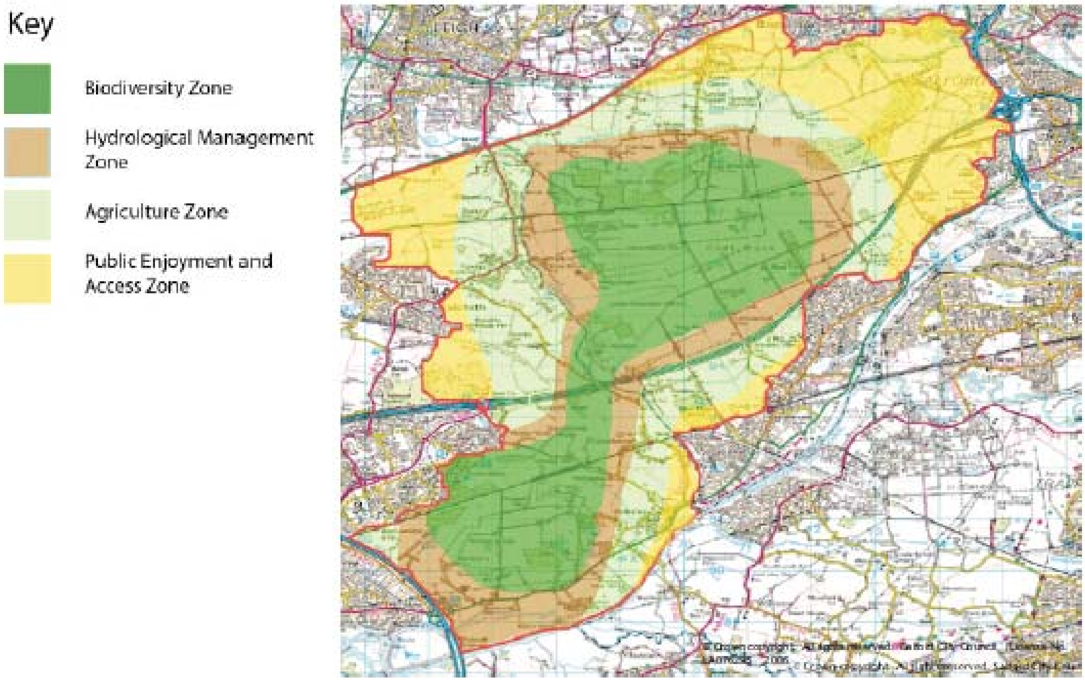
The results of this visioning process suggested three alternative pictures of the future land use changes for the study area – a zero intervention (doing nothing) vision, a wetland maximum vision and an integrated vision. Each of the three visions was comprised of four different land-use zones - a biodiversity zone, a hydrological management zone, an agricultural zone and a public enjoyment and access zone, and one is different from another in terms of the variations in the proportions of the four zones. For example, the zero intervention vision has a dominant agricultural zone, whereas the wetland maximum vision and the integrated vision have a relatively large biodiversity zone. Figures 1 to 3 show the land use plans under each of the pictures of the future.

Figure 1: Land Use Plan with Zero Intervention



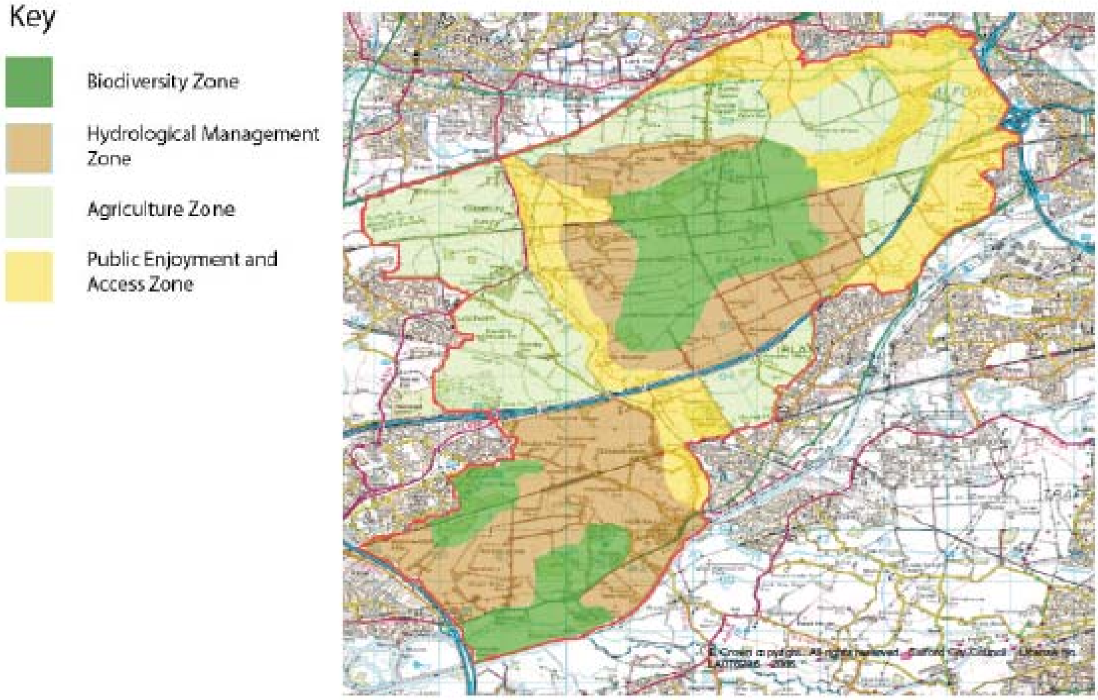
Source: Malsen Environmental, JBA Consulting and ADAS Consulting (2007)

Figure 2: Land Use Plan with Maximum Wetland



Source: Malsen Environmental, JBA Consulting and ADAS Consulting (2007)

Figure 3: Land Use Plan with Integrated Vision



Source: Malsen Environmental, JBA Consulting and ADAS Consulting (2007)

Following on from the figures above, details of the sizes of each of the four zones in each of the three visions are shown in Table 7 below. It can be seen that the areas for each "zone" varies significantly between the scenarios – with agriculture being largest under no intervention, the biodiversity zone being largest under maximum wetland and hydrological management and agriculture being jointly largest under the integrated vision.

Table 7: Size of individual zone in various visions

Zone / Vision	Biodiversity zone	Hydrological management zone	Agricultural zone	Public Enjoyment and Access zone	Total land size
No Intervention	776 ha (12%)	0	5254 ha (78%)	683 ha (10%)	6713 ha
Maximum wetland	2014 ha (30%)	1208 ha (18%)	1678ha (25%)	1813ha (27%)	6713 ha
Integrated vision	1343 ha (20%)	1947 ha (29%)	1947 ha (29%)	1477 ha (22%)	6714 ha

Method

This study applies benefit transfer tools to measure the economic benefits associated with the land use patterns associated with each vision. Benefit transfer uses estimates from other studies and adjusts, where necessary, for context. It is widely used in the literature on economic valuation, because of the costs of conducting primary studies. There are, however, significant uncertainties in the use of this method – in part because some studies that have tested the reliability of benefit transfer against new primary studies show significant differences in the estimates obtained. Hence, in this study we present both a range and "best guess" estimates. The latter either stems from judgement as to the most likely value (e.g. in the case where there are UK or regional studies) or is based on the median value of existing studies.

To proceed, we firstly identify the benefits associated with each land-use zones.
Table 8 summarises the types of land cover and each zone, and its corresponding functions and benefits. The benefits listed in the table are not in any case exclusive.

Table 8: Specifications of each zone

Zone	Land cover	Functions	Benefits
Biodiversity zone	Transiting from raised bog to lagged fen/wet woodland and reed beds	Nature reserve, heritage and cultural legacy functions (peat extraction sites)	Educational, passive recreational, nature conservation, biodiversity, climate regulation (carbon sequestration) nitrogen sink (nitrogen abatement), but no exclusive
Hydrological management zone	Extensive grassland, rush-pasture and mire habitats	Environmentally sensitive agriculture, nature conservations, passive recreation, hydrological services (water retention)	Agriculture (diversifying effects), conservation, passive recreation, landscape, biodiversity (but not exclusive)
Agricultural zone	Arable cropping, salad/vegetable growing, biomass production	Agriculture activities	Educational, leisure, tourism, agricultural benefit, landscape, environmental benefits (biomass), but not exclusive
Public Enjoyment and Access zone	**Green spaces.** For example, a linear access/leisure zone could be created along the Glaze Brook and the brook could be remodelled to create a more natural and responsive environment with seasonal water meadows, reedbeds and willow planting to increase its biodiversity and amenity value.	Reduce pressure of urban fringe, health care, bridge to the country, heritage and cultural legacy and nature reserve functions (e.g. a forest park)	Recreational (tourism), amenity value, conservation (opportunity: the Wigan Greenheart Regional Park)

Several methods are available to estimate the economic values of each of the benefits listed in the table, such as revealed preference methods, stated preference methods and benefit transfer methods. Whilst revealed preference methods and stated preferences methods are usually applied in primary studies, benefit transfer methods are widely adopted as an economical alternative when research resources are limited as these methods allow one to obtain, say, the value of biodiversity of site A from already estimated biodiversity values of other sites.

When estimating future benefits, this study adopts the future socio-economic scenarios specified by PLUREL, the IPCC and the UK Climate Impacts Programme (UKCIP). It should be noted that there is some variation in the scenarios, but for our purposes we have paired similar scenarios (e.g. A1, A2, B1, B2) under each. The reliability of this could be questioned, but it gives a good general picture of how society may be under the different scenarios.

The socio-economic effects are as a result of the changes in two factors: 1) the economic output, i.e. gross domestic production per capita, and 2) population growth. The NEMESIS model had related projection data for year 2015, 2020 and 2025, as shown in Table 9 below.

Table 9: Socioeconomic scenarios in the future

	Scenarios in 2015			
	A1	**A2**	**B1**	**B2**
Total population in the UK	62,660,000	62,490,000	62,330,000	62,490,000
GDP per capita (2000 €)	37,713	36,904	35,824	34,918
	Scenarios in 2020			
	A1	**A2**	**B1**	**B2**
Total population in the UK	63,780,000	63,480,000	63,160,000	63,480,000
GDP per capita (2000 €)	43,099	41,306	38,739	37,800
	Scenarios in 2025			
	A1	**A2**	**B1**	**B2**
Total population in the UK	64,790,000	64,320,000	63,760,000	643,20,000
GDP per capita (2000 €)	50,156	47,262	43,261	41,146

Source: NEMESIS model

These socioeconomic effects are considered to increase/decrease people's demand for public goods, such as environmental quality, biodiversity, etc. and hence increase/decrease their valuation for these goods. Hence these factors are useful to carry out an inter-temporal benefit transfer. In this study, values of goods from now to year 2015, 2020 and 2025 are projected using projections on population and GDP/capita, according to the following computation (Chiabai et al., 2009):

$$V_{i,T1} = V_{i,T0} * \left(\frac{Pop_{T1}}{Pop_{T0}} \right) * \left(\frac{GDP_{T1}}{GDP_{T0}} \right)$$, where

Where V_i : Estimated annual value per hectare (in the case of biodiversity zone hydrological zone) or per visit (in the case of public enjoyment and access zone) for a certain good i

Pop : Population

GDP : GDP per capita (2000€)

$T0$: Year 2008

$T1$: Year 2015, 2020 and 2025

The transfer function specified above is applicable to project the benefits of wetland[11] (biodiversity zone), that of grassland (hydrological zone), environmental benefit and costs of agricultural land and the benefits of peri-urban green open spaces (public enjoyment and access zone).

[11] Refers to various types of ecosystem services

Data

Biodiversity zone

The primary purpose of this zone is to enable the long-term protection and enhancement of the remnant Mosslands which are designated for their biodiversity value. It is proposed that the land between the existing sites is used to create a mosaic of wildlife habitats that integrate 'nature conservation' and 'classroom' functions by providing limited/managed access for passive recreation and educational purposes. We consider inland wetlands as the primary land type of this zone, which have the vegetation of lowland raised bog, fens, wet woodlands and reed beds. The types of wetlands that have the aforementioned vegetation can be peatlands (forested and non-forested), river floodplain, shrub-dominated wetlands, etc.

We establish a conducted a review of studies that contained estimates of the economic benefits of the ecosystem services of wetlands in temperate region, and the details of these studies are exhibited in

Table 10. We then convert the original estimates in national currency into values in 2008 British Pounds, by applying PPP exchange rates (if in currencies other than British Pound) and/or the Consumer Price Index. Note that for the sake of consistency, this study considers the studies that have unit estimates of hectare, i.e. £/ha. **The collected data shows that the estimated benefits of wetlands in temperate regions range between £747 and £21725/ha/year**. Our best guess value is £8201/ha/year, drawing on the study by EFTEC for the UK. The service values considered in these estimates include non-use preservation value, recreational value, hydrological value and ecological value.

Table 10: Valuation data for wetland zone

Study	Original value/ha/year	Base year	Type of wetlands	Method	Location
Costanza et al. (1997)	**9990 US$/ha/year** **19580 US$/ha/year**	1994US$	Tidal marsh/mangroves Swamps/floodplain	The sum of consumer and producer surplus; the net rent (the producer surplus); price times quantity	Global
Kirkland (1988)	**956.24 US$/ha/year (aggregate)**	2003 US$	Peat bog and swamp	Contingent valuation	New Zealand
Woodward and Wui (2001)	**3757 US$/ha (aggregate)**	1990US$	All kinds of wetlands	Meta-analysis	Worldwide
David Suzuki Foundation (2008)	**$14194/ha/yr** **$14248/ha/yr** **$14138/ha/yr** **$15069/ha/yr**	2005 CAN$	Bog Marsh Swamps Fens	Various types of methods	Ontario, Canada
Costanza, Wilson, Troy, Voinov, Liu and D'Agostino (2006)	**$21477 – 28573/ha/year**	2004 US$	Freshwater wetlands	Value transfer	New Jersey, USA
Economics for the Environment Consultancy and Entec (2002)	**£6616/ha/year**	2001£	Wetlands	Benefit transfer	UK

Hydrological zone

This zone is defined as an area in which artificial drainage, certain land use activities and infrastructure need to be controlled with the aim of optimising hydrological conditions within the designated lowland raised bog site. The exact width of the hydrological zone will vary around the perimeter of the raised bog area according to local conditions and typically this is likely to be in the order of 200m-400m in the Mosslands study area. Ideally, land use within the zone should contain a mosaic of permanently vegetated extensive grassland, rush-pasture and mire habitats. Grassland habitats may provide economic value. Small scrub patches and slight tree cover would also add to the overall biodiversity value of these areas. The establishment of a hydrological zone around the lowland raised bog conservation/restoration within the project area would provide them with better protection from other land uses that require much more intensive drainage. However, integrated control of water level management may be crucial aspect to look at to replace the current very piecemeal or uncontrolled way of the drainage system within the area is managed and maintained by a variety of land occupiers. The purpose of this zone is to protect and enhance the biodiversity core. It is envisaged that the land use within this zone will be a mix of agriculture and recreation. (Malsen Environmental, JBA Consulting and ADAS Consulting, 2007)

Given that at this stage the vegetation type of the future hydrological zone is not known with certainty, we assume that it will be mainly (temperate) grassland.

Table 11 exhibits the estimates of the economic values of grassland ecosystem services in literature. Similar to the case of biodiversity zone, we convert these values in original national currencies into 2008 British Pound. The collected data the table shows that **the estimated benefits of wetlands in temperate regions range between £23 and £951/ha/year. Our best guess in this case of the value is £185/ha/year**, the median value of studies conducted. The types of service value considered in these estimates include ecological value, landscape, conservation value, regulation service value, recreational value and provisional values.

Table 11:Values for Hydrological Zones

Study	Original value/ha/year	Base year	Type of grassland	Method	Location
Bateman, Willis and Garrod (1994)	£7376.57 - £8053.47/ha/year (converted from the WTP value per household per year	1991£	Norfolk Broad (being an environmentally sensitive area, with the landscape of traditional grassland, pasture)	Contingent valuation	UK
Alvarez, Hanley, Wright and MacMillan (1999)	£5.83/ha/yr for Breadalbane and	1994-1996£)	Breadalbane (grasslands, heather moorland, wetlands, and birch and ash woodlands, with increasing amounts of conifer plantation in upland areas; 179284 ha)	Contingent valuation	UK
	£21.75/ha/yr for Machair		Machair (grasslands, cultivated machair, dune systems and rough pasture; 15166ha).		

Costanza et al. (1997)	232 US$/ha/year	1994 US$	Grassland	The sum of consumer and producer surplus; the net rent (the producer surplus); price times quantity	Global grasslands
David Suzuki Foundation (2008)	$1618/ha/yr	2005 CAN$)	Grassland (cool temperate)	Various types of methods	Canada
Costanza, Wilson, Troy, Voinov, Liu and D'Agostino (2006)	$30 - $190/ha/year	2004 US$	Grassland/ranger land	Value transfer	New Jersey, USA

Agricultural zone

Land use within this zone could include extensive arable cropping and biomass production. A productive landscape focused in areas where more intensive management can occur without adversely affecting the Mosslands heartland. The economic values of agricultural areas includes provisioning values from arable cropping, as well as non-use values, such as landscape, biodiversity, etc.

The scale of provisioning values of the agricultural lands is subject to types of agricultural activities – horticulture, cereal cropping, etc, as well as the varieties of cultivated crops. Current agriculture activities in the study region are predominantly cereal cropping and some potato production, limited vegetable production and very limited livestock numbers. Non agricultural enterprises include some field scale turf production and horse grazing. Several potential directions of development in the agricultural zone were proposed in the visioning report, ranging from horticulture, horsiculture, cultivation of biomass (energy crops), etc. It is beyond the scope of this study to evaluate the plausibility in economic terms for each of these agricultural activities or to forecast the composition of various agriculture activities in each of the three visions. Instead, we use available resources to gauge the potential provisional values of cultivating a pre-defined composition of crops, including cereal (wheat and barley), potatoes and two potential energy crop (oilseed rape and sugar beets). Hence the scale of the gross margin from growing these crops can be estimated in monetary terms.

Table 12 shows the average price, yield and gross margin rate for each of the crops. The last column of the table exhibits the proposed composition of land size for each type of the crops, i.e. 51% of the agriculture zone, regardless of the total size of the zone, grows wheat, 26% for Barley, 16% for oilseed rape, 4% for potatoes and the remaining 3% for sugar beet. This composition is representative of the average situation at the UK level between year 2005 and 2009, when considering the types of crops listed in the table.

Table 12: Current Data on Agricultural Production in UK

Type of crop	Yield (2004-2008 national average) (tonne/ha/year)‡	Price (2004-2008 average price in the UK) (2008£/tonne)¶	Gross margin (% of output)†	Proposed share of crop areas§
Wheat	7.9	159	57%	51%
Barley (winter/spring)	5.8	127	61%	26%
Oilseed rape	3.2	315	54%	16%
Potatoes	41.9	148	61%	4%
Sugar beet	58.1	21	55%	3%

Data sources: ‡FAOSTAT database; ¶ FAOSTAT database; †authors' own calculation from the data available in *The agricultural budgeting & costing book 2008* and *2008/09 Farm Business Survey (FBS) database* ; § Agriculture in the United Kingdom 2009)

This study considers potential changes in agriculture production as a result of climate change and socio-economic effects in the future. We apply the projected scales of changes in crop yields and the corresponding production prices that were available in the REGIS model. This model was developed to estimate regional climate change impact and response of several sectors, including coast, water, biodiversity and agriculture in East Anglia and North West England, and more details are available in the technical report (RegIS, 2001).

Table 13 exhibits the projected relative changes in the levels of yields and prices by types of crops and future scenarios. Note that these are not region-specific. We obtain projected yields and prices by scaling up or down the historical figures in years 1997/1998. For example, the yield of wheat in 1997/1998 was 7.5 tonne/ha, and accordingly, the projected yield of wheat in 2020s is 10.5 tonne/ha (7.5*140/100) in A1 scenario. As far as production price is concerned, the price of wheat in 1997/98 was £83.24/tonne (1997£) and is projected at around £111/tonne (2008£) in scenario A1 in 2020s. Price levels are adjusted according to agriculture price indices available in Defra database. Assuming that gross margin rates remain constant in the future, we estimate the gross margin per ha for each type of crops in 2020 and 2025 (both years are considered in the period of 2020s).

Table 13: Agriculture variables by future scenarios in 2020s in the UK

	1997/98 crop yield	2020s high climate change (global market A1)	2020s high climate change (Regional enterprise A2)	2020s low climate change (global sustainability B1)	2020s low climate change (Regional stewardship B2)
Wheat	100	140	120	105	100
Barley	100	150	130	110	100
Rapeseed	100	125	120	115	105
Potatoes	100	150	120	110	100
Sugar beet	100	140	130	115	110
	1997/98 crop production price				
Wheat	100	85	90	110	120
Barley	100	85	90	110	120
Rapeseed	100	85	85	110	120
Potatoes	100	85	90	110	120
Sugar beet	100	85	90	105	120

Source: RegIS report (2001)

Table 14 shows the estimated gross margin in 2008£ per ha by types of crops in year 2015, 2020 and 2025. Due to the lack of projection information for the year 2015, we use the average gross margin during year 2004-2008 as proxy estimation. Note that the estimated gross margin of potato in years 2020 and 2025 is significantly higher than that for year 2015, and this is caused by the significance difference between the price of 1997 and that of 2008. It is observed in the data that the price of potatoes in 1997 was at the lowest level between year 1988 and 2008.

Table 14: Gross margin (in 2008£) per ha by crops and scenarios in 2015, 2020 and 2025

	Year / Scenarios	2015	2020	2025
Wheat	A1	711	660	660
	A2	711	599	599
	B1	711	641	641
	B2	711	666	666
Barley	A1	452	475	475
	A2	452	436	436
	B1	452	451	451
	B2	452	447	447
Rapeseed	A1	537	580	580
	A2	537	556	556
	B1	537	690	690
	B2	537	687	687
Potatoes	A1	3774	13720	13720
	A2	3774	11621	11621
	B1	3774	13020	13020
	B2	3774	12913	12913
Sugar beet	A1	678	663	651
	A2	678	651	640
	B1	678	672	660
	B2	678	735	722

Source: Authors' own calculation

In addition, this study provides information on energy crop cultivation and the profitability of vegetables/salad cropping.

Table 15 shows the potential yields of biofuels from various types of energy crops. It is seen that sugar beet has the highest yield rate, but this does not necessarily refer to a higher benefits. To measure the profitability of growing energy crop in the study area, more work needs to be carried out.

Table 15: Yields of energy crops

Type of crop	Yield of feedstock (tonne/ha)	Yield of biofuel (Litre/tonne of feedstock)	Yield of biofuel (Litre/ha)
Wheat[12]	8	410-480[a]	3280- 3840
Wheat straw	3.5-5[c]	290[e]	1015 - 1450
Barley straw	2.5[c]	310[e]	775
Oilseed rape (England)	3	313[d]	939
Sugar beet (England)	56	87-101[b]	4872 - 5656

Source: (a) Smith et al (2006); (b) Evans, Higson and Hodsman (2007); (c) Nexant (2007); (d) Booth et al. (2007); (e) Kim and Dale (2004)

The possibility of developing horticulture has been highlighted in the visioning report. This study provides the current average profitability of vegetable cropping activities in the UK and the

[12] However, it is noted that wheat for bioethonal production is different from that for bread making, as the former demands higher starch content whereas the latter favours higher protein (Clarke et al., 2008).

details are exhibited in

Table 16. More work needs to be done to investigate the types of vegetable cropping that would be plausible for the project area, but this is beyond the scope of this study.

Table 16: Profitability of horticulture activities by types of vegetables in the UK

	2004-2008 average production (2008£/ha/year)	Gross margin rate (2005-2008 average, %)	Gross margin (2008£/ha/year)
Asparagus	8,453	58.6 - 64.6	4,953 - 5,461
Beans, green	1,474	58.6 - 64.6	864 - 952
Cabbages and other brassicas	9,082	58.6 - 64.6	5,322 - 5,867
Carrots and turnips	20,140	58.6 - 64.6	11,802 - 13,010
Cauliflowers and broccoli	4,762	58.6 - 64.6	2,791 - 3,076
Chillies and peppers, green	206,974	58.6 - 64.6	121,287 - 133,705
Cucumbers and gherkins	302,710	58.6 - 64.6	177,388 - 195,550
Leeks, other alliaceous veg	20,917	58.6 - 64.6	12,257 - 13,512
Lettuce and chicory	8,491	58.6 - 64.6	4,976 - 5,485
Onions (inc. shallots), green	12,953	58.6 - 64.6	7,590 - 8,368
Onions, dry	7,657	58.6 - 64.6	4,487 - 4,946
Peas, green	10,505	58.6 - 64.6	6,156 - 6,786
Tomatoes	330,961	58.6 - 64.6	193,943 - 213,801

Source: Authors' own calculations, based on data from FAOSTAT and Farm Business Survey 2006/2007, 2007/2008 and 2008/2009

The importance of considering external costs of agriculture activities has also been recognised in literature and such external costs include the pollution impact of fertilisers and pesticides on soils, water air and human health in the long term. These external costs are taken as negative economic benefits of this area by adopting the estimated average external costs of agricultural activities in the UK at £229/ha/year (1996£), available in Pretty et al. (2000). It is worth nothing that this estimation refers to a national average estimation and the actual external costs specific to the project area can vary with respect to the types of agriculture activities. The non-provisioning benefits of agricultural lands in the UK were estimated at £103/ha/year (2001£) for intensive agriculture, considering only landscape value Economics for the Environment Consultancy and Entec (2002).

Public enjoyment and access zone

The primary purpose of this one zone would be to reduce the pressure of urban fringe issues on the biodiversity and agricultural zone, by diverting recreational use into areas of lesser sensitivity. This zone would consist of a series of interconnecting green spaces with active and passive recreational opportunities.

This study collects data from studies that estimated the economic benefits of urban fringe green spaces, e.g. urban forest park, woodlands, etc., in the UK. More details of these studies are exhibited in

Table 18 below. The economic benefits of open space in urban fringe was estimated at between £0.10 and £6.70/person visit (2008£). Our best guess value reflects the median value of the UK studies of £2.70/visit. The types of service considered in these estimates include amenity, recreation, wildlife and landscape.

To measure the total benefits per year, it would be ideal to know the number of potential visitors per year. Provided that such information is not available, this study uses the total population of the three boroughs - Wigan, Warrington and Salford, in which the Mosslands is located – as a proxy for the number of visitors. Hence the total annual benefits of this zone are obtained by multiplying the unit value (£0.10-6.70/per visit) by the total number of visitors (729400).

Table 17: Population of the three boroughs

Borough	**Population as of mid 2009**
Wigan	306,500
Warrington	197,800
Salford	225,100
Total population	**729,400**

Source: ONS database

Table 18: Public Enjoyment and Access Values

Study	Original value/person/year (£)	Base year	Open spaces valued	Method
Bateman, Garrod, Brainard and Lovett (1996)	£3.95 per visit	1993 £	Woodlands in Lynford Stag, Thetford forest, UK	Travel cost
Bateman, Brainard, Lovett, Langford and Saunders (1998)	£1.91 per party visit	1996£	Woodland, UK	Travel cost and Benefit function transfer
Hanley (1999)	£1.7 per trip	1987£	Rural forest park, UK	Travel cost
Hanley and Ruffel (1993)	£0.93 per person per visit	1991£	Access to public forest in the UK	Contingent valuation
Willis and Benson (1989)	£1.9 per visitor	1987£	6 state forests across England and Scotland	Travel cost
Bateman, Lovett and Brainard (1996)	£1.82 per person per visit	1990£	Woodland areas in England and Wales	Meta analysis
Bishop (1992)	£0.42 – 0.54/person/visit	1992£	Urban fringe woodlands	Contingent valuation
Willis and Garrod (1991)	£0.06 - £2.6 per visit	1988£	Forests	Contingent valuation and travel cost methods
Willis (1991)	£1.34 - £3.31 per visit	1988£	Woodlands	Travel cost
Bennett, Tranter, Beard and Jones (1995)	£1.11 per visit	1993£	Urban fringe woodlands (the Winsor forest)	Contingent valuation
Bateman, Diammand, Langford and Jones (1996)	£0.28 – £0.34/person visit	1991£	100 acre woodlands near Wantage in Oxfordshire	Contingent valuation

Results and discussion

Table 19 exhibits the estimated aggregate economic benefits for each of the three planning visions. Overall, the wide ranges of the estimation results reflect the fact that the benefits of zone are highly subject to its geographic location, the characteristics of the ecosystems located in this area, etc. This, however, can increase the ambiguity with any implications drawn from these results.

Table 19: Estimated range of benefits (2008£/year)

	2015	2020	2025
No intervention vision			
A1	3,231,481 -37,948,334	5,050,535 - 45,434,317	4,921,681 - 52,662,830
A2	3,246,137 - 37,126,195	4,425,810 - 42,947,879	4,318,318 - 48,978,043
B1	3,264,976 - 36,069,339	4,996,692 - 40,942,930	4,916,532 - 45,439,778
B2	3,278,068 - 35,334,880	5,057,639 - 40,310,110	4,994,102 - 43,874,428
Maximum wetland vision			
A1	3,301,457 -106,513,255	4,254,078 - 124,313,426	4,693,802 - 146,626,305
A2	3,251,445 - 103,975,489	3,932,634 - 118,457,185	4,299,460 - 137,071,014
B1	3,187,155 - 100,713,197	3,946,754 - 110,813,464	4,220,305 - 124,694,275
B2	3,142,476 - 98,446,079	3,920,858 - 108,725,028	4,137,682 - 119,727,320
Integrated vision			
A1	2,596,053 - 98,392,346	3,497,336 - 114,930,725	3,746,035 - 135,481,049
A2	2,567,767 - 96,055,045	3,191,050 - 109,487,304	3,398,520 - 126,630,776
B1	2,531,406 - 93,050,451	3,298,715 - 102,487,324	3,453,431 - 115,271,652
B2	2,506,137 - 90,962,418	3,293,362 - 100,567,619	3,415,993 - 110,700,809

Source: Authors' calculation

Given the wide ranges of estimated benefits as shown in the table above, this study alternatively develops point estimates as the best guesses for the study site. To select these point values, we choose the values transferred from studies originally carried out in the UK, or otherwise use the median value of a selection of original estimates, as shown in Table 14.

Table 20: Best guess values

	Best guess	Criterion of selection
Biodiversity zone	£8201/ha/year	A UK-based estimate
Hydrological zone	£185/ha/year	Median value of the selected original estimates (temperate zones)
Agricultural zone	No point estimation is needed.	-
Public enjoyment and access zone	£2.70/visit	Median value of the selected original estimates (all UK based)

Source: Authors' own calculation

By using the post estimates chosen above, the differences in economic benefits between scenarios with intervention and the one without are shown in
Table 21 below and Figures 3 and 4 below. The results confirm that scenarios with interventions have greater benefits than the scenario of no policy interventions. The benefits of the maximum wetland vision outweigh those of the no intervention one by from £14.2 million/year to £21.1 million/year (2008£), depending on the timing and socioeconomic conditions in the future. In comparison, the benefits of the integrated vision exceed those of the no intervention vision by between £6.2 million/year and £9.2 million/year (2008£).

Table 21: Net economic benefits of interventions (undiscounted 2008£/year)

		2015	2020	2025
Maximum wetland vision v.s. No intervention vision	***A1***	15,610,318	17,280,579	21,142,543
	A2	15,171,076	16,750,499	19,972,223
	B1	14,606,431	15,040,715	17,443,237
	B2	14,214,033	14,643,321	16,547,623
Integrated vision v.s. No intervention vision	***A1***	6,888,028	7,198,332	9,170,293
	A2	6,663,746	7,113,321	8,758,368
	B1	6,375,432	6,091,898	7,318,652
	B2	6,175,070	5,875,253	6,847,610

Source: Authors' own calculation

Figure 3:Net Benefits of Maximum Wetland Scenario over No Intervention (£2008)

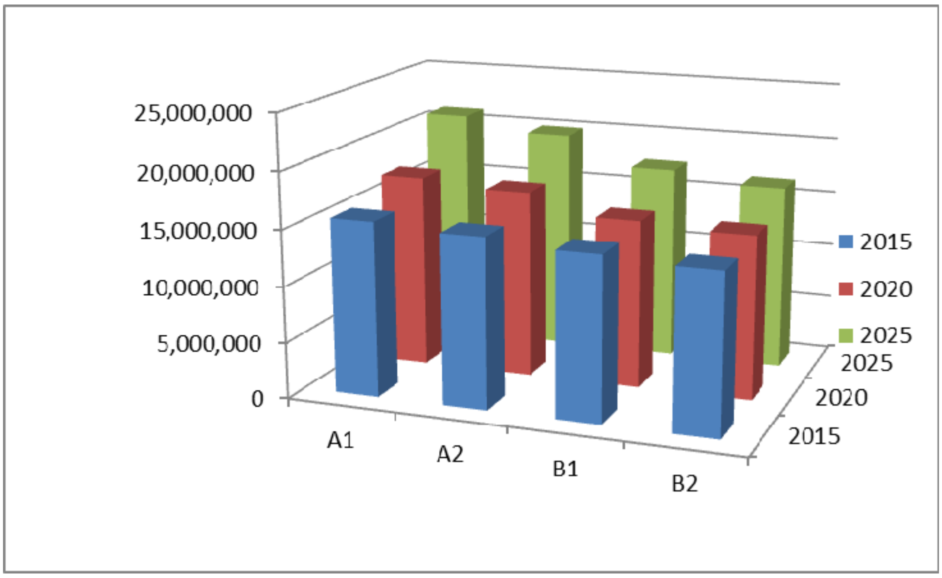
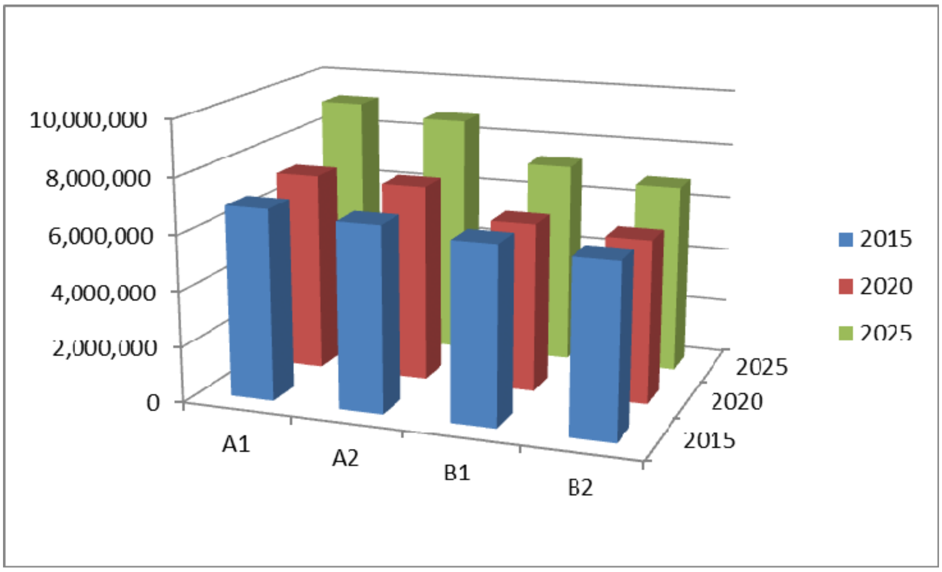


Figure 4:Net Benefits of Integrated Vision over No Intervention



Despite the evidence that the maximum wetland vision demonstrates higher benefits than the integrated vision, this does not necessarily suggest that the wetland vision is a better policy to adopt in economic terms. This is due to that there is no cost data available that we can draw upon to measure the costs side of each the planning visions. For example, it may require higher investment costs to convert the current project area to a maximum wetland condition, than to one of the integrated picture. Nevertheless, these benefits figures can be considered to be upper bounds of the costs of potential intervention measures associated with any of the two policy visions. That is, in a planning process, if the total costs with respect to achieving a maximum wetland vision would outnumber the extra benefits specified above, this would be considered to be economically unsound.

The uncertainties in this analysis are significant. First, the use of benefit transfer of values can be critiqued. It would certainly be better to conduct a primary study, but these are costly and time consuming – and beyond the scope of the PLUREL project in the Manchester case. We also do not vary the values with different sizes of areas – we assume that the values applied are constant. Non-marginal changes may have significantly different values – as the marginal rate of substitution between goods will change.

There are also uncertainties over value transfer over time, in the case where there are social changes that may significantly alter preferences for environmental quality that we cannot take into account. We have adjusted our analysis to take into account some changes incomes over time, populations and agricultural crop yields. However, if the population in 2020 is far less interested in recreation outdoors because of developments in computer technology, this could not be taken into account.

Conclusions

We show there are significant benefits of interventions in the Mosslands case, be it in terms of the Maximum Wetland or Integrated Vision. The benefits may be between £6.8 and £21.1 million by 2025, depending on the socioeconomic scenario and vision. Overall, the Maximum Wetland seems to yield the highest benefit, but the uncertainties in the analysis and the need to consider the relative costs of getting to these visions of the future makes clear policy guidance difficult.

The use of the combining of socioeconomic scenarios with valuation and land use planning is clear. Future populations will change and will have different incomes to the current populations. If current preferences for environmental quality hold, this means that the value placed on better environmental quality will rise. Under different scenarios, there may be variation in the appropriate policy to implement – this is not shown here.

For better peri-urban land use planning, tools such as cost-benefit analysis and environmental accounting may be useful in giving guidance to policy makers in weighing the advantages of different areas.

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Acknowledgements

Our thanks go to Joe Ravetz, Andrew Long, Tony Hothersall, Pam Warhurst and other participants in the Manchester case study as part of the PLUREL project. All errors are our own.

PLUREL

Cost Benefit Analysis of Transport Infrastructure Projects

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Abstract

This paper explores the land transformation process and growth pattern emerging in the functional urban regions of Europe with particular attention paid to growth impacts on peri-urban areas. The process is considered in the light of the growth pattern of selected Plurel Regions which is analysed based upon international economic and social statistical evidence. Provision of *transport infrastructure* as a critical determinant of growth pathways will be examined.

In the last decade in particular the emergence of discontinuous patterns of development and rapidly expanding functional urban areas has been observed in many developing city regions such as Dublin. Evidence of contrasting trends have emerged with an urban regeneration driven return of development to central areas of economically strong regions, and a concurrent significant dispersal of housing and employment activities development in a sprawl type manner. In turn, in regions with lower levels of economic growth a gradual dispersal of development into peri-urban areas has occurred potentially weakening central core areas.

It is recognised that dispersed patterns have significant implications for the long-term regional development patterns of Plurel Regions. Therefore, this paper will include empirical evidence on development patterns emerging in Dublin and other regions, which it is expected will assist in evaluating the effectiveness of policy measures. In addition the paper will focus on policy support evaluation measures relating to the Cost Benefit Analysis (CBA) tool in assisting the evaluation of new transport infrastructure proposals.

Keywords: Rural/Urban transportation-land use relationship; Rapid rail investments; Greater Dublin Area; Cost-Benefit Analysis; Scenario Analysis; Plurel regions.

Introduction and Context[13]

Following rapid growth of peri-urban areas in many of the European cities in the form of dispersed and scattered type of developments (such as urban sprawl), sustainable urban development and urban growth management has become a central issue both in planning theory and practice. The main issue among researchers and practitioners is the search for linkages between rural and urban spatial structure and transportation systems which will achieve sustainable urban form and efficient transport provisions (see for example Hillman, 1996; Breheny, 1995). Efficiency in transportation which is closely related to the urban structure is generally achieved by “reducing trip lengths and times, enabling efficient transit as the dominant mode of transport, and reducing transport-related emissions, pollution and accidents” (Williams, 2005: 1).

The theory suggests that compact city is preferred to more dispersed patterns in terms of sustainable spatial development and transportation efficiency. The reason is related to the reduction in travel demand and travel time since most of the activities are closely located in the compact form (see for example Hillman, 1996; Bertaud, 2004). It is also argued that compact form can support public transport services better than dispersed form since population densities in the former case are high enough to provide efficiency in different modes of public transportation (see Williams, 2005). In the other extreme of the literature, there are also studies questioning the sustainability of compact form (see Breheny, 1995) and suggesting that decentralised or polycentric solutions will be better. One reason for this is that multi-centred cities provide significant transport benefits by locating residences close to employment centres (see Williams et.al. 2000).

Related to these theoretical findings, existing planning practice has shown that there are attempts such as dispersion of facilities over residential areas to achieve mixed development and pedestrian oriented transportation (Ritsema van Eck et.al. 2005) on the one hand; and on the other hand, there are strategies such as transit oriented development (Jenks, 2005), containment policies (Nelson, 1999), and polycentric urban areas (Meijers, 2005) which focus on various modes of transportation to support development along or near the existing public transportation axis. Therefore, both theory and planning practice imply that accessibility to various services is important in sustainable development which could be encouraged by provision of high quality and efficient transport systems.

[13] This chapter replicates some material contained in an earlier deliverable as part of M2 in PLUREL.

In relation with differing sustainability implications resulting from various land-use policies, scenario development has become a common tool among scholars, practitioners and policy makers for the impact assessment of various policies on the land use changes. In practical applications, scenario analysis is achieved through the use of computer-based land-use/transportation modelling, which provides the basis to simulate alternative land development patterns ranging from urban containment to managed sprawl and transport-oriented corridor developments. Within the framework of the Dublin and Mid East Regional Authority's aim to provide Strategic Environment Assessment for the Greater Dublin Area (GDA), the MOLAND (Monitoring Land Use/Cover Dynamics) Model is developed as part of the Urban Environment Project (UEP)[14] for evaluating the impacts of different policies and programmes on urban development considering the sustainability in urban form and peri-urban-rural relationships. This paper will evaluate the results of this modelling work on the basis of transportation and associated development trends and policy implications. The CBA methodology and outcomes from this study will also shed light on a similar research carried out in Plurel regions.

In the last decades, the Greater Dublin Area (GDA)[15] has experienced significant changes in employment, population and socio-economic structure, which in turn has had substantial impacts on the physical and social structure. Integration with the global economy has enhanced role of the Dublin Region in attracting high volumes of foreign direct investment; in this respect, the Region has become the national focal point of knowledge-based economic growth. The economy has experienced GDP increase of 6.3% and 5.7% respectively between 1990-2001 and 2002-2008 periods (CSO, 2009). As the economy has continued to expand, the population growth has resulted in substantial increases in demand for urban space in order to house the activities of business and employees. However, supply response to this dramatically increasing demand was not adequate. The shortage in land supply, legal restrictions on densities, and limitations on the land allocations to residential development within the boundaries of Dublin Metropolitan Area are some of the factors influencing the supply-side of the real property markets in the GDA. The planning system and policy measures have also played a significant role in giving shape to the GDA. The evidence has shown that some key problems in the Irish planning and administrative system are: highly fragmented decision making

[14] UEP is carried out at University College Dublin in the School of Geography, Planning and Environmental Policy/Urban Institute Ireland, and funded by the Environment Protection Agency.

[15] The GDA is defined in Regional Planning Guidelines (2004) as: Dublin Region (Dublin City, Dun Laoghaire-Rathdown, South Dublin, Fingal), and the Mid-East Region (Kildare, Meath, and Wicklow).

processes based on the local and regional government structures; the problem of overlapping responsibilities among central and local governments resulting in inadequate policy implementations; and the mismatching of administrative borders and executive powers of local/regional authorities with the strategic planning territory (see Orsini and Williams, 2009).

The market imperfections, conflicts in the planning and administrative system and the economic growth of 1990s which came after a long period of recession are the main contributory factors to disperse or sprawl development patterns in the GDA, which can be characterised by single use and low density developments. Such an urban development process can be identified as unsustainable considering wasteful consumption of scarce land and infrastructure resources; high infrastructure costs of servicing low density population; and other undesirable consequences such as negative effects on the air and water quality, increased travel and accessibility costs, and unwanted social equity costs.

In this respect, this paper focuses on sustainability of the land development and transportation relationship in the GDA with a specific focus on various land development scenarios ranging from urban compaction to dispersal and finger expansion. In relation to finger expansion and consolidation scenarios, there will be rapid rail infrastructure provision i.e. Metro North in the north part of Dublin Region. Based on this, a methodology will be provided for the scenario-based impact evaluation of Metro North investment linked with land development in the GDA. The emphasis will be on Cost-Benefit Analysis (CBA) approach which provides basis for the evaluation of impacts of various transport projects and policy changes on land development processes. This is done through the selection of relevant impacts and indicators, used for assessing costs and benefits in terms of their contribution to social welfare. The methodology and initial outcomes from the scenario-based CBA model developed for the GDA will construct a framework to analyse the impacts of rapid rail investments and policies in the Plurel areas such as Leipzig and others.

The second section examines the MOLAND Model which is extensively used in Plurel research as a tool for the scenario analysis. In section three, the study area and various land development scenarios of GDA are presented. In section four, the CBA methodology for the land-use impact assessment of metro investment is provided with the initial CBA results, and followed by conclusions.

PLUREL

The MOLAND Model

The MOLAND Model is a state-of-the-art land use model used widely in the EU and has been applied to an extensive number of cities and regions such as Plurel study areas providing the methodology for the impact evaluation of a wide variety of policies. The most important feature of the model is the application of cellular modelling to the land cover which is named as cellular automata (CA). The CA is based on a variety of inputs to determine the state of the land use in each cell according to a set of transition rules representing the compatibility of land-uses with each other. Petrov et.al. (2009) stated that the model is an improved version of the CA first developed by White et.al. (1997) and achieved robustness through the successful applications in European Region and some other areas. Among them, we can refer to the Dublin Metropolitan Area and other areas in Plurel region.

At the regional level, there are four sub-models utilised in MOLAND and identified as: (a) *regional economic sub-model* which calculates sector production and employment followed by a spatial allocation among the regions, (b) *regional demographic sub-model* calculates the growth of regional population and allocates the regions housing demand, (c) *transportation sub-model* which is a four-stage model calculating the changes in traffic flows and the resultant impacts on land-use accessibility and inter-regional distances, (d) *land-claim sub-model* which translates the regional socio-economic growth numbers into a spatial representation for a further detailed allocation at the cellular (local) level (see Engelen et.al. 2007).

The model developed for Dublin Area has two components including regional and urban land-use sub-models. The model includes an extensive data set covering the years 1990, 2000 and 2006 and utilises both macro and micro-type parameters. Macro-level data such as GDP and population growth are inputs for the regional sub-model, also affecting the urban land-use sub-model which is run through a CA model. Since the data incorporated in this model came from a disaggregated data set, the micro-model parameters i.e. neighbourhood effects, accessibility, zoning, population, employment indicators etc. can be utilised to explain the micro-level spatial issues, which diverge the model from those incorporating aggregate data sets and rely on large geographic districts.

The Study Area and Scenario Analysis

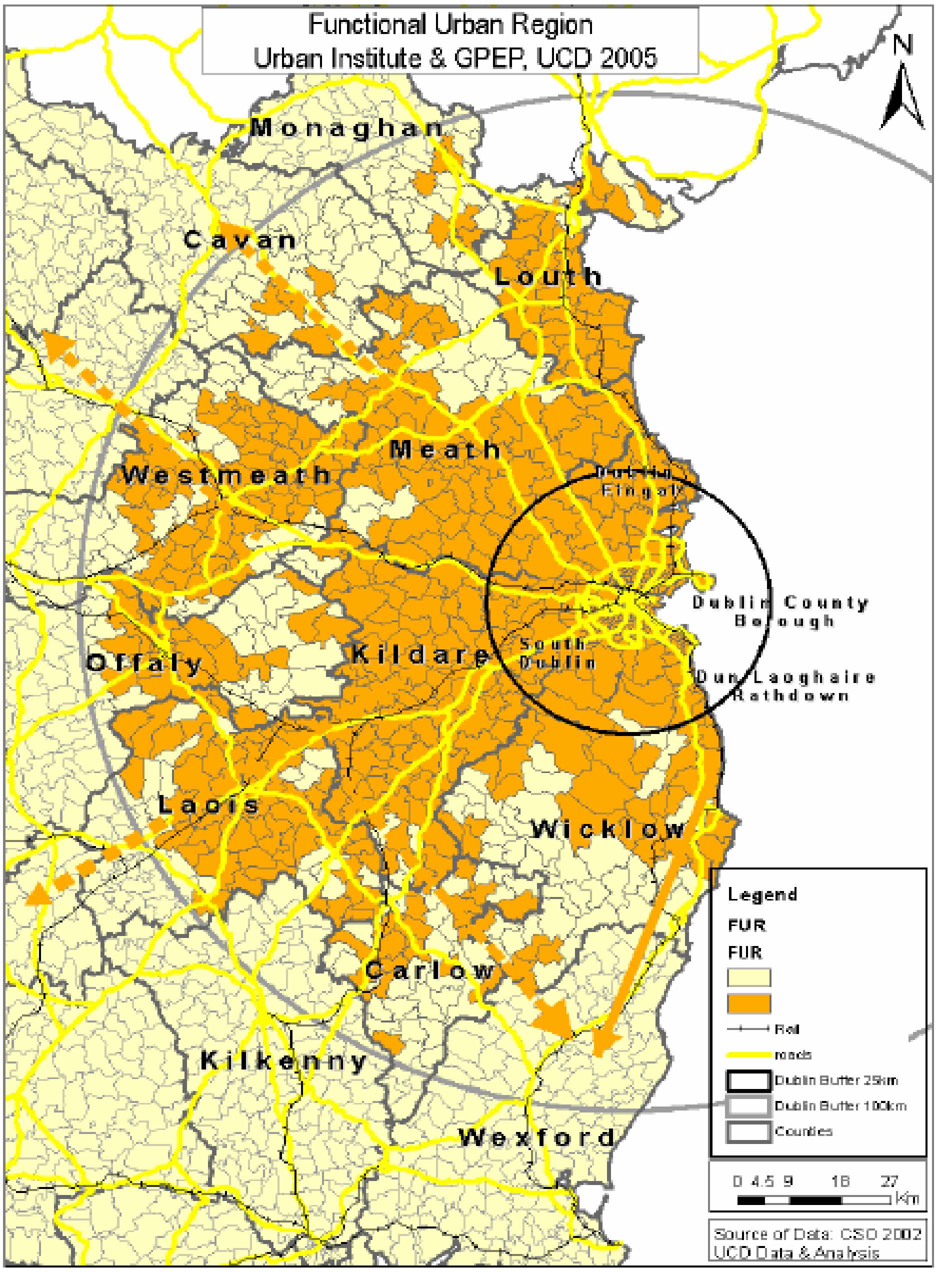
Greater Dublin Area (GDA)

Greater Dublin Area (GDA) consists of not only the business and urban core of Dublin, but also the surrounding Counties of Kildare, Meath, and Wicklow. The area has a land cover of around 7,000 km^2, and has a total population in excess of 1.6 million (CSO, 2007). There are seven local authorities governing the area. Four of them i.e. Dublin city, Dun Laoghaire-Rathdown, South Dublin and Fingal comprise the Dublin Region, while the other three are in the adjacent counties including Kildare, Meath and Wicklow (see Figure 1).

Dublin Area is considered as one of the most negatively affected cities by sprawl development patterns within the European Union in the study carried out by European Environment Agency (see EEA, 2006: 13). According to Williams et.al. (2007), "*the outward extension of the commuter belt reaches over 100 kilometres from the Dublin area into Outer Leinster and now adjacent to Ulster counties of Monaghan and Cavan*" (Williams et.al. 2007: 6). Considering the uncontrolled urban growth that the Dublin Area has experienced from early 1990s, problems in transportation and land-use planning have also contributed to sprawl type development patterns in the peri-urban areas of the Dublin Region. Since this is the case, the Region has required further examination considering future land development processes and new infrastructure provisions.

There are recent attempts in the GDA related to Regional Plans for GDA and the Transport21 project which aim to achieve coordination between transportation/infrastructure provision and land-use development and planning. Regional Plan is searching solutions to mitigate the effects of urban sprawl by focusing on new development centres beyond the Dublin Metropolitan Area. Transport 21 Plan, on the other hand, gives importance to the transportation projects which strengthen the role of existing urban settlements or the settlements having the potential of attracting new residential or industrial growth (see Figure 2). Transport 21 covers the period 2000-2016, and aims at "managing travel demand by reducing overall travel and by increasing share of public transport" (Ellis and Kim; 2001: 363). There is specific emphasis on the rail investments including light rail and metro in order to achieve more compact and mixed developments along the rail lines and in urban centres. In relation with the goals set in Planning Guidelines and Transport 21 Investment Programme, the three scenarios derived from the MOLAND Model will be evaluated in the next section.

Figure 1. Growth Paths and Spatial Structure of GDA

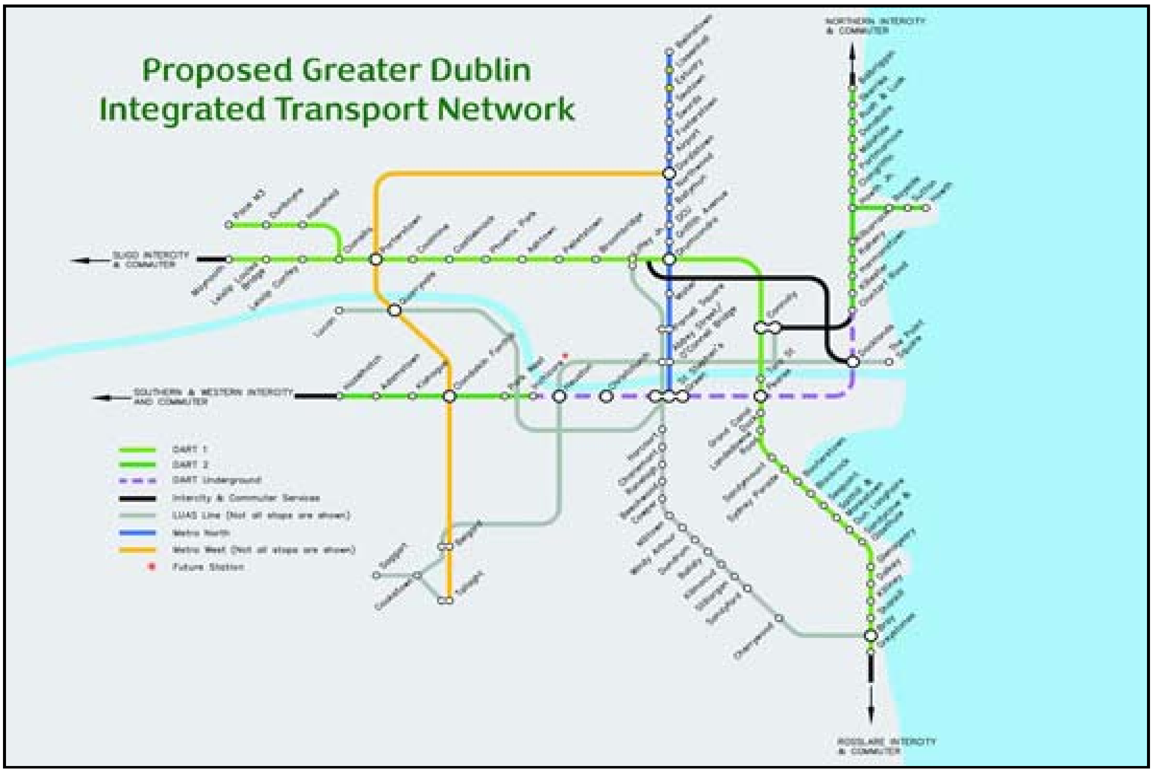


Source: Williams et.al. (2007)

Notes: (a) Functional Urban Region (FUR) is defined in relation with the labour force travel patterns (see Williams, 2006).

(b) Arrows show current FUR growth paths along arterial routes.

Figure 2. Rapid Rail System in Transport 21 Project



Source: Transport 21 (2009)

Scenarios for the GDA

Within the framework of Strategic Environment Assessment for the GDA, three scenarios are subject to evaluation including: 1) Business-as-usual scenario 2) Finger expansion scenario 3) Consolidation scenario.

Scenario 1: Business-As-Usual

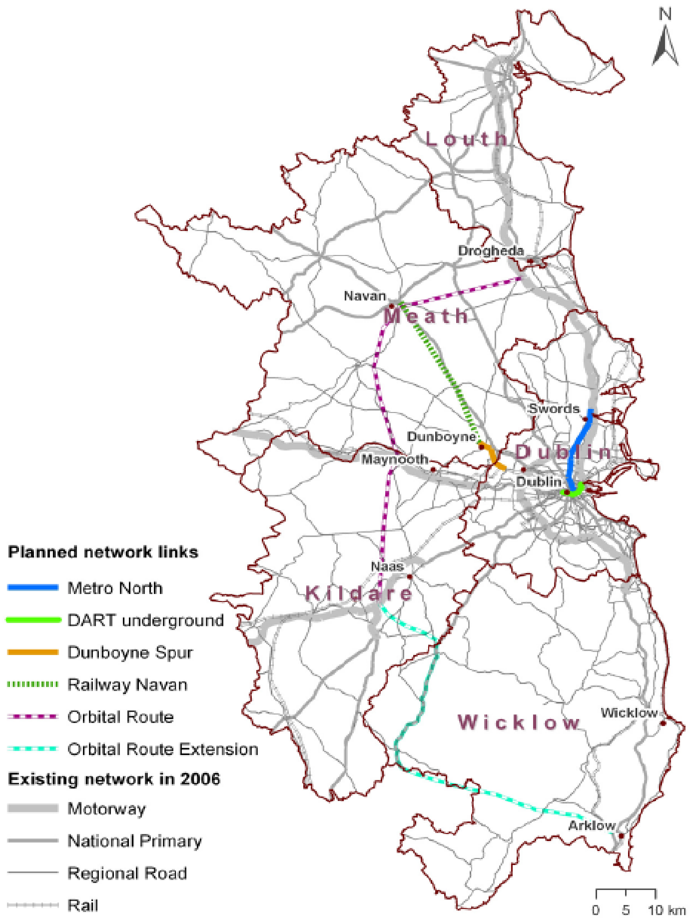
In this scenario, current trends in land zoning, land development and transportation are continuing with a limited implementation of Transport 21 project (see Figure 3) and planning/policy decisions stated in the RPGs (2004). This implies that proposed growth nodes of the RPGs are not supported by the necessary public transportation networks and/or land zoning decisions and implementations. In the Regional plan, the primary and the secondary growth nodes are attached the role of self-containment, and will be separated from each other by greenbelts surrounding them. Since there is limited integrated transportation/land-use planning supporting the development of the primary growth nodes; this situation acts as an obstacle in this scenario for the development of the new growth centres. Consequently, new development spreads to the outskirts of the existing development where there is abundant of greenfield land at lower prices. The final result is dispersed type of settlements around the Dublin Region with high employment dependency on the core of the Dublin Area (see Figure 4).

Increase in car dependency associated with dispersed development and the resultant increase in traffic congestion are some problems seem to have significant impacts in the GDA. Low density and private car dependent developments -as the sprawl patterns in this scenario-are less accessible, requiring more travel to reach urban activities, and reducing transportation options i.e. cycling, pedestrian and public transit access. The result is the increase in transportation costs-both user costs and external costs. Furthermore, the characteristic of dispersed development in this scenario is seen to be unsustainable considering that it necessitates providing infrastructure and services to the low density population on urban periphery reflecting the main cost of infrastructure provision on the society as a whole. It also causes loss in productive agricultural land and reduction of landscape amenity, and related to indirect externalities such as: negative effects on air/water quality, increased accessibility costs, and unwanted social equity costs.

Scenario 2: Finger Expansion

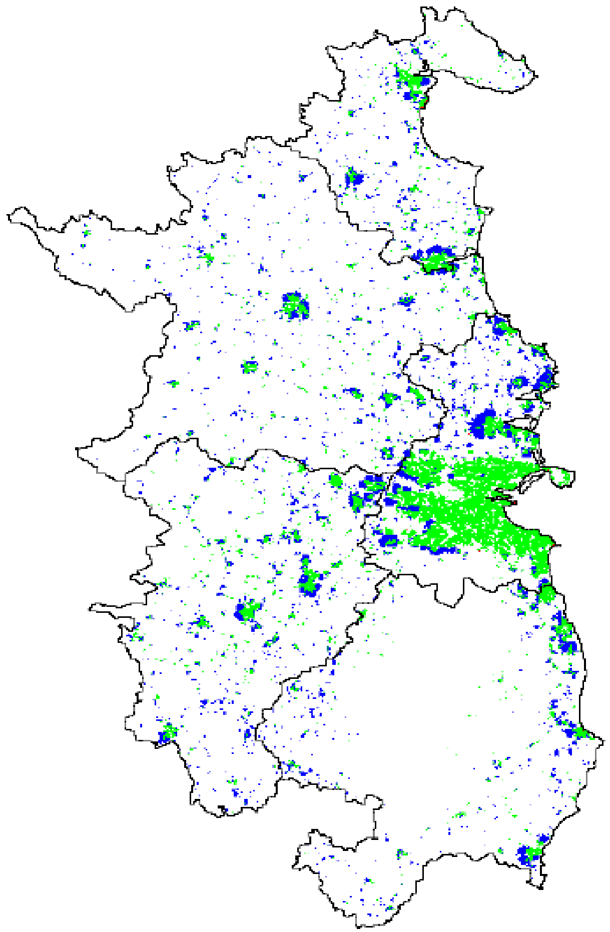
In this scenario, compact form of Dublin city is protected and new development is directed to the main transportation corridors associated with the supportive land-use zoning policies and planning decisions (see Figure 5). The new growth will benefit from accessibility of current and newly constructed transportation network along catchment areas and low costs of extensions from the existing infrastructure. In this scenario, the dependence of employment on single-centred Dublin city is continuing with an increase in density in the core area, and new growth is supported by densely developed settlements along the transportation corridors. The high population densities are effective in the provision of public transportation, public services and investments in infrastructure and housing. Therefore, in comparison with the business-as-usual scenario, this scenario achieves lower costs of public service provision, higher accessibility to land uses and public transportation modes, reduction in transport-related emissions and pollution (as a result of closer locations and less dependency on private car) and reduction in energy consumption. The newly invested Metro North line-supported by various transport connections in this scenario- may seem to add value to its catchment area, which incorporate old suburban sites.

Figure 3. Transport 21 Network Used for Scenario Analysis



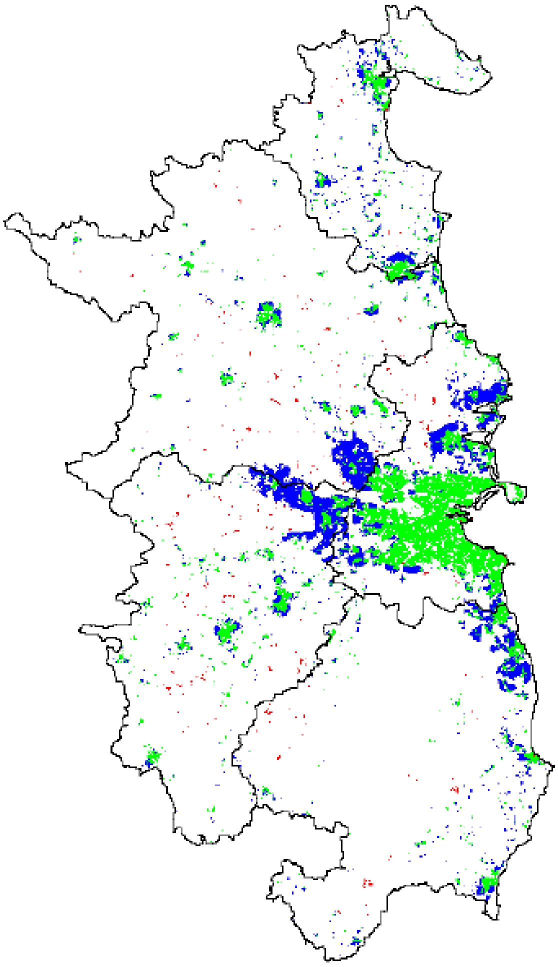
Source: Brennan et.al. (2009)

Figure 4. Scenario 1: Business-As-Usual



Source: Brennan et.al. (2009)

Figure 5. Scenario 2: Finger Expansion



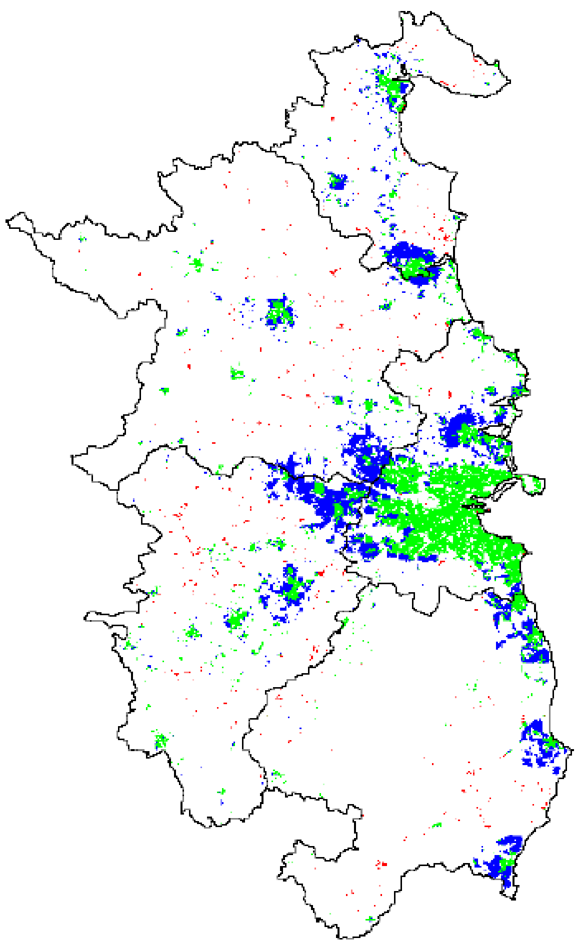
Metro North investment may encourage the re-generation process of the related areas, and thereby, can provide high quality housing and neighbourhood activities for the future demand in new housing markets.This may play a significant role in meeting excess demand in housing markets; and therefore, contribute to the compact growth of the city in contrast to sprawl development patterns. In contrast to these benefits, there are also costs in this scenario such as provision of limited amounts of green space and rural amenities for the people who may benefit living in less densely populated rural areas as in the business-as-usual scenario. Other one is the probable increase in public service provision costs which are expected to rise at high densities due to congestion and high land costs resulted from more densely compact form of development (see Ewing, 1997).

Source: Brennan et.al. (2009)

Scenario 3: Consolidation

The main goal of the RPG's (2004) self-sufficient growth nodes is achieved through this scenario by consolidating the growth in existing urban area and a few numbers of key towns (see Figure 6). In other words, the area is performing a multi-centred development supported by the integration of land-use and transportation policies. Compared to the business-as-usual scenario, consolidation scenario has benefits similar to those achieved through the finger expansion scenario. Key Transport21 projects including Metro North Project which will serve public transport from key towns to Dublin City are included in this scenario. However, in this case, mixed-use developments could be more intense considering the self-sufficiency of the new growth centres supported by the required transportation networks.

Figure 6. Scenario 3: Consolidation



This implies that dependence on the Dublin City Centre is less than those in the finger expansion scenario which may result in less traffic congestion and reduction in some other costs of travel. This may include increase in access to urban activities i.e. jobs, public services, recreation etc., benefits from access to multi-modal travel options i.e. walking, cycling etc. and reductions in transport-related emissions and pollution. The pressure on dense development in land values is reduced with the Dublin centre and resultant increase in consolidation of growth to new centres. This will contribute to meet future demand in affordable housing and prevent dispersed patterns of development which may stem from search for less expensive land for residential and some other uses in the urban periphery.

Source: Brennan et.al. (2009)

Proposed CBA Methodology for the Land-Use Impact Assessment of Rapid Rail Investments in the GDA

Impact or Indicator Specification

Assisted by the literature on the comparison of international and EU country examples for the transport policy evaluations, common impacts are specified for the appraisal of metro investment and land development in the GDA. The international literature on the inclusion of different impacts in evaluation process and transport appraisal methods in use for different countries can be found in Bristow and Nellthorp (2000); Hayashi and Morisugi (2000); Janic (2003); Odgaard et.al. (2005), and others. At a common ground, these studies share a number of impacts and indicators which are more or less similar to each other despite the existence of differences in their policy evaluation goals and appraisal methodologies. These common impacts for transportation investment and policy decisions can be analysed under four main titles including:

1. *Direct Impacts of Transportation Infrastructure Provisions*: Land costs, development costs and capital investment costs of transportation infrastructure investments.
2. *Socio-Economic Impacts:* Changes in vehicle operation costs, travel time, accident risk/costs, land-use/transportation accessibility.
3. *Transportation Network Effects:* Reliability and quality of transport service, system operation costs.
4. *Energy and Environmental Impacts:* Energy consumption, air/noise pollution exposure, climate change impacts.

These studies pointed out that it is important to consider all related impacts of transport policy changes in the evaluation process; however, specific emphasis should be given for the choice of number and type of criteria, and the indicators for particular criteria to be involved in the decision making process. However, care should be taken in order to minimise the problem of double counting and to reduce the impacts of overestimation of benefits and costs in the transport policy evaluations.

The selection of related indicators for this study are based on these four main types of criteria including direct impacts (costs/capital investments of metro transportation infrastructure), socio-economic impacts (costs of providing public services, road vehicle operation costs, travel time, accident costs, area property values[16]), transportation network effects (operating costs and revenues of metro), and energy and environmental impacts (CO_2 emissions and local area pollution), as suggested by the international literature. Data limitations for the impact evaluation of rapid rail investments in the GDA are also influential in the process of the selection of indicators. Metro North project is selected for the scenario-based impact assessment in this study, considering its wide impacts in the GDA and in particular, data availability for this project published in various sources.

From the literature review, there are few studies with a capacity of incorporating all of the possible externalities into their analysis. This stems from the fact that it is difficult to quantify most of the impacts of transportation provisions. Some of the impacts and indicators can be represented in monetary values while others can be only expressed in a qualitative way. There may be also correlations among various indicators such as the positive correlation between land-use accessibility and land values, or the negative correlation between air pollution exposure and area property values. Considering the correlation effects, data limitations and the marginal role of some specific impacts in CBA, only a limited number of indicators are selected in the present analysis.

Implementation of CBA for Impact Evaluation of Metro North Investment in the GDA

Scenario analysis- comprising a baseline scenario (reference scenario) which is compared with several alternative scenarios- can construct a base for the impact evaluation of rapid rail investments. The research is mainly based on the consideration of two scenarios: A baseline-*business-as-usual* and alternative *with rail* scenarios. According to the baseline scenario, it is assumed that the urban area would continue to grow with the present trends and there would be only sufficient maintenance and renewal investments to maintain the existing infrastructure (see Figure 4). Therefore rail services in future years would be broadly comparable to the current level leading to a dispersed form.

16 In relation to area property values, there are two key points to highlight: First, the land value-gains accrue to private property owners to a large extent. Second, it is important to mention the existence of relocation effects stemming from local development i.e. the gain achieved by one area may be lost in another area in the region implying a net zero effect overall. Therefore, it is suggested that effects on local development reflected in adjusted property values are not to be taken into account in CBA but can be evaluated separately subject to a qualitative assessment.

Considering the land development impacts of rapid rail investments, it can be expected *with rail* scenario will generate more compact forms of urban development (see Figure 5 and Figure 6). By encouraging a transfer from private transport, rapid rail investments can assist in improving accessibility, and land-use change which supports compact and mixed developments (see Vuchie, 1991; Litman, 2008). The potential for efficiency and environmental impacts can be examined through the impacts and indicators specified in the previous sections. The economic appraisal process can be summarised in six stages (see Table 1).

Table 1. Stages of Economic Appraisal Process for the Rapid Rail Investments

1.	Forecasting transportation demand with a transportation model consisting of: - Forecasts of future growth and land-use change (population, employment, economic activity, income) - Assumptions of the supply side of transportation activities - Assumptions and scenarios for external conditions - Four stage method: trip generation, trip distribution, modal split and network assignment
2.	Quantifying, where possible, incremental costs and benefits relative to the baseline scenario
3.	Identifying unquantifiable impacts
4.	Adjusting quantified costs and benefits for: - Inflation - Relative price changes - Risk and optimism bias
5.	Undertaking sensitivity analysis
6.	Calculating the net present value

Adapted from: EC Final Report (2008)

In accordance with the estimations from the transportation model[17] and the parameters/values specified for the capital costs, costs of accident, vehicle (and system) operation, public service provision, travel time and carbon dioxide emissions, Table 2 presents the related data requirements for the scenario analysis of baseline *business-as-usual* and *with rail* cases. Based on the impact evaluation data given in Table 2, some specific issues in impact-indicator valuation methods are then explained in the following sections.

[17] MOLAND Model and Metro North Transportation Model will be utilised in this study.

Capital Cost Estimation of Rapid Rail Investments

A broad estimate of the capital costs for any rapid rail provisions is obviously obtained at project initiation stage. These estimates are expressed in constant prices and are generally built up using unit cost data, expert advice and experience of similar projects in the past. Given the inherent uncertainty at this stage, the detailed risk analysis is necessary to reduce the uncertainty around the expected infrastructure costs of rapid rail projects. In the literature, there are examples showing that cost escalations are globally common in transport infrastructure projects particularly in urban rail projects. For instance, Flyvbjerg et.al. (2002) showed that transport infrastructure projects worldwide experience large construction cost escalations; and it is the length of the implementation phase which strongly leads to larger percentage cost escalations. Economic and demographic factors, technology, and differences between forecasted and actual operating service plans are considered as the main reasons for uncertainty in project cost estimations. This implies large underestimation of costs resulting in inflated figures and benefit-cost ratios from the CBA, which ends up with misleading conclusions in project evaluations (Flyvbjerg, 2007). Based on this, adjustments for capital cost bias should be added to the initial cost estimations in any of the countries where rapid rail projects are taken place. However, a detailed risk analysis could also reduce the uncertainty in cost estimations, and therefore, the need for estimation bias adjustments could be reduced. For the EU countries, HEATCO (2004) -a EC 6th Framework Research Programme- suggests an average of 34% capital expenditure up-lift for the rail projects based on the results in Flyvbjerg et.al. (2002) representing average cost escalations in Europe. This will be applied in the current study in evaluating the capital costs of Metro North.

Table 2. Impact Evaluation Data for Rail-Based Infrastructure Investments: With-Rail vs. A Baseline Scenario Approach

Impacts/ Indicators	**Impact Evaluation Data Requirements of *With-Rail* Scenario vs. Baseline Scenario**
1. Capital Costs of Rail Infrastructure Investment	Direct construction cost estimates include the following: Land acquisition costs, railway infrastructure, stations, civil engineering works, operational systems, planning and design
2. Provision of Public Services	Future estimated numbers for new residential development (numbers of new housing units) in the case study area within the appraisal period specified for rapid rail investments
3. Accident Rates/Future Accident Risks	Three types of data are required: -The most recent data related to the *number of personal fatality, serious injury, and minor injury accidents along* the catchment area of the newly proposed rail line -Estimated numbers for future accident risks from the national and local accident rates and trends -Quantification of changes in the number of fatalities, serious injuries, and slight injury accidents due to a rapid rail investment by using country specific risk functions
4. Change in Road Vehicle Operation Costs	For the calculation of the economic benefits (costs) associated with vehicle operating costs, two types of data are required: -***Demand***: the number of private vehicles (cars) making a particular origin-destination trip for the baseline scenario and the alternative *with rail* scenario (peak/off-peak traffic flow data for the baseline and alternative scenarios) -***Vehicle kilometres***-total change in vehicle kilometres from the local highway network for the baseline and *with rail* cases
5. Change in Travel Time	Estimates related to; -*Travel time*-change in travel time for private vehicles (cars) in peak/off-peak traffic for the baseline and *with rai*l scenarios -*Demand*: peak/off-peak traffic flow data for the baseline and *with rail* cases
6. Rail Operating Costs and Revenues	-Expected operating pattern and service frequency of newly proposed rapid rail system -Key characteristics (route length, journey time, peak and off-peak headway etc.)
7. Change in Emissions	-Total change in greenhouse gas emissions (i.e. CO_2, in particular) and local air pollutants for the baseline and *with rail* cases.

Source: Authors own research

Valuation of Traffic Safety

It can be argued that any limited economic analysis underestimates the value of human life to family, society etc. However, for the purpose of this research an input based upon conventional economic statistics can be used. The statistical value of human life (SVHL) has been determined using two methods: Human capital and stated preferences. The former method measures discounted loss of production due to the injury or death of the individual member of the workforce while the later is used for estimating willingness-to-pay (WTP) values of individuals-indicating their preferences to reduce the risk of being injured or die in an accident.

The previous transport appraisal studies in Ireland pointed out to the difficulties in estimating Irish accident costs from first principles since there has been little research undertaken to date in the Irish context (see DKM Report, 1994; Goodbody Economic Consultants Report, 2004). In a study carried out by Goodbody Economic Consultants for the Department of Transport Ireland, accident cost estimates are computed for the Irish case for the year 2002 by following the methodology given below:

1. UK accident costs (including social costs i.e. damage to property, insurance administration, police costs; and system external costs i.e. output loss, human costs, medical costs) are set for the base year: the year 2000.
2. These are adjusted to Irish values at Purchasing Power Parity
3. Year 2000 values are inflated to 2002 values by using the growth in average hourly earnings per person employed in Ireland in the period 2000-2002.
4. System external cost estimates are translated into estimates of accident costs on the basis of the number of casualties per accident on Irish roads.

These costs are also re-computed in order to get a composite value for accidents of varying severity. The estimated number of casualties per road accident is used to weight each accident and to produce an estimate of road accident costs which is given in Table 3. For the forecast of future growth in road accident costs, the rate of growth in real GNP per person employed is suggested and will be used in the present study.

Table 3. Road Accident Costs for Ireland by type of Accident (2002, Market Prices; Factor Costs)

Accident Type	Values at Market Prices		Values at Factor Costs	
	Per Casualty* (€)	Per Accident (€)	Per Casualty (€)	Per Accident (€)
Fatal	2,018,126	15,882	1,694,480	13,335
Serious Injury	226,757	6,769	190,392	5,683
Slight Injury	17,486	3,896	14,682	3,271
Damage Only	NA	2,403	NA	2,017

*per person injured or killed; Source: Goodbody Economic Consultants in association with Atkins, 2004.

Vehicle Operation Costs

(a) Road Vehicle Operation Costs:

The unit vehicle operating costs are clearly dependent on the prices of goods within a region (i.e. price of oil, vehicle parts etc.), the transport network characteristics, and vehicle utilisation. However, operating cost relationships for road vehicles is more generic and transferable between countries (see HEATCO D:5, 2004). For instance, fuel and non-fuel consumption parameters-for private car and busses-can be computed by the following formulas in (1) and (2), respectively:

$$C= a + bV + cV^2 +dV^3 \quad (1)$$

$$C= a_1 + (b_1/V) \quad (2)$$

where C is the cost in cents per kilometre, V is the average link speed in kilometres per hour, and a, b, c, d, a_1 and b_1 are the parameters defined for each vehicle category. Economic appraisal studies in Ireland are generally based on the adjusted parameter values which are derived from external sources. There is one study carried out by Goodbody Economic Consultants utilised a method by adapting estimated vehicle operation cost values for UK to the Irish prices and tax rates for the year 2002. Based on the technique used in this study, a similar methodology will be utilised in the current research.

(b) Rail Operating Costs:

Railway costs can be analysed as fixed and variable costs: Fixed costs are incurred costs for operation, maintenance, and replacement which are independent of traffic volume changes. Variable costs, on the other hand, are those which depend on traffic volume. The elements of the variable unit operating costs for railways are specified by World Bank in its 1995; 2005 Infrastructure Reports, and given in Table 4. In relation with Table 4, rapid rail operating cost estimations require three main sets of data including:

- Crew Wages (drivers and operation staff, working time directives)
- Maintenance Costs (rolling stock, equipment, security, insurance)
- Power Usage Costs (power traction/auxilliaries, power depots and stations).

Table 4. Elements of Rail Operating Costs

Cost Type	
• ***Vehicle Ownership Costs***	
Locomotives/Coaches	Replacement Cost
• ***Vehicle Maintenance Costs***	
Locomotives/Coaches	Unit cost/loco. Unit-km
	Unit cost/coach-km
	Unit cost/coach-year
• ***Transportation Costs***	
Train fuel	Unit cost (gross ton-km)
Train crew wages	Actual by cost centre
Locomotive crew wages	Actual by cost centre
Station operations	Unit cost/train-km
Billing	Unit cost/car load
Other	Unit cost/train-km

Source: Anderson (1995), World Bank (2005)

Value of Time

There are two categories of time that are involved for valuing travel time savings of passengers i.e. working and non-working, the former of which is related to commuting for working purposes while the later is comprising all other non-working activities. Travel time is evaluated by standard values of time for each vehicle category assuming a constant marginal unit value of time regardless of the time saved and the variance of income levels of individuals. The cost saving approach, which considers wage rates as a measure of productivity loose or gain by the labour force, is selected as a minimum approach for the valuation of work time savings (see HEATCO, 2004). In this study, national values for net average hourly wages for work time valuation are used (see Table 5), and for the non-work time valuation Department for Transport of UK has published results from various surveys which are related to the values of time.

Table 5. Net Average Labour Costs (2006, market prices, factor costs)

Gross Annual Earnings €	**Net Annual Earnings (net of holiday, sick etc. payments) €**	**Net Earnings per week €**	**Weekly paid hours €**	**Net Earnings per hour € (at market prices)**	**Net Earnings per hour € (at factor costs)**
34,357.96	30,922.164	594.657	34.8	**17.08**	**14.36**

Note: The value of average hourly earnings i.e. ***€ 17.08*** and ***€ 14.36*** are the *estimated values of work time* at market prices and factor costs, respectively for all the workers who are working in various sectors for the year 2006.

The non-work value of time used in UK was derived in 1985, representing the 40 percent of the mileage weighted hourly earnings of commuters. The recent studies on the value of time in UK concluded that although there are 10 to 20 percent reductions in value of time of commuting and other non-work trips, it is not suggested to depart from the rule of 40 percent considering the existence of errors associated with value of time measurements (see Report to Department for Transport, UK, 2003). Based on the results from the UK research, this study will measure the value of non-work time 40 percent of mileage weighted hourly earnings of commuters (see Table 6). The most appropriate method to measure future growth in value of time is the growth rate in real earnings. In the absence of full estimates related to real earnings growth, the most commonly used statistic is the annual growth rates in GNP per person employed (see Goodbody Economic Consultants Report, 2004). The estimates of GNP per person employed are from ESRI (2009).

Table 6. Average Earnings-Wage, Salary, Irregular Payments (2006)

Gross Annual Earnings €	Annual Earnings (inc. wage, salary, irregular payments) €	Earnings per week €	Weekly paid hours	Earnings per hour € (at market prices)	Earnings per hour € (at factor costs)
34,357.96	26,112.0496	502.1548	34.8	**14.43**	**12.13**

Note: Average hourly earnings were estimated to be €14.43and €12.13 at market prices and factor costs, respectively. The *value of non-working time* for 2006 will then be equal to €14.43 x 0.40 or *€ 5.77* per hour (market prices) and €12.13 x 0.40 or *€4.85* per hour (factor costs).

Environmental Impacts

An environmental impact assessment will usually be required for any significant rapid rail infrastructure development in the European Union. In relation with this, two environment impacts are considered: 1) Global air pollution 2) Local air pollution. Global air pollution which is mainly caused by carbon emissions could be calculated from the values attributed to the carbon dioxide by using the methods specified for 'social costs of carbon' (SCC). Due to the uncertainty of future emissions and climate change, there is wide uncertainty among the SCC estimates. Kuik et.al.'s (2008) meta-analysis study is well known in the literature verifying this considerable variability across the SCC estimates. Kuik et.al. (2007) in the CASES Project points to the study performed by DEFRA (2005) as the most recent policy oriented study on the social costs of carbon. It is noted that DEFRA (2005) combines the results from a number of Integrated Assessment Models (IAM) in a transparent way, and the policy context in which the values are used is very well determined. This study is based on the idea that future emission years will have stronger total impacts than present emissions; thereby stressing future increases in value estimates. CASES Project (2007) recommends using the carbon prices obtained by DEFRA (2005) as a central estimate for the price of global carbon emissions (see Table 7). Thus, this approach is considered to be the most appropriate for the present study.

Table 7. Shadow Prices per tonne of CO_2 Emitted (2000 values, factor prices)

Year of Emission	Central Values, €
2000-2009	23
2010-2019	28
2020-2029	33
2030-	41

Source: CASES, D 3.2. (2007: 103)-results based on DEFRA (2005)

Local pollution differs from global pollution in that it is caused by road transportation is absolutely case specific since it has impacts on human health and environment in local areas. The main pollutants (i.e. NO_2, PM_{10} and $PM_{2.5}$) are directly related with the number of vehicles travelling on each of the local roads, and therefore, the change in number of vehicles results in changes in concentrations of emissions in the affected areas. Willingness-to-pay methods are generally used for the valuation of the estimated damage. The evaluation could be based on the number of properties or people experiencing better or worse air quality in terms of the pollutants of NO_2, PM_{10} and $PM_{2.5}$ in relation with the baseline and *with rail* scenarios.

Public Service Provision Costs

Public service provision costs can be a significant indicator in the CBA reflecting the change in public service costs following the shift from dispersed to more compact developments after the introduction of metro transportation systems. Public service cost estimations are case specific and could be identified as the costs of road construction, housing and community development, education, fire and police protection, water and electricity distribution, sewerage, and social and recreational facilities. Unit public service costs including school transportation, electricity connection and distribution will be computed for the GDA in relation with baseline and *with rail* scenarios.

Cost-Benefit Evaluation and Initial Results

A CBA approach which is based on a straight net present value calculation is considered appropriate for the scenario-based evaluation of the transport and land-use impacts of metro investment in the GDA. In CBA, all costs and benefits are reduced to their present value and discounted at a standard rate over the pre-specified evaluation period through the formula given below:

$$ENPV = \sum_{t=0}^{n} a_t S_t = \frac{(b_0 - c_0)}{(1+r)^0} + \frac{(b_1 - c_1)}{(1+r)^1} + \ldots + \frac{(b_n - c_n)}{(1+r)^n} \qquad (3)$$

Where S_t is balance of cash flow funds comprising flow of benefits, b_t, and flow of costs, c_t; a_t is discount factor, r is discount rate, and n is the evaluation period (see European Commission Final Report, 2008). This is also used to produce a benefit-cost ratio and internal rate of return (IRR). The former is the ratio of the discounted aggregate net benefits (i.e. benefits minus costs) to the discounted investment costs and the later is the rate of discount equating discounted net benefits to discounted investment costs. The social discount rates and project appraisal periods vary among countries reflecting the local variations in opportunity costs of capital, project risks, and lifetimes of rapid rail investments. The UNITE project suggests the use of a European social discount rate of 3 % while EC HEATCO suggests a rate of 5 % (see HEATCO D:5, 2004). This implies the use of a range of discount rates between 3% and 5% in CBA, which will be considered in the present analysis.

For the CBA of the alternative land development scenarios-i.e. baseline (see Figure 4) and *with rail* scenarios (see Figure 5 and Figure 6), the balance of cash flows for each year starting from 2011 are computed in the first stage[18]. Here, the period 2011-2015 is the assumed construction period for the Metro North Project, 2016 is the first year of metro operation, and 2029 is the forecast year in which the whole Transport 21 program is assumed to be carried out (see Figure 2). From this data, economic net present value (ENPV), benefit-to-cost ratio (B/C) and internal rate of return (IRR) values are derived and presented in Table 8. For the discounted cash flow analysis, a 35 year period is chosen starting from 2011 and ended in 2045. All the values are calculated considering five different discount rates of 3.0%, 3.5%, 4.0%, 4.5%, and 5%. From Table 8, ENPV is significantly positive in *with rail* scenarios across all the different discount rates and there are also benefit-to-cost ratios exceeding 1.0 for each discount rate. IRR is computed as 6% greater than all the discount rates considered.

[18] The details for each of the cost-benefit cash flows could be accessed from authors' original research.

Table 8. Initial Results from Net Present Value of Costs and Benefits as at 2010

<table>
<tr><th>Discount Rate</th><th>ENPV</th><th>B/C Ratio</th><th>IRR</th><th>Evaluation Period</th></tr>
<tr><td>3.0 %</td><td>1,305 million €</td><td>1.65/1</td><td rowspan="5">0.05967 (6 %)</td><td rowspan="5">2011-2045
(35 years)</td></tr>
<tr><td>3.5 %</td><td>1,009 million €</td><td>1.51/1</td></tr>
<tr><td>4.0 %</td><td>749 million €</td><td>1.38/1</td></tr>
<tr><td>4.5 %</td><td>521 million €</td><td>1.27/1</td></tr>
<tr><td>5.0 %</td><td>321 million €</td><td>1.16/1</td></tr>
</table>

Note: Initial CBA results exclude the value of local air pollution

Further to the calculation of cost-benefit indices, there is an additional step that may influence the final valuation of the impacts of metro investments: sensitivity analysis. This is mainly used for testing the effects of uncertainty in the value of indicators. A summary of sensitivity testing is provided in Table 9.

Conclusions

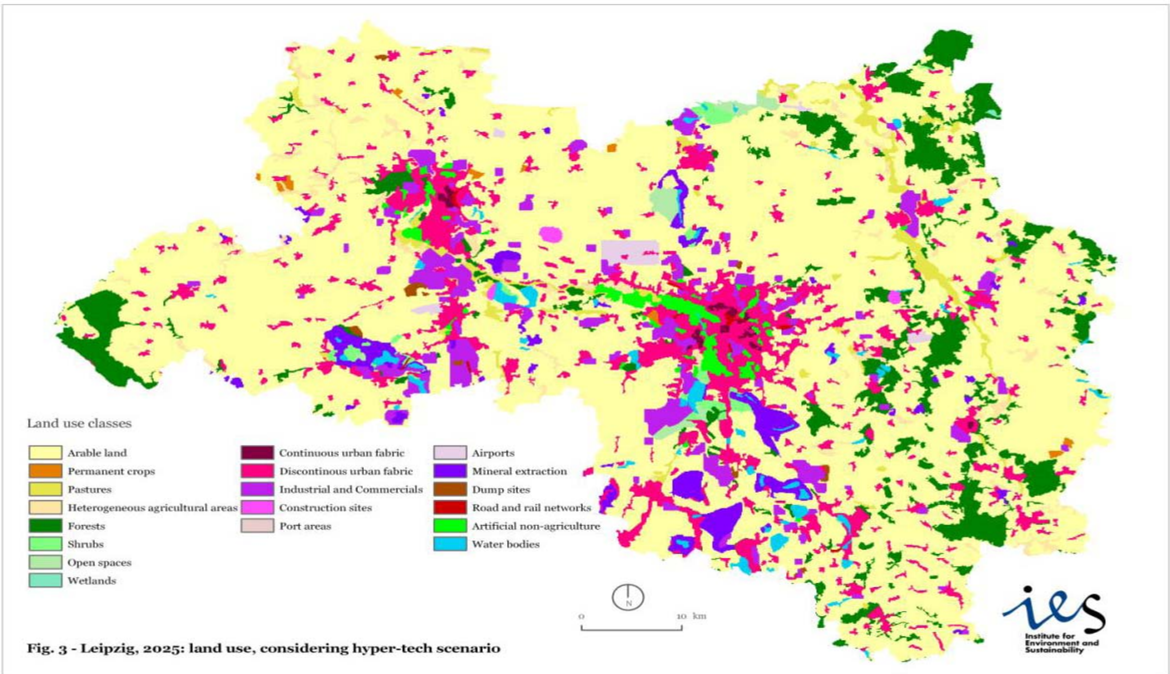
In order to assess the sustainability implications of various urban forms resulting from differences in planning policies and implementations, the potential urban future of GDA has been analysed by utilising scenario analysis carried out by the MOLAND Model examining potential future urban structures and settlement strategies. Three scenarios were generated from the MOLAND applications, ranging from urban containment and transport-oriented corridor developments to sprawl. In terms of sustainable urban development considerations, initial results from CBA show that uncontrolled sprawl in the baseline scenario is the least desirable one since costs of such development exceeds the benefits. In contrast, the containment policies -as in the transit-oriented development and consolidation- could achieve considerable benefits over the baseline scenario by reducing the negative consequences of unregulated sprawl. The evidence has pointed out to the difficulties of controlling the land development by applying development restrictions and zoning codes, particularly in the post-1990 period when there is significant shift in the economic climate and associated changes in the socio-economic structure of the Dublin Area. In this case, the government has been hardly successful in enforcing effective land use controls following 1990s where undeveloped land is easily accessible to urban areas.

Table 9. Summary of Sensitivity Testing

Factors/ Impacts subject to Sensitivity Testing	Sensitivity Test	Explanation
Estimation-bias in capital costs	-estimation-bias uplift %	Original capital cost estimates will be tested to the capital costs with estimation-bias uplifts
Value of time	VTTS -20% VTTS +20%	*Uncertainty in National Value of Travel Time Savings (VTTS):* Appraisal results from national appraisal guidelines will be sensitivity tested to VTTS values +/- 20 % of those national values
Inter-temporal elasticity to GDP for work and non-work trips	$E_{\text{Inter-temporal}} = 0.7$ vs. $E_{\text{Inter-temporal}} = 1.0$	*Treatment of VTTS over time:* Inter-temporal elasticity to GDP per capita growth of 0.7 will be sensitivity tested to elasticity to GDP per capita growth of 1.0 for both work and non-work trips.
Elasticity to income for work trips	$E_{\text{VTTS, Income}}=0.5$ vs. $E_{\text{VTTS, Income}}=1.0$	*Treatment of VTTS based on income variations:* A cross-sectional elasticity to income of 0.5 for passenger work trips will be sensitivity tested to the cross-sectional elasticity to income of 1.0.
Metro operation costs & revenues	World Recovery vs. Prolonged Recession projections in metro operation costs and revenues	Metro operation costs and revenues computed for world recovery scenario inflation projections will be tested to the costs and revenues with prolonged recession scenario inflation projections
Accidents	Value of safety /3 Value of safety×3	Appraisal results will be sensitivity tested by using v/3 as low and v*3 as high sensitivity
	World recovery vs. prolonged recession projections in accident costs growth rates	Accident costs computed for world recovery scenario (GNP/per worker projections) will be tested to the costs with prolonged recession scenario projections
Social discount rate	3%, 3.5% , 4.5%, 5% compared to 4%	Appraisal results from various discount rates will be tested to those computed by applying the base discount rate of 4%.
Public service provision costs	High growth vs. Low growth projections in population	Public service provision costs computed for high growth scenario population projections will be tested to the costs with low growth scenario population projections
	World Recovery vs. Prolonged Recession projections in public service provision costs	Public service provision costs computed for world recovery scenario inflation projections will be tested to the costs with prolonged recession scenario inflation projections
Global air pollution	Year of Emission / Central Estimates Lower / Upper 2000 / 4 / 53 2010 / 5 / 65 2020 / 6 / 88 2030 / 8 / 110	*Uncertainty in costs of global carbon emissions:* Shadow values of carbon will be sensitivity tested with lower and upper estimates for each corresponding year (the number are given in 2000 prices, €/tonne of carbon dioxide)

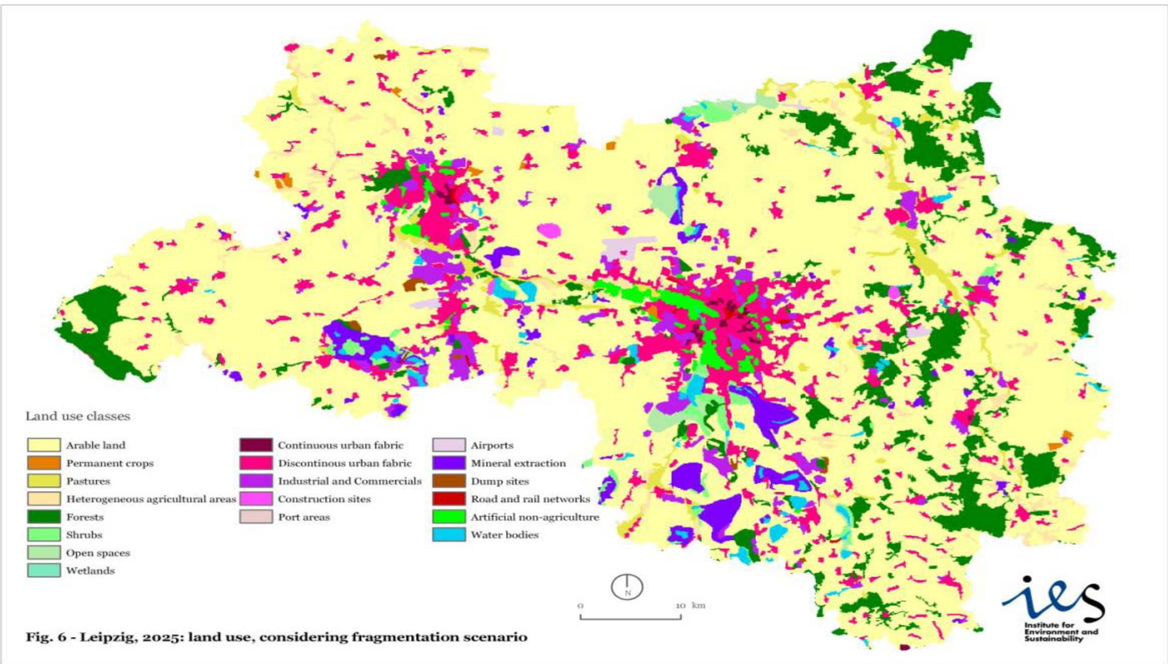
The MOLAND Modelling and scenario analysis provide the basis for governments and local authorities to assess the future of their planning and policy making actions from the point of social welfare gains and losses. In this scenario modelling work, this is emphasised through the significance of integration in transportation and land-use planning and effective coordination between economic interest groups. Many participants of the development process and planning authorities are included in the analysis. This approach can be used to assess rapid adjustment mechanisms in the planning tools in order to react to the changes stemming from the external effects. This trend towards the use of evidence based policy making and planning is increasingly necessary as resource decisions particularly linked to transportation investments have major implications for the long term development of all urban regions, particularly the Plurel regions such as Dublin, Leipzig and other regions (see Figures 7 and 8 for the Leipzig scenarios).

Figure 7. Hyper-Tech Scenario: Dispersed Development in Leipzig, 2025



Source: Lavalle et.al. (2009)

Figure 8. Fragmentation Scenario: Compact Development in Leipzig, 2025



Source: Lavalle et.al. (2009)

The cost-benefit methodology and outcomes obtained for the GDA in this paper constructs a framework for scenario-based CBA evaluation of transportation-land-use relationships. This will assist policy formulation, decision making and reviews concerning the transport infrastructure investment policies and decisions in the Plurel regions. This research has focused on CBA modelling research and analysis as a basis for best policy implications and practices. Such analysis is required for the sustainable transportation-land use strategies in the GDA and the transfer of this knowledge and findings to the Plurel case study areas. The links with Plurel areas in terms of experiences in urban development, policy making, institutional structures and legislative settings will provide an evidence-based framework for developing a common European methodology for the best policy practices. In addition, the research and methodology developed for the GDA and Plurel regions will shed light on trans-national research and evaluation of major infrastructure projects and programmes.

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Acknowledgements

The research presented in the current paper takes place in collaboration with the Urban Environment Project (UEP) at Urban Institute Ireland/UCD, and funded by PLUREL project: PERI-URBAN LAND USE RELATIONSHIPS-STRATEGIES AND SUSTAINABILITY ASSESSMENT TOOLS FOR URBAN-RURAL LINKAGES funded by the European Commission's Sixth Framework Programme for Research (EC FP6 036921).

Applying Economic Valuation to Peri-Urban Land Use Scenarios: The case of Leipzig

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Introduction

The application of green accounting techniques to the case of scenarios under the PLUREL project requires the use of a variety of techniques. This paper outlines the application of the methods in a limited way for the case of Leipzig. A range of indicators were developed under the PLUREL project, for which a limited amount of valuation can be applied. In this paper we evaluate first the impact of the scenarios on GDP, on carbon storage and on green space.

The paper is structured as follows. First, the methodology is presented for GDP, carbon storage and open space estimation and valuation. Second, results are presented for the case of Leipzig. Finally, some conclusions are drawn as to the implications of different indicator values.

Methodology

GDP

A document review was conducted of the scenarios constructed in M1 (see Ravetz & Rounsevell, 2008, for a brief description) and M3 to assess the appropriate method to estimate the GDP indicators. In some cases these were explicitly mentioned in the briefing documents for scenario construction or statements were made about GDP growth in M3 documentation. GDP was calculated in M1 using the NEMESIS model. The estimates for GDP reported here were based on an interpretation of these model results or based on interpretation of scenarios developed in M3.

Carbon storage

The value of carbon storage can be derived from literature on the social costs of climate change. Kuik et al (2008), based on a review of relevant literature, suggests marginal damage costs of CO_2 emissions across time by year of emission (see Table 1). Using this as a corollary of carbon storage, we can use the midpoint for 2015 and 2025- i.e. €30.5/tCO_2 for 2015 and €37/tCO_2 for 2025. The indicator is given in terms of MgC/ha – so adjustment needs to be made for carbon-carbon dioxide (multiplying by 44/12 to get cost in terms of tC). This leads to estimates for a MgC/ha of €111.83 for 2015 and €135.67 for 2025. Multiplying by the area (ha) under consideration gives the carbon storage benefit in terms of captured emissions in the given year.

Table 1: Marginal damage costs of CO2 emissions (€2000/tCO2) – by year of emission

	Lower	Central	Upper
2000	4	23	53
2010	5	28	65
2020	6	33	88
2030	8	41	110

Source: Kuik et al, 2008

Open space

A number of studies have used hedonic analysis to assess the value of urban green space. Transferring these values to the PLUREL context is difficult. First, if construction of housing occurs on park fringes, but the park itself remains in existence then one would generally expect a neutral impact on the values attributed to the parks in terms of amenity through hedonics – there would be a transfer to the new build properties of the benefits of being closer to the green spaces. Some studies have included size of park in their analysis of the hedonic effects – and if this were significant then one may extract a negative impact on economic welfare from this.

An example is given by Poudyal et al (2008) for the case of Virginia in the USA. In this study, a hedonic function was used and estimated the effect of both distance from a park and park size. They found that a 1% increase in distance from the park lead to a -0.016% decrease in house price and that a 1% increase in the size of a park increases house price by 0.03%. The mean house price was $95,134 implying a marginal implicit price of €0.79 per sq foot of park.

A critical simplifying assumption is made about the spatial allocation of new housing development. It is assumed that new houses are built with the same distribution as the previous housing stock on the newly developed land. This means that the distance effect is constant across scenarios – i.e. there is no marginal loss due to increased distance from housing to open space. The increased distance for some is offset by the new houses having small distances from the open space – this is a transfer issue. Further work may be done to improve on this, based on Moland simulations.

In the case of Leipzig for one open space area, this assumption does not hold. This is because the significant decline in open space in the one area leads to a fragmentation of the space – which would have consequences for the costs.

To estimate changes in the size of open space, results from the Moland simulations were used. A count was made of changes to number of cells covered by open space in various locations. The baseline was taken to be 2005 BAU – and changes were shown on maps generated by Metronamica.

Average densities of population were used to create "uniform world" type estimates of welfare loss due to park size changes[19]. The number of houses per sq km were estimated based on population and household size estimates. Based on internet data, rough estimates of average house price in the different case study regions were derived.

Urban/Peri-Urban/Rural allocation

For the case of GDP, it is extremely difficult to allocate the income at the urban/peri-urban and rural level. This is in part because of the nature of GDP – it may be possible to estimate a Gross Value Added per hectare, but this is highly uncertain as we go ahead to 2025. The uncertainties mean that it would be best to view this as a regional only indicator.

Carbon storage is slightly simpler – if the tC storage per hectare of the urban, peri-urban and rural land is known, then it is a case of multiplying by the per tC social cost of carbon and then by the area.

For the case of open space, the allocation rule would have to depend on the geographical location of the spaces. It is important to note that we have assumed an equal distribution of housing across urban/peri-urban areas – for rural this would certainly need to be reduced.

[19] Uniform world type estimations have been used, e.g. in estimating the costs of air pollution, see Spadaro and Rabl (2002)

Results

GDP

For the Leipzig-Halle case, the GDP growth description was given in the storylines used as inputs to the MOLAND model[20]. This then had to be interpreted – as shown the third column in Table 2 and described here. For the BAU case, the growth rate was assumed to be the same as in 2008 for the whole of Germany (at 1.3%). For the rapid growth scenario, growth rates from the fastest growing Nemesis model scenario (A1) were used – though smoothing was applied. It is important to note that these are not predictions, but scenarios and are largely not the outcome of any model analysis. For comparison, the results of the NEMESIS model at Nuts 2 are also presented as Table 3.

Table 2: GDP by Scenario for Leipzig – €million – 2000 prices

Scenario	GDP growth description	Interpretation	2005	2010	2015	2020	2025
BAU	"slowly increasing"	Same as 2008, whole Germany growth =1.3%	20675	22054	23526	25095	26769
HyperTech	"rapid growth"	As in fastest Nemesis scenario 2.33% growth per annum - smoothed	20675	23204	26042	29227	32802
Eco-Environmental	"GDP is doubled"	GDP doubles in period 2005-2025 - 3.5% growth	20675	24587	29239	34771	41350

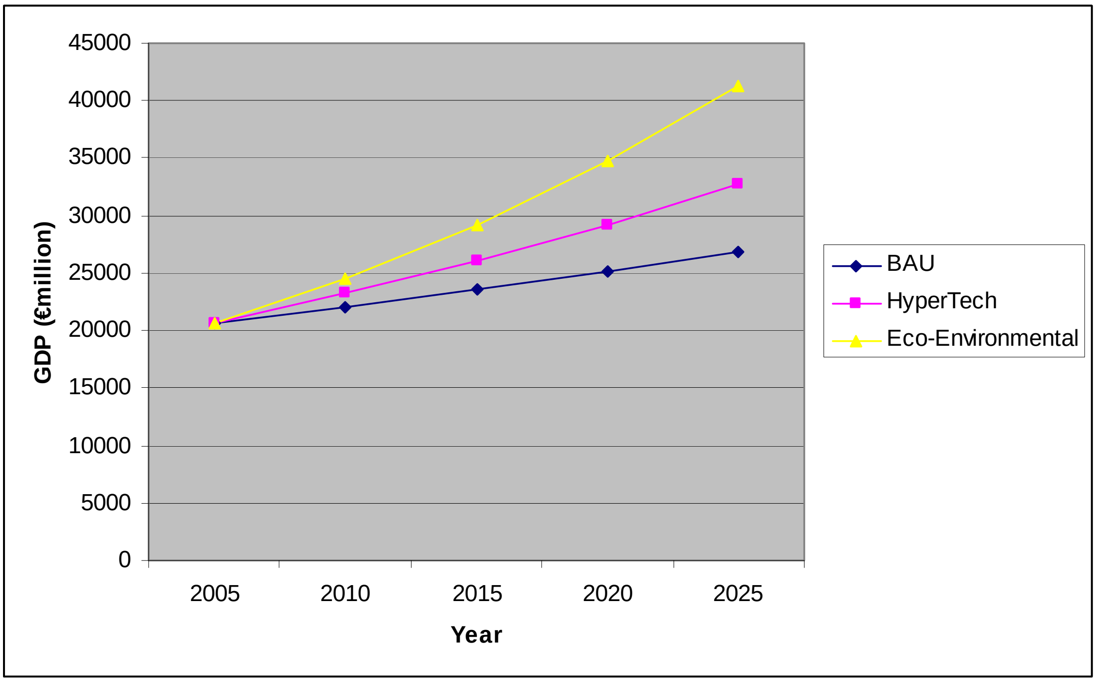
Table 3: GDP by M1 scenario for Leipzig region – €million – 2000 prices

Scenario	2005	2010	2015	2020	2025
A1	20675	22551	25296	28542	32802
A2	20675	22643	24855	27434	30523
B1	20675	22634	23930	25755	28154
B2	20675	22307	23710	25421	27318

Source: NEMESIS model

[20] The storylines can be found at http://www.research.plurel.net/Download.ashx?file=%2fModule+3%2fWP+3.4+LAND+USE+SCENARIOS%2fLeipzig+scenario+works%2fMOLAND_ScenarioStorylines_forLeipzig.pdf

Figure 2: GDP in Leipzig by Scenario – 2000 prices



Carbon Storage

Using the method above and results from the iIAT table, we can derive per hectare values for Leipzig-Halle for carbon storage provided as shown in Table 5. This shows that the per hectare value of carbon storage rises across time.

Table 5: Per hectare values and carbon storage (MgC/ha) for Leipzig

Scenario	2000	€/ha value	2015	€/ha value	2025	€/ha value
BAU	0.164	13.83067	0.163	18.22883	0.163	22.11367
Eco-Environmental	0.164	18.34067	0.162	18.117	0.161	21.84233
Hypertech	0.164	13.83067	0.161	18.00517	0.159	21.571

Multiplying by the area of Leipzig (438600 ha) gives the total value of carbon storage in Leipzig in the years under the scenarios in question, as shown in Table 6. It can be seen that the change in carbon stored across the scenarios is not that significant in overall value terms in terms of the social costs of carbon.

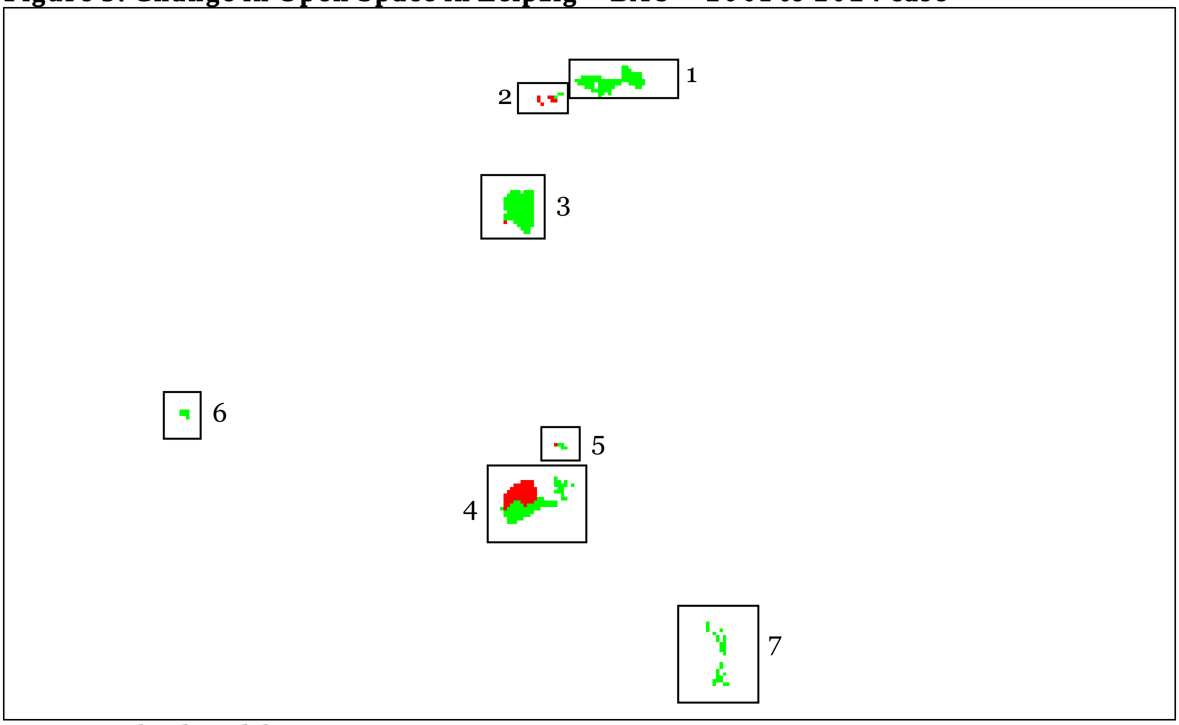
Table 6: Carbon storage values by scenario

Scenario	2000 Mg/ha	Value (€mn)	2015 Mg/ha	Value (€mn)	2025 Mg/ha	Value (€mn)
BAU	0.164	6.07	0.163	8.00	0.163	9.70
Eco-Environmental	0.164	6.07	0.162	7.95	0.161	9.58
Hypertech	0.164	6.07	0.161	7.90	0.159	9.46

Open space

Open space in Leipzig was identified using the Moland model, as shown in Figure 3 below. It was estimated that 501 houses were in the 457.2 metre radius of the open spaces[21]. This is likely an overestimate for the areas in consideration. From the maps, 7 distinct open space areas could be identified – as shown in Figure 3[22]. Changes in the areas of these regions under the scenarios were estimated based on a manual count of the squares impacted. An example for the change for BAU 2024 is shown below as Table 7 (further tables are contained in an annex to this report).

Figure 3: Change in Open Space in Leipzig – BAU – 2001 to 2024 case



Source: Moland model outputs

[21] Based on estimates from Leipzig of 1,677 inhabitants per square km, and average German household size of 2.2.(Source: UNECE, 2001, p74)

[22] This demarcation is based on the distances shown in the distance decay effects for open space valuation.

Table 7: Change in area – BAU 2025 compared to BAU 2005

Area	Cells in both 2024 and 2005	Cells in 2005 but not in 2024	Area orig (m2)	Area reduced (m2)	% of original area lost
1	755	0	7550000	0	0
2	22	67	890000	670000	75.3
3	846	2	8480000	20000	0.2
4	708	560	12680000	5600000	44.2
5	36	3	390000	30000	7.7
6	68	0	680000	0	0
7	232	0	2320000	0	0.0

Source: Manual count of Moland output

Table 8 shows the estimations of welfare loss for the BAU 2025 case in terms of amenity. The impact in terms of lost amenity is then estimated using the elasticity of 0.03 – i.e. a 1% reduction in area leads to a 0.03% reduction in premium. We used an average house price for Leipzig of €100,000. This led in the case for BAU 2025 of a loss of €1.9million (with losses per house around open spaces of up to €2,258).

Table 8: Estimates of lost amenity (losses in €) – BAU 2025

Area	% of original area lost	Elasticity wrt size	% change in house price	Average house price	Change per house	Number of houses	Welfare loss
1	0	0.03	0	100,000	0	501	0
2	75.3	0.03	2.26	100,000	2258	501	1131472
3	0.2	0.03	0.01	100,000	7	501	3545
4	44.2	0.03	1.32	100,000	1325	501	663785
5	7.7	0.03	0.23	100,000	231	501	115615
6	0	0.03	0	100,000	0	501	0
7	0.0	0.03	0	100,000	0	501	0
						Total	**1914418**

The losses per scenario are as shown in Table 9. This shows a cost of between €1.15million and €3.07million dependent on the scenario – and for HyperTech 2025 is likely higher because of the fragmentation experienced by Area 7.

Table 9: Amenity losses per scenario in Leipzig (€million – 2005 prices)

	2015	2025
BAU	1.15	1.91
HyperTech	2.26	3.07

Discussion

In this report, we have summarised the evidence for GDP change, carbon storage and open space in the case of Leipzig. We have applied monetary values as appropriate from the literature. Some broad conclusions can be drawn:

1. The methods used in M3 case studies affects the comparability of results. The GDP assumptions made in building scenarios were not necessarily compatible with the M1 scenarios. Hence here we present the most consistent evidence possible. This shows the following:
    a. Under the "BAU" scenarios growth is consistently lower than estimates from either NEMESIS based outputs for chosen scenarios or scenarios developed in case studies. This may be suggestive of an optimism over economic growth in the PLUREL scenarios.
    b. For Leipzig, the Eco-Environmental scenario is the most extreme, outstripping even the most optimistic growth scenario based on NEMESIS for the same region.
2. For carbon storage, in the case of Leipzig variation across scenarios is not that significant in terms of avoided social costs of carbon. It is important to note that the variation in the social cost of carbon outstrips the change in carbon retention of soils.

3. For open space, in the case of Leipzig costs of between €1.15million and €3.07million can be identified dependent on the scenario. These estimates are quite uncertain and are based on a number of simplifying assumptions – notably equal distribution of population. If housing is more dispersed around the open areas than the average in Leipzig, then these values may decline. Demographic change has also not been reflected in these estimates (e.g. decline in household size).

To summarise, the economic implications of changes in land use in the PLUREL scenarios range from changes in GDP and changes in the social costs of carbon to changes in house prices arising from smaller open spaces. The overall changes in GDP in all cases outstrip losses in terms of amenity values of open spaces, though it should be noted that a number of other uses of open space have not been valued.

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PLUREL

Annex 1: Calculation of Amenity Loss in Leipzig

Amenity Losses in BAU 2015

Area	Cells in both	Cells in 2005 but not 2015	Area orig (m2)	Area reduced (m2)	% of original area lost	Elasticity wrt size	% change in house price	Average house price	Change per house	Number of houses	Welfare loss
1	755	0	7550000	0	0	0.03	0	100,000	0	501	0
2	35	54	890000	540000	60.7	0.03	1.82	100,000	1820	501	911933
3	846	2	8480000	20000	0.2	0.03	0.01	100,000	7	501	3545
4	1069	199	12680000	1990000	15.7	0.03	0.47	100,000	471	501	235881
5	39	0	390000	0	0.0	0.03	0.00	100,000	0	501	0
6	68	0	680000	0	0	0.03	0	100,000	0	501	0
7	232	0	2320000	0	0.0	0.03	0	100,000	0	501	0
										Total loss	**1151358**

Amenity Losses in BAU 2025

Area	Cells in both 2024 and 2005	Cells in 2005 but not in 2024	Area orig (m2)	Area reduced (m2)	% of original area lost	Elasticity wrt size	% change in house price	Average house price	Change per house	Number of houses	Welfare loss
1	755	0	7550000	0	0	0.03	0	100,000	0	501	0
2	22	67	890000	670000	75.3	0.03	2.26	100,000	2258	501	1131472
3	846	2	8480000	20000	0.2	0.03	0.01	100,000	7	501	3545
4	708	560	12680000	5600000	44.2	0.03	1.32	100,000	1325	501	663785
5	36	3	390000	30000	7.7	0.03	0.23	100,000	231	501	115615
6	68	0	680000	0	0	0.03	0	100,000	0	501	0
7	232	0	2320000	0	0.0	0.03	0	100,000	0	501	0
										Total	**1914418**

Amenity Losses in HyperTech 2015

Area	Cells in both	Cells in 2004 but not 2015	Area orig (m2)	Area reduced (m2)	% of original area lost	Elasticity wrt size	% change in house price	Average house price	Change per house	Number of houses	Welfare loss
1	755	0	7550000	0	0	0.03	0	100,000	0	501	0
2	35	54	890000	540000	60.7	0.03	1.82	100,000	1820	501	911933
3	846	0	8460000	0	0.0	0.03	0.00	100,000	0	501	0
4	969	299	12680000	2990000	23.6	0.03	0.71	100,000	707	501	354414
5	39	0	390000	0	0.0	0.03	0.00	100,000	0	501	0
6	68	0	680000	0	0	0.03	0	100,000	0	501	0
7	68	134	2020000	1340000	66.3	0.03	1.99	100,000	1990	501	997040
										Total loss	**2263386**

Amenity Losses in HyperTech 2025

Area	Cells in both	Cells in 2005 but not 2025	Area orig (m2)	Area reduced (m2)	% of original area lost	Elasticity wrt size	% change in house price	Average house price	Change per house	Number of houses	Welfare loss
1	755	0	7550000	0	0	0.03	0	100,000	0	501	0
2	22	67	890000	670000	75.3	0.03	2.26	100,000	2258	501	1131472
3	848	0	8480000	0	0.0	0.03	0.00	100,000	0	501	0
4	626	642	12680000	6420000	50.6	0.03	1.52	100,000	1519	501	760983
5	39	0	390000	0	0.0	0.03	0.00	100,000	0	501	0
6	68	0	680000	0	0	0.03	0	100,000	0	501	0
7	51	181	2320000	1810000	78.0	0.03	2.340517	100,000	2341	501	1172599
										Total loss	**3065054**