

**Table 1.** Characteristics of the Urban Development Scenarios in the GDR

	<b><i>Business-As-Usual Scenario:</i></b>	<b><i>Compact Development with Rail Scenario:</i></b>	<b><i>Recessionary Development Scenario:</i></b>
	<i>Continuous Economic Growth</i>	<i>Continuous Economic Growth</i>	<i>Prolonged Recession</i>
<b>Population</b>	Steady population growth: -In migration of young -Increased fertility rates	Steady population growth: -In migration -Increased fertility rates	Moderate population growth: -No immigration -Increased fertility rates
<b>Economic Trends</b>	-Steady increase in GDP -Investments in manufacturing, human capital, high tech sectors, agriculture -Increase in exports -Local products are being more promoted -Tourism, agro-tourism and service sectors (health care, public transport, accessibility to public green space, accommodation, food and beverage, entertainment etc.) are strongly encouraged	-Steady increase in GDP -Invest <i>more</i> in: manufacturing and human capital - <i>More</i> people employed in science and research -Continued investment in high-tech sectors which concentrated in existing urban environment -Exports are highly encouraged -Reinforcement of agro-tourism	-A decline in GDP followed by economic stagnation or a modest increase by the end of crisis -Either no new investment or very few developments in manufacturing, human capital, high tech sectors and agriculture following the economic stabilisation -During the recession there is increase in imports and decrease in exports and the balance can be stabilised at the end of the recession -Tourism, agro-tourism and service sectors are in decline
<b>Spatial Development/ Planning</b>	-New constructions occur in rural hinterland -Improvement of urban infrastructure (roads, information networks, sports/recreation, stores)	-Polycentric urban agglomeration associated with the conservation/ restoration of existing buildings. -New residential development inside the city– increased density by multi-stories buildings	-Decline in demand for new development -New residential development in the country side but in very limited numbers -Increase in vacancy rates with many constructions left unfinished
<b>Transport</b>	-Improvement of regional and local roads - Better links to the motorways and airport extensions	-Public transport is encouraged -Investment in Metro North in 2014 -Investment in other Transport21 railways in post-2020	-Investment in Metro North potentially in 2014 -No investment in other Transport21 railways
<b>Overall Trends</b>	- Economic growth - Low environmental protection - Dispersed single-dwelling housing growth in the country side	-Economic growth -High environmental protection -Self-sufficient towns limiting commuting to Dublin Area	-Economic stagnation -Low environmental protection -Small-scale housing growth in the country side

**Table 2.** Impact Evaluation Data for Rail-Based Infrastructure Investments: With-Rail vs. Business-as-Usual Scenario Approach

Impacts/Indicators	Impact Evaluation Data of With-Rail Scenario vs. Business-as-Usual 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. Source: RPA [78].
2. Greenfield land values	Total amount of greenfield land within 1km catchment area of Metro North and estimated change of the value of greenfield land across <i>with rail</i> and <i>business-as-usual</i> scenarios. Source: RPA [78].
3. Provision of public services	-Future estimated numbers for population and new residential development (numbers of new housing units) in the case study area within the appraisal period specified for rapid rail investments. Source: CSO [79]. -Public service provision costs (e.g. school transportation costs, electricity connection and distribution costs). Source: Department of Education and Science, Ireland, [80]; ESB Networks Ltd. Statement of charges [81].
4. Accident rates/future accident risks and accident costs	Three types of data are specified: -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. Source: RPA [78], -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, -Road accident costs by type of accident were adapted from the study of Goodbody Economic Consultants Report [82].
5. Change in road vehicle operation costs	For the calculation of the economic benefits (costs) associated with vehicle operating costs, three types of data were utilised: - <i>Demand</i> : number of private (cars) and public (bus) vehicles making a particular origin-destination trip for the <i>business-as-usual</i> scenario and the alternative <i>with rail</i> scenario (peak/off-peak traffic flow data for the baseline and alternative scenarios), - <i>Vehicle kilometres</i> -total change in vehicle kilometres from the local highway network for the <i>business-as-usual</i> and <i>with rail</i> cases, - <i>Operation costs</i> : fuel cost and non-fuel cost parameters were obtained from UK Department for Transport [83] and adapted to the Irish case following Goodbody Economic Consultants Report [82].
6. Change in travel time	Estimates related to: - <i>Travel time</i> -change in travel time for private (cars) and public (bus) vehicles in peak/off-peak traffic for the <i>business-as-usual</i> and <i>with rail</i> scenarios, - <i>Demand</i> : peak/off-peak traffic flow data for the <i>business-as-usual</i> and <i>with rail</i> cases, - <i>Value of time</i> : The proxy for the value of work time is the average wage rate plus an allowance for employment related overheads. The non-work value of time used in the UK was adapted in the current study, representing 40 percent of the mileage weighted hourly earnings of commuters [84].
7. Rail operating costs and revenues	-Expected operating pattern and service frequency of newly proposed Metro North, -Key characteristics (route length, journey time, peak and off-peak headway etc.), -Estimated annual operation cost and revenues. Source: RPA [78].
8. Change in CO <sub>2</sub> emissions	-Total change in greenhouse gas emissions (i.e. CO <sub>2</sub> , in particular) for the <i>business-as-usual</i> and <i>with rail</i> cases, - <i>Social cost of carbon</i> : The CASES Project [85] recommends using the carbon prices obtained by DEFRA [86] as a central estimate for the price of global carbon emissions as this is the most recent policy oriented study on the social costs of carbon. This is considered for the current study.
9. Change in local area pollutants	-Total change in local area pollutants (CO, NO <sub>x</sub> , UHC-Unburned Hydro Carbons) along the Metro North corridor for the <i>business-as-usual</i> and <i>with rail</i> cases, -Cost factors for local area pollutants are from HEATCO [87] and UNITE [88].

**Table 3.** Change in Land Uses along the 1 km Metro North Catchment Area for the Baseline and With Rail Scenarios

Land Use Types	Land Area (in ha)		% Change in Land Area from Baseline to With Rail Scenario
	With Rail Scenario	Baseline Scenario	
Residential continuous dense urban	24	16	+50%
Residential continuous medium dense	104	156	-33.3%
Residential discontinuous urban fabric	484	444	-9.1%
Residential discontinuous sparse urban	68	60	+13.3%
Industrial areas	136	140	-2.9%
Commercial areas	244	240	+1.6%
Public and private services	164	144	+13.8%
Arable land	4	8	-50%
Pastures	76	68	+11.8%
Heterogeneous agricultural areas	28	56	-50%

Source: Urban Environment Project, UCD

**Table 4.** Net Present Value of Costs and Benefits as at 2010

Discount Rate	ENPV	B/C Ratio	IRR	Evaluation Period
<b>45 YEARS OF APPRAISAL (5 years construction+40 years operation)</b>				
3.0 %	553 million €	1.28	<b>0.04166(4%)</b>	2011-2055
3.5 %	289 million €	1.15		
<b>4.0 %</b>	<b>64 million €</b>	<b>1.03</b>		
4.5 %	-126 million €	0.93		
5.0 %	-289 million €	0.85		
<b>40 YEARS OF APPRAISAL (5 years construction+35 years operation)</b>				
3.0 %	242 million €	1.12	<b>0.03596 (4%)</b>	2011-2050
3.5 %	36 million €	1.02		
<b>4.0 %</b>	<b>-141 million €</b>	<b>0.93</b>		
4.5 %	-293 million €	0.85		
5.0 %	-425 million €	0.78		
<b>35 YEARS OF APPRAISAL (5 years construction+30 years operation)</b>				
3.0 %	-68 million €	0.97	<b>0.027960 (3%)</b>	2011-2045
3.5 %	-222 million €	0.89		
<b>4.0 %</b>	<b>-356 million €</b>	<b>0.82</b>		
4.5 %	-473 million €	0.75		
5.0 %	-575 million €	0.70		
<b>30 YEARS OF APPRAISAL (5 years construction+25 years operation)</b>				
3.0 %	-380 million €	0.81	<b>0.01607 (2%)</b>	2011-2040
3.5 %	-487 million €	0.75		
<b>4.0 %</b>	<b>-582 million €</b>	<b>0.70</b>		
4.5 %	-666 million €	0.65		
5.0 %	-740 million €	0.61		

**Table 5.** Annual Expected Changes in the Greenfield Land Values within 1 km Catchment Area of Metro North

<b>Total Amount of Greenfield Land</b>	<b>Expected Change in Annual Value per hectare of Greenfield Land in Business-As-Usual vs. With Rail Scenarios*</b>	<b>Expected Change in Total Greenfield Land Values, in €</b>
254.1 ha	Price rises from 60.000 € /ha to 1,500,000 € /ha implying a net change of 1,440,000 € /ha.	365,904,000 (=254.1×1,440,000)

\*Source: Publicly available data of auction and transaction sales which had been tested by consultations with property market experts.

**Table 6.** Evaluation of Cost-Benefit Assessment Results

<b>Description</b>	<b>Findings from Current Study</b>	<b>Findings of NTA (2015)</b>
	Full scheme 2045 (€ thousand, 2010 prices)	Full scheme 2033 (€ thousand, 2009 prices)
Total costs	2,140,762	1,026,853
Total benefits	1,999,746	1,562,716
Economic Net Present Value (ENPV)	-141,000	535,863
Benefit-to-cost ratio (B/C)	0.93	1.5
Discount rate	4%	NA

**Table 7. The Health Impacts of Rail Transit Systems**

<b>Health Benefits*</b>	<b>Rail Transit Impacts*</b>	<b>Impact Evaluation Criteria</b>	<b>Expected Impacts of Metro North</b>
<i>Traffic safety.</i> Reduced traffic crash injuries, disabilities and death on the road network	Reductions in traffic injuries and deaths resulting from shifts from road transportation to rail transit system	Accident cost savings from death and injury traffic crashes	Reduction in traffic accidents and related costs along the Metro North catchment area as Metro North will provide a reduction in car-based trips
<i>Pollution reduction.</i> Reductions in air, water and noise pollution	Reductions in traffic induced emissions and noise following a shift from car-based transport to rail	Savings in Greenhouse Gas (GHG) emissions, savings from local air/water pollutants, and savings from noise pollution	The introduction of Metro North to the network will introduce a new pollution source to the Metro catchment area. However, there will be an overall reduction in the pollution levels due to reduced traffic on the road networks
<i>Improvement in physical fitness.</i> Increased physical activity by walking and cycling	Rail transit oriented development improves alternative modes of transport (walking, cycling), which tend to increase physical fitness	Savings from medical expenditures resulting from increased physical activity, value of reductions in heart diseases, hypertensive diseases, diabetes and others	Recent policies and plans introduced in anticipation of Metro North support mixed land-uses of medium to high-density developments within the Metro North catchment area. Metro North enhances transportation diversity in the GDR and supports walking, cycling and other transport modes. There will be overall reduction in health costs as a result of improvement in physical activity by walking and cycling
<i>Mental health.</i> Reduced emotional stress	High quality rail transit systems and transit oriented development provide comfort and reduces emotional stress, and provide access to social, economic and recreational opportunities	Cost savings from medical expenditures related to emotional stress and depression	It is estimated by the RPA (2010) that a considerable proportion (around 12 million) of car trips per annum will be reduced from the highway network following a shift to the Metro system. Metro North provides a high quality transportation option. It is expected that this will reduce emotional stress and associated health costs
<i>Affordability.</i> Reduced financial burdens, particularly for lower income residents	Rail transit and transit oriented development reduces cost of transportation, which leaves money to purchase housing, healthy food and medical care	Cost savings from transport-related expenditures	Metro North provides a cheaper transportation option compared to automobile-oriented transportation, particularly along the catchment of Metro North Line. This will reduce the costs of transportation and supports incomes of residents
<i>Basic mobility.</i> Improved accessibility to essential goods and services	Rail transit and transit oriented development improves mobility and locational accessibility	Changes in accessibility of land-uses following the provision of rail transport system	Metro North will provide the required transport options to the existing residents to reach to key employment, social, recreational and other services in the GDR. Hence it improves accessibility of various goods and services

Note: \*Source: Litman [97]

**Table 8.** Per Capita Surface Area for Alternative Development Patterns

	Compact Development	Mixed Development	Sprawled Development
Vehicles per capita	0.5	0.65	0.8
Road space per vehicle (sq-ft)	235	453	670
Off-street parking spaces per vehicle	2	4	6
Land area per parking space (sq-ft)	275	300	325
Housing footprint per capita (sq-ft)	250	375	500
Road and parking land area per capita (sq-ft)	878	1,344	1,811

Source: Litman [111]

**Table 9.** Total Number of Work Trips by Means of Travel to Work in the GDR, 2002 and 2006

<b>Year: 2002</b>					
<b>County of Residence</b>	<b>Means of Travel</b>				
	<b>Bus</b>	<b>Train or DART</b>	<b>Car</b>	<b>Walking/Cycling</b>	<b>Others</b>
Dublin	75,916	22,822	264,192	85,408	28,055
Kildare	3,942	2,962	49,861	7,043	6,226
Meath	2,869	743	40,369	4,521	5,751
Wicklow	1,807	2,934	29,549	5,229	4,289
<b>GDR Total</b>	<b>84,534</b>	<b>29,461</b>	<b>422,342</b>	<b>102,201</b>	<b>44,321</b>
<b>Year: 2006</b>					
<b>County of Residence</b>	<b>Means of Travel</b>				
	<b>Bus</b>	<b>Train, DART, LUAS</b>	<b>Car</b>	<b>Walking/Cycling</b>	<b>Others</b>
Dublin	79,219	40,810	288,115	93,985	27,624
Kildare	3,889	4,443	60,149	9,114	7,577
Meath	3,636	1,416	54,748	5,706	7,818
Wicklow	2,258	3,197	36,673	5,476	4,908
<b>GDR Total</b>	<b>89,002</b>	<b>49,866</b>	<b>439,685</b>	<b>114,281</b>	<b>47,927</b>
<b>% Change between 2002 and 2006</b>	<b>+ 5.3%</b>	<b>+ 69.3%</b>	<b>+ 6.6%</b>	<b>+ 11.8%</b>	<b>+ 8.1%</b>

Source: CSO (2003; 2007)

**Table 10.** A Combined Sensitivity Analysis: Simultaneously Set Parameters in Economic Growth and Recessionary Development Cases

<b>Factors/Impacts subject to Sensitivity Testing</b>	<b>Parameters in Economic Growth (EG)-links to business-as-usual and with rail (economic growth case) scenarios</b>	<b>Parameters in Recessionary Development (RD)-links to business-as-usual and with rail (prolonged recession case) scenarios</b>
Capital Expenditure Uplifts	EG-Case A: No capital estimation bias EG-Case B: -40 % bias in capital estimation	RD-Case A: No capital estimation bias RD-Case B: -40 % bias in capital estimation
Value of Time	World Recovery Scenario	Prolonged Recession Scenario
	$E_{\text{Inter-temporal}} = 1.0$	$E_{\text{Inter-temporal}} = 0.7$
	$E_{\text{VTTS, Income}} = 1.0$	$E_{\text{VTTS, Income}} = 0.7$
Accident Costs	World Recovery Scenario	Prolonged Recession Scenario
Road Vehicle Operation Costs	Moderate Price Scenario	High Price Scenario
Metro Operation Costs & Revenues	World Recovery Scenario	Prolonged Recession Scenario
School Transportation Costs	World Recovery Scenario	Prolonged Recession Scenario
	High Growth Scenario	Low Growth Scenario
Electricity Connection & Distribution Costs	World Recovery Scenario	Prolonged Recession Scenario
	High Growth Scenario	Low Growth Scenario
Climate Change	Higher CO <sub>2</sub> Values compared to Central Values	Lower CO <sub>2</sub> Values compared to Central Values
Local Air Pollution	World Recovery Scenario	Prolonged Recession Scenario
	High Growth Scenario	Low Growth Scenario
	$E_{\text{LAP, Income}} = 1.0$	$E_{\text{LAP, Income}} = 0.7$
Commencement Period of Metro Construction	2013	2013
Appraisal Period	2011-2047	2011-2047

Notes:  $E_{\text{Inter-temporal}}$ : inter-temporal elasticity to GDP per capita growth representing the variations in value of travel time savings over time,  $E_{\text{VTTS, Income}}$ : the cross sectional elasticity to income representing the variations in value of travel time savings (VTTS) according to income variations,  $E_{\text{LAP, Income}}$ : income elasticity of demand showing the differences in the value of local air pollution (LAP).