SAVi Sustainable Asset Valuation

Sustainable Asset Valuation (SAVi) of the Contournement de Rabat, Morocco:

A focus on road infrastructure

SUMMARY OF RESULTS

INTERNATIONAL ROAD FEDERATION
FEDERATION ROUTIERE INTERNATIONALE

الطرق السيارة بالمغرب
Autoroutes du Maroc

IISD International Institute for Sustainable Development

MAVA FONDATION POUR LA NATURE

Andrea M. Bassi
Liesbeth Casier
Oshani Perera
Georg Pallaske
David Uzsoki

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Head Office

111 Lombard Avenue, Suite 325
Winnipeg, Manitoba
Canada R3B 0T4

Tel: +1 (204) 958-7700
Website: www.iisd.org
Twitter: @IISD_news

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The MAVA Foundation was established in 1994 and is a family-led, Swiss-based philanthropic foundation with offices in Switzerland and Senegal.

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About SAVi

SAVi is a simulation service that helps governments and investors value the many risks and externalities that affect the performance of infrastructure projects.

The distinctive features of SAVi are:

- Valuation: SAVi values, in financial terms, the material environmental, social and economic risks and externalities of infrastructure projects. These variables are ignored in traditional financial analyses.
- Simulation: SAVi combines the results of systems thinking and system dynamics simulation with project finance modelling. We engage with asset owners to identify the risks material to their infrastructure projects and then design appropriate simulation scenarios.
- Customization: SAVi is customized to individual infrastructure projects.

For more information on SAVi:

https://www.iisd.org/project/SAVi-sustainable-asset-valuation-tool

Executive Summary

The International Road Federation and Autoroute du Maroc (ADM) asked IISD to use the SAVi tool on the “Contournement de Rabat” (or Rabat bypass) road project, which was officially inaugurated in August 2017. It has a length of 41.1 km and includes the Mohammed VI Bridge, an important landmark. The toll road was built to improve mobility around the city and reroute traffic not destined for Rabat.

ADM also manages the visitor centre close to the Mohammed VI Bridge. This space includes a museum and a picnic area that were developed to draw attention to the design and engineering aspects of the bypass and bridge—which is the first of its kind in Morocco.

The SAVi assessment is based on six scenarios and four externalities.

The scenarios are described in the table below. Each scenario represents an operating risk for ADM. This is also the first time that ADM will have insight into the costs of these risks.

The externalities valued in this assessment are:

- Discretionary spending from labour income
- Social cost of carbon
- Value of time saved
- Cost of accidents.

This is the first time that ADM has worked on identifying and valuing externalities.

Table ES1. Scenarios and assumptions

Scenario	ADM reference	Assumption
Scenario 1: Business as Usual	BAU	• Capital and operational expenditure as budgeted by ADM over the lifetime of the road
Scenario 2: Reduced Maintenance Expenditure	RE2	• 5% reduction in maintenance expenditure due to the budgeted cuts
Scenario 3: Increase in Road Works	RD1 RE1	• 200 metres of road is closed for reconstruction, every year from 2018 to 2060
Scenario 4: Short-term Traffic Increase	MO3	• 200% traffic increase in the short term
Scenario 5: Increase in Heavy Vehicle traffic	PL30pc	• 30% increase in heavy vehicles from 2018 to 2030
Scenario 6: Road Damage Due to Climate Change	CC	• 2 km of road is damaged as a direct result of climate change, every 10 years

The SAVi integrated cost-benefit analysis (CBA) is calculated as project revenues – costs + externalities. With its results, ADM is able to understand the costs of the six risk scenarios. In this case, the costs of risks are not particularly high, with Risk Scenario 3 – Increase in Road Works, coming out as the highest. When we build in the cost of externalities, the CBA registers negative values, with the cost of externalities reaching 13 to 19 per cent of capital and operating and management costs.

The SAVI project finance analysis demonstrates that the project is not financially viable when relying solely on its own revenues under any of the risk scenarios modelled. This is evident based on all the different financial indicators measured. The project has negative net present value (NPV), insufficient internal rate of return and credit ratios below what lenders usually require under all the scenarios.

In addition, the financial analysis illustrates effectively the financial materiality of externalities. All the key financial indicators measured improve when externalities are included under Scenario 1: Business as Usual (with externalities) compared to the "Scenario 0: Business as Usual (without externalities)."

Particularly accidents and value of time saved can have a significant impact on the financial performance of the project. This is well illustrated by Scenario 2: Reduced Maintenance Expenditure, when the decreased spending during operations results in more accidents. The economic and social costs of the increased number of accidents is significantly higher than the cost savings realized by lower maintenance. Finally, the cumulative negative effects of climate change are well demonstrated by the worsening of all financial indicators under "Scenario 6: Damage to the road due to climate change."

Valuing the cost of the risks identified by ADM provides important information for future management of risks and operational costs of road investments.

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Glossary

Debt Service Coverage Ratio (DSCR): A measure of the cash flow available to pay current debt obligations. The ratio states net operating income as a multiple of debt obligations due within one year, including interest and principal.

Development planning: A range of public and private planning and decision-making processes (e.g., ranging from a national land-use plan to the annual budgetary process, and including infrastructure projects as well as sectoral policy formulation exercises) that typically involve trade-offs between competing demands for scarce resources and which have implications for the environment.

Econometrics: A methodology that measures the relation between two or more variables, running statistical analysis of historical data and finding correlation between specific selected variables.

Feedback loop: Defined by Roberts et al. (1983) as "a process whereby an initial cause ripples through a chain of causation ultimately to re-affect itself."

Geographic Information System (GIS): A system designed to capture, store, manipulate, analyze, manage and present all types of geographical data. Put simply, GIS is the merging of cartography, statistical analysis and computer science technology.

Green economy: An economy that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities (UNEP, 2011).

Indicator: An instrument that provides an indication, generally used to describe and/or give an order of magnitude to a given condition.

Internal Rate of Return (IRR): An indicator of the profitability prospects of a potential investment. The IRR is the discount rate that makes the net present value (NPV) of all cash flows from a particular project equal to zero. Cash flows net of financing give us the equity IRR.

Loan Life Coverage Ratio (LLCR): A financial ratio used to estimate the ability of the borrowing company to repay an outstanding loan. It is calculated by dividing the NPV of the cash flow available for debt repayment by the amount of senior debt outstanding.

Methodology: The underlying body of knowledge for the creation of different types of simulation models. It includes theoretical foundations for the approach, and often encompasses both qualitative and quantitative analyzes and instruments.

Model transparency: A transparent model is one for which equations are available and easily accessible and it is possible to directly relate structure to behaviour (i.e., numerical results).

Model validation: The process of deciding whether the structure (i.e., equations) and behaviour (i.e., numerical results) are acceptable as descriptions of the underlying functioning mechanisms of the system and data.

Net Present Value (NPV): The difference between the present value of cash inflows net of financing costs and the present value of cash outflows. It is used to analyze the profitability of a projected investment or project.

Optimization: Simulation that aims at identifying the best solution (with regard to some criteria) from some set of available alternatives.

Policy Cycle: The process of policy-making, generally including issue identification, policy formulation, policy assessment, decision making, policy implementation and policy monitoring and evaluation.

Scenarios: Expectations about possible future events used to analyze potential responses to these new and upcoming developments. Scenario analysis is thus a speculative exercise in which several future development alternatives are identified, explained, and analyzed for discussion on what may cause them and the consequences these future paths may have on our system (e.g., a country or a business).

Simulation model: A model is a simplification of reality, a representation of how the system works, and an analysis of (system) structure and data. A quantitative model is built using one or more specific methodologies, with their strengths and weaknesses.

Spatial aggregation/disaggregation: Aggregated simulation models provide a single value for any given simulated variable (e.g., population and agricultural land). Spatial models instead generate results at the human scale and present them on a map, e.g., indicating how population and agricultural land would be geographically distributed within the boundaries of the country.

Stock and flow variables: A stock variable represents accumulation and is measured at one specific time. A flow variable is the rate of change of the stock and is measured over an interval of time.

System dynamics (SD): A methodology to create descriptive models that focus on the identification of causal relations influencing the creation and evolution of the issues being investigated. Its main pillars are feedback loops, delays and nonlinearity through the explicit representation of stocks and flows.

Vertical/horizontal disaggregation of models: Vertically disaggregated models represent a high degree of sectoral detail; horizontal models instead include several sectors and the linkages existing among them (with a lesser degree of detail for each of the sectors represented).

Abbreviations

BAU	business as usual
CAPEX	capital expenditure
CBA	cost-benefit analysis
CLD	causal loop diagram
DSCR	debt service coverage ratio
IRR	equity internal rate of return
NPV	equity net present value
FTE	full time equivalent
GDP	gross domestic product
LLCR	loan life coverage ratio
SAVi	sustainable asset valuation tool
SD	system dynamics

Part I: Introduction

The Autoroute du Maroc (ADM) is the agency responsible for the construction, operations, maintenance and management of road projects in Morocco. ADM asked IISD to use SAVi on the "Contournement de Rabat," (or Rabat bypass) road project, which was officially inaugurated in August 2017. It has a length of 41.1 km and includes the Mohammed VI Bridge, an important landmark and project of national significance. ADM also manages the tourist sites close to the Mohammed VI Bridge. They include a museum and a picnic area developed to illustrate the importance of this piece of civil engineering in the region.

The toll road was built to improve mobility around Rabat and to reroute traffic not destined for the city.

The construction phase of the project is financed through a EUR 212.4 million loan from the European Investment Bank, EUR 44.3 million equity financing from ADM and EUR 54.6 million from the state of Morocco.

SAVi was used to simulate six different scenarios. Four externalities were identified and valued in the integrated cost-benefit analysis: discretionary spending from labour income, social cost of carbon, value of time saved and the cost of accidents. The scenarios and externalities are explained in Part II.

For each scenario, SAVi calculated the net benefits, the internal rate of return, the net present value and two debt coverage ratios. The results are presented in Part III.

Part IV explains how SAVi for the Rabat bypass was built and provides more detail on the system dynamics and project finance model.

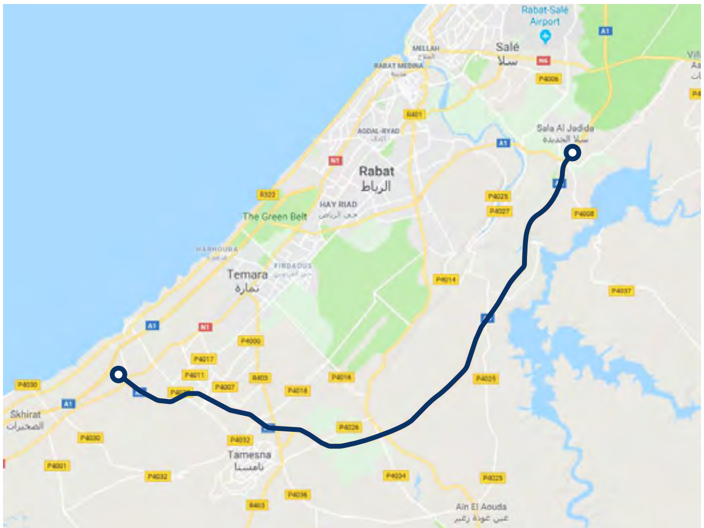

Figure 1. Map of the bypass

Part II: Scenarios and Externalities

Scenarios

We simulated six scenarios to show changes on the budgeted capital and operational expenditure of ADM over the lifetime of the road. The user life of the road is assumed to be 50 years. All scenarios are based on extensive research about the local context, on-site exchange with local stakeholders and discussions with ADM.

Table 1. Scenarios

Scenario	ADM reference	Assumption
Scenario 1: Business as Usual	BAU	• Capital and operational expenditure as budgeted by ADM over the lifetime of the road
Scenario 2: Reduced Maintenance Expenditure	RE2	• 5% reduction in maintenance expenditure due to the budgeted cuts
Scenario 3: Increase in Road Works	RD1 RE1	• 200 metres of road is closed for reconstruction, every year from 2018 to 2060
Scenario 4: Short-term Traffic Increase	MO3	• 200% traffic increase in the short term
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Scenario 6: Road Damage Due to Climate Change	CC	• 2 km of road is damaged as a direct result of climate change, every 10 years

Valuation of Externalities

ADM and IISD selected the following externalities as being material to the road project:

- Discretionary spending from labour income
- Social costs of carbon
- Costs of accidents
- Value of time saved

DISCRETIONARY SPENDING FROM LABOUR INCOME

The discretionary spending from labour income is the income spent on additional consumption. The assessment assumes that approximately 30 per cent of the labour income produced from the project is spent on consumption and generates value in the domestic economy.

SOCIAL COSTS OF CARBON

The social cost of carbon represents the economic cost caused by an additional ton of carbon dioxide or its equivalent. It can be regarded as the discounted value of economic welfare from an additional unit of CO_2e emissions (Nordhaus, 2017). The social cost of carbon is estimated at USD 31 per ton of CO_2e emissions generated.

COSTS OF ACCIDENTS

The costs of accidents are calculated based on the number of accidents and their economic valuation. The assessment considers three different types of accidents: light, medium and fatal. Light accidents represent accidents where only equipment was damaged, but no harm done to humans. Medium accidents assume damage to equipment and human life, and are valued higher than light accidents. Fatal accidents are accidents where a human life is lost and are valued the highest of the three. Table 2 provides information about the economic value by type of accident.

Table 2. Valuation of accidents

Type of accident	Economic valuation	Unit
Light accident (Damage to vehicle only)	3,862	USD / Accident
Medium accident (Accident with injury)	55,740	USD / Accident
Fatal accident (At least one person dies)	1,398,920	USD / Accident

Source of valuation: U.S. Department of Transportation, 2010.

VALUE OF TIME SAVED

The value of time saved represents the economic value resulting from improved mobility through the bypass. The increase in average travel speed as a result of the bypass project reduces the travel time per trip, which leads to cumulative time savings from reduced commuting time. To calculate the value of time saved, the total hours of time saved for each scenario was multiplied by the hourly salary.[1]

[1] A net annual salary of USD 3,700 per person, 250 working days per year and 8 hours per day of productive time underlie the calculation of the hourly salary. This is based on an estimation of the annual salary of an asphalt worker.

Part III: Results

Integrated Cost-Benefit Analysis (CBA)

Table 3 presents the results of the Integrated CBA. It integrates the six scenarios and four externalities discussed in Section II.

Table 3. Integrated CBA for the Rabat bypass

	Unit	Scenario 1: BAU	Scenario 2: Reduced Maintenance Expenditure	Scenario 3: Increase in Road Works	Scenario 4: Short-Term Traffic Increase	Scenario 5: Increase in Heavy Vehicle Traffic	Scenario 6: Road Damage Due to Climate Change
EXPENDITURE(S)							
Capital investment[2]	**mn EUR**	**329.79**	**329.79**	**406.97**	**329.79**	**329.79**	**337.12**
Average capital cost (2018–2060)	mn EUR / Year	0.031	0.031	1.667	0.031	0.031	0.168
O&M expenditure	**mn EUR**	**73.64**	**65.34**	**73.64**	**73.90**	**80.84**	**73.66**
Average O&M expenditure (2018–2060)	mn EUR / Year	1.74	1.54	1.74	1.75	1.91	1.74
Total investment and O&M	**mn EUR**	**403.4**	**395.1**	**480.6**	**403.7**	**410.6**	**410.8**
EXTERNALITIES							
Additional cost of accidents	**mn EUR**	**—**	**23.8**	**—**	**0.3**	**14.6**	**-0.8**
Total estimated cost of accidents	mn EUR	212.2	236.0	212.2	212.5	226.8	211.4
Average costs of accidents (2018–2060)	mn EUR / Year	4.88	5.44	4.88	4.89	5.22	4.86
Social cost of carbon	**mn EUR**	**4.61**	**4.58**	**5.64**	**4.61**	**4.63**	**4.71**

2 This includes the capital expenditures (CAPEX) and the cost of financing.

	Unit	Scenario 1: BAU	Scenario 2: Reduced Maintenance Expenditure	Scenario 3: Increase in Road Works	Scenario 4: Short-Term Traffic Increase	Scenario 5: Increase in Heavy Vehicle Traffic	Scenario 6: Road Damage Due to Climate Change
Average social costs of carbon (2018–2060)	mn EUR / Year	0.006	0.005	0.027	0.006	0.006	0.007
Discretionary spending from labour income	**mn EUR**	**1.26**	**1.12**	**1.34**	**1.26**	**1.37**	**1.27**
Average discretionary spending	mn EUR / Year	0.025	0.022	0.027	0.025	0.027	0.025
Value of time saved	**mn EUR**	**162.6**	**162.6**	**147.1**	**148.0**	**159.5**	**162.2**
Average value of time saved	mn EUR / Year	3.746	3.75	3.40	3.40	3.67	3.74
Total value of externalities	mn EUR	159.25	135.34	142.8	144.35	141.64	159.56
Total value of externalities (considering total accidents)	mn EUR	-52.9	-76.8	-69.4	-67.9	-70.5	-52.7
REVENUES							
Revenues	**mn EUR**	**456.10**	**456.10**	**456.10**	**456.03**	**464.89**	**454.68**
Average annual revenues (2018–2060)	mn EUR / Year	10.49	10.49	10.49	10.49	10.70	10.46
Total revenues	mn EUR	456.10	456.10	456.10	456.03	464.89	454.68
Conventional CBA (revenues less cost)	**mn EUR**	**52.7**	**61.0**	**-24.5**	**52.3**	**54.3**	**43.9**
Integrated CBA (incl. externalities)	**mn EUR**	**211.95**	**196.34**	**118.3**	**196.68**	**195.93**	**203.44**
Integrated CBA (incl. externalities and total accidents)	**mn EUR**	**-0.2**	**-15.9**	**-93.9**	**-15.6**	**-16.3**	**-8.8**

The integrated CBA demonstrates that:

- The value of externalities is significant. The value of time saved and the cost of accidents across the different scenarios are particularly high.
- Integrating the value of externalities in the CBA may lead to different decision making on which risks to prioritize for mitigation strategies.

THE VALUE OF EXTERNALITIES IS SIGNIFICANT

The estimated value of externalities is significant, reaching between 13 per cent and 19 per cent of capital and O&M costs. Externalities considered are accidents, social cost of carbon, discretionary spending and value of time.

Accidents in the model increase with traffic volume, congestion, pavement quality and through parts of the road being affected by reworking and maintenance. The cumulative cost of accidents is highest in the Scenario 2: Reduced Maintenance Expenditure, with EUR 236 million in total, due to the reduction of planned maintenance, and in Scenario 5: Increase in Heavy Vehicle Traffic with EUR 226.8 million, due to the increase number of trucks and resulting degradation of the pavement. The cost of accidents in these two scenarios is EUR 23.8 million and EUR 14.6 million higher compared to BAU (Scenario 1).

Construction and road maintenance require energy, which impacts the social cost of carbon. As a result, the value is higher than the baseline in the cases where maintenance increases, namely for Scenario 3: Increase in Road Works and the Scenario 6: Road Damage Due to Climate Change, by EUR 1.03 million and EUR 0.1 million cumulatively. The value is lower in Scenario 2: Reduced Maintenance Expenditure as a result of reduced maintenance activities.

The cumulative value of time saved, compared to a situation in which the ring road did not exist, is highest for Scenarios 1, 2 and 5 with cumulative savings of EUR 162.6 million between 2018 and 2060. Additional traffic or traffic peaks in Scenarios 2, 4 and 5 cause congestion delays that reduce the value of time saved.

INTEGRATING THE VALUE OF EXTERNALITIES IN THE CBA MAY LEAD TO DIFFERENT DECISION MAKING

When carrying out a conventional economic assessment it would seem that the baseline scenario is a well-balanced approach, and that most risks do not represent meaningful threats to the management of the road. The only exception is Scenario 3, which carries higher costs.

On the other hand, when considering externalities, the results of the analysis change considerably. First, the baseline scenario barely breaks even when considering the full cost of accidents, with externalities representing EUR 52.9 million. The result is positive when excluding the cost of accidents, in the range of EUR 212 million. The situation worsens in the other scenarios, which all show negative results relative to the baseline, from EUR -8.6 million in Scenario 6 to EUR -93.7 million in Scenario 3. These results indicate that all risks would be underestimated when using a conventional approach that considers only investments and operation and maintenance expenditure.

Specifically, if we analyze the key elements of the CBA one by one:

All the scenarios result in an increase in capital costs and/or O&M costs. This is to be expected as all scenarios represent a risk that materializes: the increase in capital costs in Scenario 2 and Scenario 6 is due to a higher frequency of road disruptions, while increased O&M is due to wear and tear from heavy trucks. The graph in Figure 2 shows the disruption of roads (left) and the cumulative capital expenditure (right) for all scenarios. With the assumptions currently utilized, total capital expenditure can be up to 23 per cent higher than the baseline scenario.

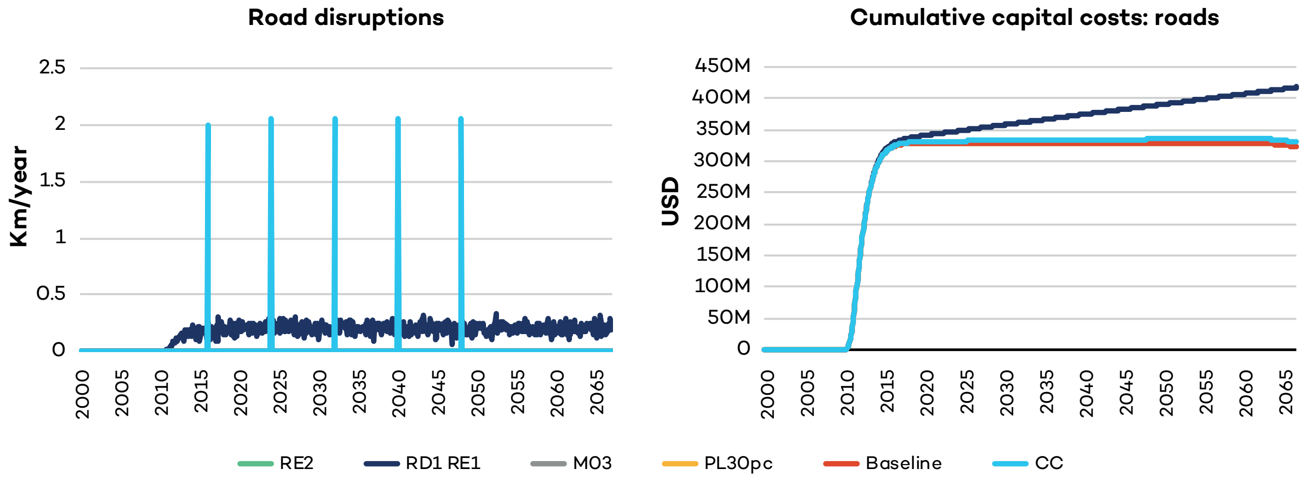

Figure 2. Road disruptions and cumulative capital costs

Total O&M costs range between EUR 65 million and EUR 81 million over 60 year, which is equivalent to approximately 25 per cent of total capital cost. The O&M costs are affected by several dynamics in the model, including the number of vehicles on the road, especially the heavy ones. The PL30 scenario shows the strongest increase in O&M costs, which are EUR 7.2 million, or almost 10 per cent higher than in the BAU scenario. An increase of EUR 0.26 million and EUR 0.02 million respectively is observed for the M03 and CC scenario. The RE2 scenario incurs with EUR 65.3 million (by design) the lowest O&M costs, which is approximately 11.3 per cent lower compared to the baseline scenario, but produces several negative side effects. Time series of pavement depreciation (left) and cumulative O&M expenditure (right) for all scenarios are displayed in Figure 3.

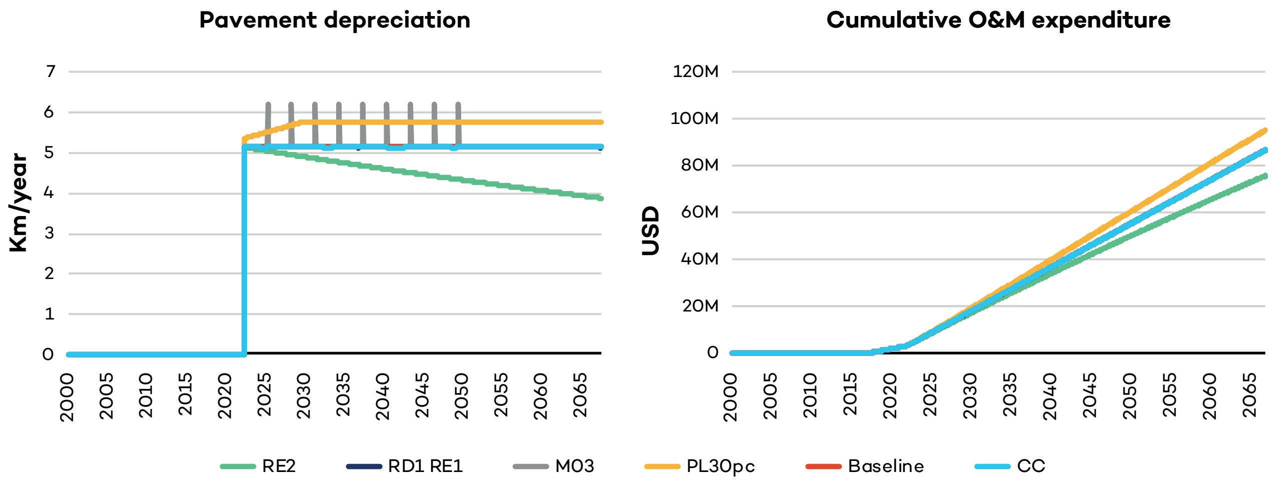

Figure 3. Pavement depreciation and cumulative O&M costs

The number of vehicles is assumed to be constant across all scenarios, with the exception of the PL30 and M03 scenarios. A baseline growth rate for vehicles could be assumed in new alternative scenarios. As illustrated in Figure 4, the M03 scenario shows sudden increases in traffic due to special events. Based on the traffic loads, the model shows the impact on other operational variables such as revenues, congestion, speed of travel and the number of accidents. The model also forecasts a decline in travel volume after the event as a strategy that commuters would use to avoid heavy traffic.

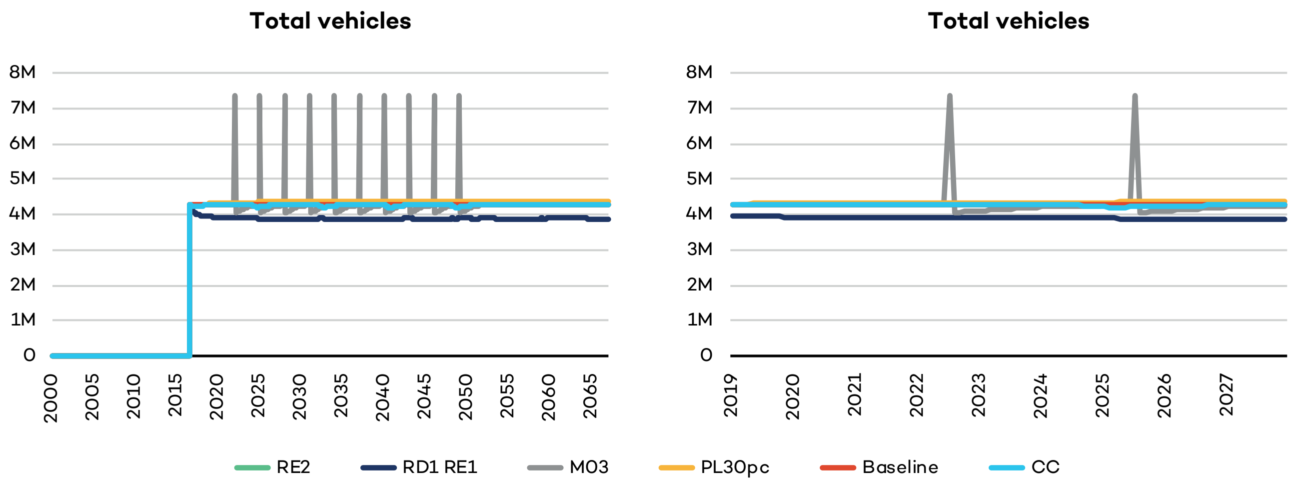

Figure 4. Total vehicles on the road and traffic patterns

The revenues generated by the road depend on the number of vehicles using it. In most scenarios, revenues remain unchanged because of the underlying assumption that the number of vehicles does not change. In all scenarios, the undiscounted annual revenues are higher than the annual O&M costs, and exceed total capital investment around 2056, depending on the scenario. Annual revenues start accruing with the beginning of operations in 2017, as illustrated in Figure 5.

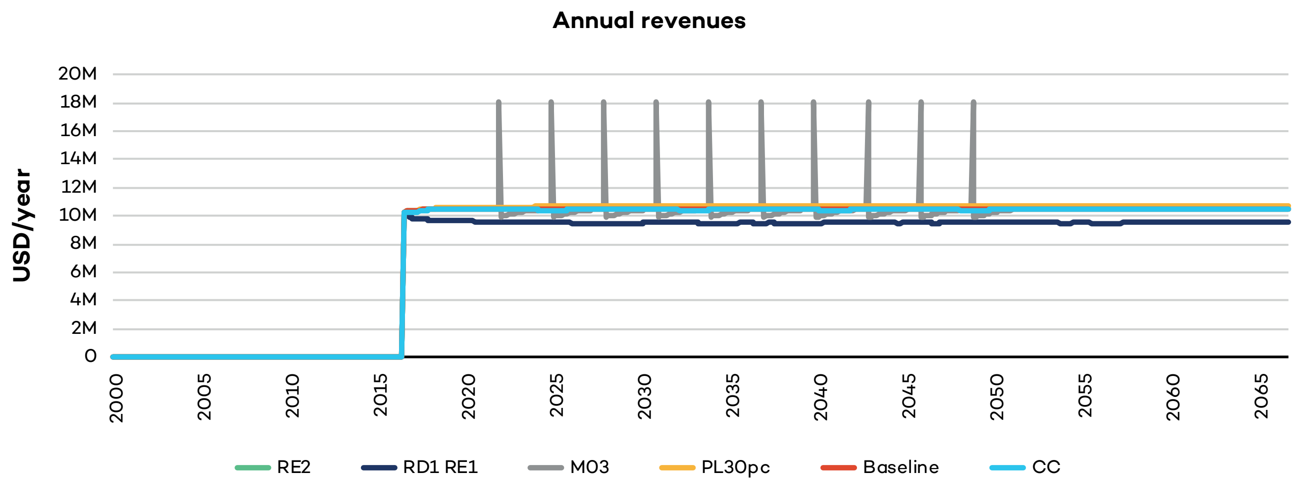

Figure 5. Annual revenues

Financial Analysis

Table 4 presents the financial assessment of the Rabat bypass. It integrates the six scenarios and four externalities discussed in Section II. The business-as-usual scenario has been modelled without externalities as well (Scenario 0) in order to better demonstrate their financial impact on the project. All other scenarios (Scenario 1 to 6) have the four externalities included in the calculations.

Table 4. Financial assessment

Scenario	IRR (%)	NPV (EUR mn)	Min. DSCR (ratio)	Ave. DSCR (ratio)	Min. LLCR (ratio)
Scenario 0: Business as Usual (without externalities)	1.63%	(103)	(0.08x)	0.67x	0.48x
Scenario 1: Business as Usual (with externalities)	3.39%	(29)	0.21x	1.04x	0.82x
Scenario 2: Reduced Maintenance Expenditure	3.14%	(41)	0.17x	0.98x	0.76x
Scenario 3: Increase in Road Works	1.63%	(132)	0.05x	0.66x	0.51x
Scenario 4: Short-term Traffic Increase	3.25%	(36)	0.19x	1.00x	0.79x
Scenario 5: Increase in Heavy Vehicle traffic	3.34%	(32)	0.20x	1.03x	0.81x
Scenario 6: Road Damage Due to Climate Change	3.25%	(37)	0.20x	1.00x	0.79x

KEY FINDINGS

- The project is not financially viable when relying solely on its own revenues, under any of the scenarios.
- Externalities have a material financial impact.
- All the key financial indicators measured improve significantly when externalities are included under Scenario 1: Business as Usual (with externalities).

PROJECT IS NOT FINANCIALLY VIABLE

The negative net present value (NPV) under all the scenarios means that the discounted cash flows of the project cannot cover the capital and operating expenditures. In other words, the project is not a sound investment for either debt or equity investors.

While the internal rate of return (IRR) is positive when externalities are included, it is below the expected market rate of return of projects with similar risk profiles in the region.

DSCR indicates the financial health of a project. DSCR lower than “1” means that the cash flows are insufficient to service the debt in that period. Both the average and minimum DSCR ratios are below the lockup ratio of 1.15x usually required by lenders.

LLCR also indicates the financial health of a project. LLCR lower than "1" means that the net present value of the remaining cash flows during the tenor of the debt are insufficient to service the outstanding debt amount with interest. In addition, the minimum LLCR is significantly below the lockup ratio of 1.10x usually required by lenders.

EXTERNALITIES HAVE A MATERIAL FINANCIAL IMPACT

The difference between Scenario 0: Business as Usual (without externalities) and Scenario 1: Business as Usual (with externalities) demonstrates well the positive financial impact of socioeconomic externalities. All the key financial indicators measured improve significantly under Scenario 0.

Under Scenario 2: Reduced Maintenance Expenditure, the project's yearly operating costs decrease by -11.40 per cent. However, the decreased spending results in a higher number of accidents compared to the BAU scenario. The economic and social costs of the increased number of accidents (+ EUR 0.16 / vehicle), are significantly higher than the cost savings realized by the lower maintenance, resulting in the IRR dropping to 3.14 per cent and the NPV decreasing by EUR 12 million. By increasing the average price from EUR 2.45 to 2.65 EUR/vehicle, the financial indicators would match those of the BAU scenario. **This scenario demonstrates that decreasing on operating and maintenance spending does not result in savings in overall costs when externalities are considered.**

In case of Scenario 3: Increase in Road Works, the significant increase of annual maintenance costs (+333.45 per cent) due to the inferior quality of the road and higher capital expenditures (+ EUR 77.17 million) decrease the IRR to 1.63 per cent and the NPV to EUR -132 million, as the cash flows are not large enough to cover the higher expenses. **The additional maintenance work also results in a higher social cost of carbon compared to Scenario 1: Business as Usual.**

Under Scenario 4: Short-term Traffic Increase, the operating expenses increase by 0.40 per cent due to the temporary increase of traffic. This will also result in an increased number of accidents (+ EUR 0.002 / vehicle). The impact of these changes on the IRR is negligible, while the NPV decreases by EUR 7 million. **Due to the heavy traffic, the value of time saved is lower and the accidents higher than in the case of Scenario 1: Business as Usual.**

In case of Scenario 5: Increase in Heavy Vehicle Traffic the number of heavy trucks using the road increases, resulting in a 2 per cent increase in traffic yearly. As the road requires more maintenance in case of heavy trucks compared to personal vehicles, the annual operating expenses of the project increases by 8.40 per cent. Due to the busier traffic, the number of accidents also rises by EUR 0.06 / vehicle. **This scenario has a negligible impact on the project IRR**, while the NPV decreases by EUR 3 million.

Finally, under Scenario 6: Road Damage Due to Climate Change traffic decreases by 1.39 per cent due to the frequent climate-related disruptions. This also results in an additional operational CAPEX (EUR +7.3 million) as major reconstruction works are needed to fix the damage done due to climate events. These disruptions also decrease the value of time saved. **The cumulative negative effects of climate are well demonstrated by the worsening of all financial indicators compared to Scenario 0: Business as Usual (without externalities).**

Part IV: How SAVi for the Rabat Bypass Was Designed

Model Overview System Analysis

SYSTEMS THINKING AND SYSTEM DYNAMICS

The SAVi analysis focuses on the assessment of opportunities and externalities related to the road construction and management for the Rabat bypass. To analyze those, SAVi first identified the driving forces and key indicators of the dynamics of the transport sector. These are summarized in the Causal Loop Diagram (CLD) displayed in Figure 1.

The CLD includes the main indicators analyzed during this SAVi assessment, their interconnections with other relevant variables in the sector, such as vehicle stocks or material use, and the feedback loops they form.

IISD and ADM developed and customized the CLD together. ADM provided the necessary information for the SAVi analysis, and IISD complemented this information with other data identified and captured in the SAVi In-Depth Review of Roads (IISD, 2018).

BOX 1. READING A CAUSAL LOOP DIAGRAM

Causal loop diagrams include variables and arrows (called causal links), with the latter linking the variables together with a sign (either + or −) on each link, indicating a positive or negative causal relation (see Table 5):

- A causal link from variable A to variable B is positive if a change in A produces a change in B in the same direction.
- A causal link from variable A to variable B is negative if a change in A produces a change in B in the opposite direction.

Variable A	Variable B	Sign
↑	↑	+
↓	↓	+
↑	↓	-
↓	↑	-

Table 5. Causal relations and polarity

Circular causal relations between variables form causal, or feedback, loops. These can be positive or negative. A negative feedback loop tends toward a goal or equilibrium, balancing the forces in the system (Forrester, 1961). A positive feedback loop can be found when an intervention triggers other changes that amplify the effect of that initial intervention, thus reinforcing it (Forrester, 1961). CLDs also capture delays and nonlinearity.

The creation of a CLD has several purposes:

- Combining ideas, knowledge and opinions
- Highlighting the boundaries of the analysis
- Allowing all stakeholders to achieve basic-to-advanced knowledge of the analyzed issues and their systemic properties.

Having a shared understanding is crucial for solving problems that influence several sectors. The creation of a CLD relies on cross-dimensional knowledge. It supports the development of a shared understanding of the factors that contribute to the problem. It also helps identify actors that can make decisions on solutions—and implement them. As such, the solution should emerge from the system, not be imposed on it. In other words, interventions should be designed to make the system start working toward solving the problem, rather than generating more.

In this context, the role of feedback is crucial. It is often the very system we have created that generates the problem, due to external interference or a faulty design, which shows its limitations as the system grows and increases in complexity. The causes of a problem are often found within the feedback structures of the system. We are too often prone to analyze the current state of the system, or to extend our investigation to a linear chain of causes and effects, which does not link back to itself and limits our understanding of open loops and linear thinking.

MODEL OVERVIEW

IISD used the SAVi roads model for the analysis of the bypass project. The assessment monetizes risks and externalities and provides information about social and environmental impacts and their impact on the financial performance of the road.

The Causal Loop Diagram (CLD) of the SAVi roads model is presented in Figure 1. For the assessment of the management strategies for the bypass, the model considers revenues and costs from the use of the bypass as well as monetized externalities resulting from its construction. Impacts on traffic flow and accidents are captured. Emissions and labour income resulting from the construction of the road are also factored into the assessment to provide a more comprehensive picture of road-related impacts. The externalities that are considered in this assessment are described in more detail in Section IV.

The outputs of the SAVi roads model emerge from the dynamics generated by different feedback loops. As described above, feedback loops can be reinforcing (R) and balancing (B).The dynamics of the roads model are driven by three reinforcing and six balancing loops. The behaviour of each loop is described below.

- The **first reinforcing loop (R1)** captures the beneficial impacts of the road network on total factor productivity and GDP. The construction of roads contributes to the size of the road network, which improves connectivity and hence positively impacts productivity. The higher GDP resulting from increased productivity leads to higher tax and other revenues for the government, which increases the budget for building and maintaining roads and stimulates road construction.
- The two other **reinforcing feedback loops (R2+R3)** capture the impact of road construction on the risk of flooding. The loop R2 captures the impact of road construction on vegetation cover. Land is converted for constructing roads, which reduces the amount of permeable ground cover and hence water absorption capacity. The reduced permeability of the ground causes rainwater to percolate more slowly and increases the risk of flooding. If floods occur, they typically lead to damages to roads and hence a reduction of the total road network. Reinforcing loop R3 captures the impact of road construction on ground density. The use of heavy machinery for the

construction of roads causes the ground beside roads to be more dense, as machinery needs to be moved, which increases soil density. This increase in soil density leads to a reduction in water absorption capacity and hence increases the risk of floods.

- The **first balancing loop (B1)** captures the need for road maintenance resulting from the use of the road network. The bigger the road network, the more maintenance activities need to be conducted, which increases the required maintenance costs for roads. The amount of money required for maintaining the current road network impacts the ability to spend money on the construction of new roads. If the costs of road maintenance increase, the amount of new roads under construction will decrease as a result of a lower budget for road construction. This reduces the growth of the road network and ensures that there are sufficient resources to maintain the current network.
- The **second balancing loop (B2)** captures the replacement costs of end-of-lifetime roads. Once roads reach the end of their lifetime, they typically need to be replaced, which requires additional rework and costs. The costs of replacing existing end-of-lifetime roads are considered as maintenance costs in the SAVi roads model. The costs of replacing roads increase the maintenance costs and consequently reduce the budget for the construction of new roads.
- The depreciation of roads is captured by the **third balancing loop (B3)**. The model assumes that the depreciation of the road network depends on the size of the existing road network. The bigger the road network, the larger the amount of roads in need of maintenance or replacement. The depreciation of roads reduces the total road network and increases the costs of road maintenance and replacement.
- **Balancing loop (B4)** is implicit in the diagram presented in Figure 1. It captures the increase in congestion and its impacts on macroeconomic performance. The size of the road network determines the road density within a country or region. The higher the road density, the more traffic there will be in certain areas, which increases congestion. Congestion leads to people spending more time in traffic, which takes productive time out of their day and reduces total factor productivity. This in turn reduces macroeconomic performance (GDP), which leads to lower revenues for the government and hence a lower budget for the construction of roads.
- The impact of health costs on the budget for road construction is captured by **balancing loop (B5)**. As outlined above, the amount of roads determines the amount of traffic on the road. An increase in traffic leads to higher amounts of traffic-related emissions, which leads to a higher incidence of emission-related health impacts such as respiratory and cardiac diseases. Higher incidence of diseases leads to an increase in the public health care expenditure, which reduces spending on infrastructure, and consequently lowers the budget for constructing new roads.
- The sixth **balancing loop (B6)** captures the impact of natural capital depletion and habitat fragmentation on macroeconomic performance. The construction of roads leads to an increase of the road network, which increases road density. Road network expansion oftentimes leads to the fragmentation of habitats followed by a reduction of ecosystem services provided. The reduction in ecosystem services threatens the livelihoods of population groups dependent on these ecosystem goods and services and reduces the value added generated from ecosystem dependent actors.

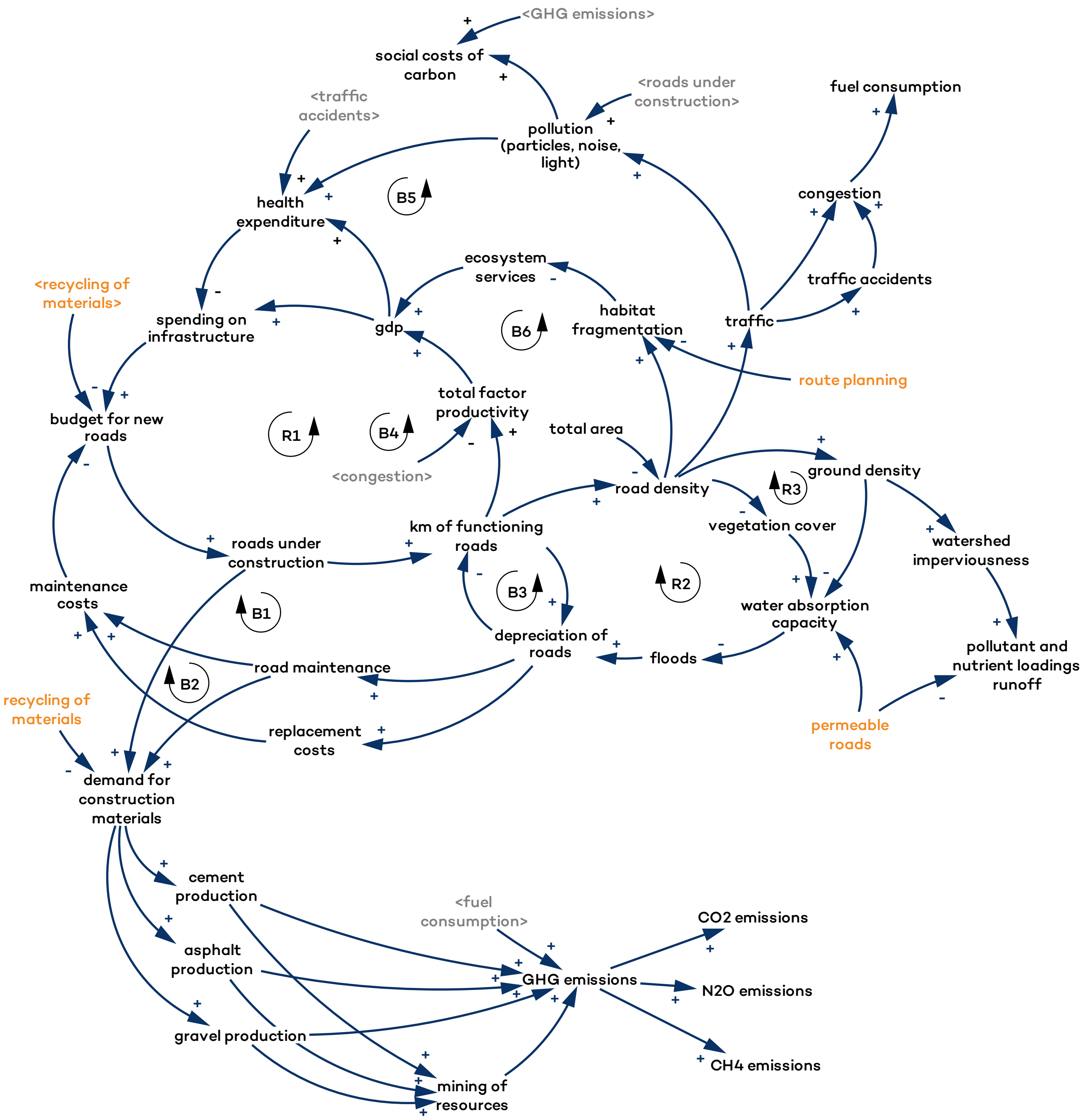

Figure 6. Causal Loop Diagram Morocco roads assessment

INDICATORS CONCERNING EXPENDITURE, AVOIDED COST AND ADDED BENEFITS

SAVi calculates expenditure, avoided costs and added benefits, whereby expenditure includes both capital investment and O&M expenditure over the lifetime of the asset. The assessment integrates both social and environmental avoided costs and added benefits in addition to the more traditional economic ones. For example, different road management approaches affect energy use, energy costs and emissions, which in turn impact capital and maintenance expenditure as well as multiple other aspects related to road maintenance.

Expenditure

From a private sector perspective, expenditures refer to the monetary costs of project implementation, such as investment, operation and maintenance (O&M) costs and extrabudgetary expenditure. For utility operators, complying with emission standards might entail, for example, purchasing efficient mitigation technologies. Contractors will consider the costs for selected mitigation technologies, certification fees for new power generation capacity and auditing for existing ones. From a public sector point of view, expenditures refer to the allocation and/or reallocation of financial resources with the aim of reaching a stated policy target. For example, providing subsidies for investments in efficient power generation technologies to stimulate the construction of renewable capacity or capacity that delivers the best value for money according to the determined indicators.

Avoided Costs

The estimation of potential avoided costs considers the results of the successful implementation of an investment or policy. In the case of road management, avoided costs refer to direct savings derived from the operation of roads, such as for example reduced material cost for road maintenance, avoided investments in machinery and equipment or general O&M-related expenditure, such as water costs.

Added Benefits

Among the added benefits are the monetary value of economic, social and environmental outcomes obtained from investment or policy implementation. Added benefits are assessed by comparing the investment scenario against the baseline scenario, focusing on short-, medium- and long-term impacts across sectors and actors. In the case of road infrastructure, added benefits include job creation, a reduction in health impacts from emissions, opportunity costs of land use and social costs of carbon (Nordhaus, 2017). This category captures additional benefits generated by planned investments that would not accrue in a business-as-usual scenario.

Model Overview Project Finance

The main purposes of a project finance model are: 1. to identify the optimal capital structure; 2. to assess the financial viability of the project; and 3. to calculate the expected return on investment under different operational and risk scenarios.

1. Project sponsors use financial models to determine what should be the optimal debt-equity split used in the financing of the project. This largely depends on the project's revenue and cost profile: the timing and size of incoming cash flows during operations and the associated costs in each period. Most infrastructure projects follow a so-called "J-curve": having high upfront costs and relatively small, but steady revenue streams. The "J" represents that it takes a certain number of years before the project breaks even and generates a return on investment.
2. Project finance models can also calculate whether the cash flows generated by the project will be sufficient to service the debt and generate an attractive risk-adjusted return for both equity and debt investors. This assessment includes the calculation of key profitability and credit indicators, such as the internal rate of return (IRR), net present value (NPV), debt service coverage ratio (DSCR) and loan life coverage ratio (LLCR). The definition of these indicators can be found in the glossary.
3. Project finance models are also well placed to stress test projects and assess how the expected return changes under certain operational and risk scenarios. This is calculated by a so-called "scenario table," which modifies key project assumptions and shows how key financial indicators react to these changes. Scenarios could be simple operational events, such as an increase in the price of feedstock, disruption in operation, or more complex climate events, such as heat waves, sea level rise or carbon tax.

The project finance model used in SAVi is built in Microsoft Excel and follows Corality SMART best practices in order to improve readability and auditability of the model by a third party. The outputs of the system dynamics model in SAVi are used as inputs in the project finance model and vice versa. The system dynamics model quantifies and monetizes the relevant environmental, social and economic externalities associated with the project. It also helps to identify the scenarios used in the scenario table. Depending on the purpose of the assessment and the target audience, some of the externalities are included as costs or benefits in the scenario table. Outputs of the system dynamics model can also change some of the key assumptions of the project finance model.

The main outputs of the project finance model are the financial indicators mentioned earlier. During the customization of the model, the list of indicators can be changed or extended as needed. Project-specific data, such as cost of financing, can also be extracted from the project finance model and fed back into the system dynamics model.

Part VI: Conclusion

SAVi was used to simulate six different scenarios. Each of those represent an operational risk to ADM. In addition, four externalities were identified and valued in the integrated cost-benefit analysis: discretionary spending from labour income, social cost of carbon, value of time saved and the cost of accidents. Finally, SAVi was also used to calculate financial indicators that demonstrate the viability of the project.

The SAVi assessment demonstrated that monetizing the risks and undertaking a scenario analysis are valuable, as they showed the magnitude of the impact on project revenues and benefits. As such, ADM has information to be better prepared should such risks materialize. The SAVi assessment also showed that the value of externalities is significant when incorporated in a cost-benefit and project finance analysis. In particular, the value of time saved had a large impact. Finally, the project finance analysis demonstrated that the cash flows of the project cannot cover the capital and operating expenditures.

Next steps: ADM's Research and Development Program is undertaking research on better management of flooding, run off and soil erosion on roads. Freak weather and climate change are now real risks on the operation and management of motorways in Morocco. As part of that research, ADM is looking at 2 new soil fixation techniques to combat erosion. The first technique is biological engineering, the second consists of concrete arcades that are build on the slopes next to the road to break water flow speeds. IISD will explore with ADM SAVi applications on motorways in Morocco that compare the costs and benefits of the new techniques for soil fixation in financial terms. A future SAVi application can, for example, include a comparison between different technologies for soil fixation, and include a scenario where no specific risk mitigation measures for soil erosion are taken. This can inform ADM about the impact and value of these new techniques for future road projects. It can also provide ADM with information about the longer-term benefits of these techniques, especially considering the increased likelihood of climate change-related impacts on road infrastructure.

References

Bassi, A.M., McDougal, K. & Uzsoki, D. (2017). *Sustainable Asset Valuation Tool: Roads*. Retrieved from https://www.iisd.org/sites/default/files/publications/sustainable-asset-valuation-tool-roads.pdf

Environmental Protection Agency (EPA). (2013). *Estimating the benefit per ton of reducing pm2.5: Precursors from 17 sectors*. U.S. Environmental Protection Agency. Retrieved from https://www.epa.gov/sites/production/files/2014-10/documents/sourceapportionmentbpttsd.pdf

Forrester, J.W. (1961). *Industrial dynamics*. MIT Press.

National Highway Traffic Safety Administration of U.S. Department of Transportation (2015). *The economic and societal impact of motor vehicle crashes*. Retrieved from https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812013

Nordhaus, W. (2017). Revisiting the social cost of carbon. *Proceedings of the National Academy of Sciences of the United States of America (PNAS), 11*(7), 1518–1523. Retrieved from https://www.pnas.org/content/114/7/1518

Roberts, N., Andersen, D., Deal, R., Garet, M., & Shaffer, W. (1983). *Introduction to computer simulation. The system dynamics approach*. MA: Addison-Wesley.

United Nations Environment Programme (UNEP) (2011). *Towards a green economy. Pathways to sustainable development and poverty eradication*. Retrieved from https://sustainabledevelopment.un.org/content/documents/126GER_synthesis_en.pdf

PROJECT-SPECIFIC DOCUMENTS AND STUDIES PROVIDED BY THE AUTOROUTE DU MAROC (ADM):

ADM (n.d.). *Cartographie des processus d'ADM*.

ADM (n.d.). *Statistiques accidentologie section Contournement Rabat. Période 07/07/2016 Au 31/12/2017*.

ADM (n.d.). *Trafic mensuel par Catégorie du contournement de Rabat en 2016*.

ADM (n.d.). *Management of the risk of flooding and water erosion on motorways in Morocco*.

ADM. (2009). *Etude d'impact sur l'environnement du projet de construction de l'autoroute contournement de Rabat. Rapport Provisoire*.

ADM. (2009). *Etude d'impact sur l'environnement du projet de construction de l'autoroute contournement de Rabat. Rapport Provisoire. Avril 2009. Annexe 2: Plan de gestion de l'Environnement*.

ADM. (2009). *Matrice des risques majeurs de ADM*.

ADM. (2017). *Autoroute de contournement de rabat. Rapport d'achèvement des travaux*.

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Head Office

111 Lombard Avenue, Suite 325
Winnipeg, Manitoba
Canada R3B 0T4

Tel: +1 (204) 958-7700
Website: www.iisd.org
Twitter: @IISD_news

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