Validating a Balanced Score Card Benefit Assessment Framework Indicator Set

The Case of the South African National Roads Agency Ltd SOC Research and Development Programme

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ABSTRACT

Investment in Research and Development (R&D) is scrutinised where funding is limited such as in developing counties. There is therefore an increased emphasis on benefit and impact assessment tools and systems for such R&D programmes. In sectors like roads and transport, deliverables from R&D could include new materials and equipment. However, it usually, and more often, delivers novel design methods, new techniques and models for enhancing transport system performance and free software for use by professionals in the industry. The nature of these "soft" deliverables complicates the measurement of the performance of R&D in roads and transport. The South African Roads Agency Ltd SOC (SANRAL) developed a Balanced Score Card (BSC) with associated indicators that can be used to monitor the performance of its research programme across the full innovation value

chain. This article aims to review the indicator set by assessing its balance in terms of SANRAL's systems-based R&D model, by evaluating it against the SANRAL strategic objectives and through a survey among 175 stakeholders and researchers. It was found that the indicator set is well balanced and addresses all aspects of the innovation value chain.

INTRODUCTION

Technological innovation through science and engineering benefits economies and ultimately social development (Bessant *et al.* 2014:1). R&D investment is a primary driver for technological innovation (Link 1993:2; Link and Scott 2013:15). This plays a fundamental role in maintaining sustainability and industry development and competitiveness.

Worldwide there is, however, greater emphasis on determining the benefit, both economic and social, achieved from the required R&D for technological innovation (Bessant *et al.* 2014:1). This is of particular importance in poorer countries where resources are scarcer, and impact must be optimised, resulting in increasing importance of R&D metrics (Rust and Sampson 2019:547; Lazarotti *et al.* 2011:212).

Transport and transport infrastructure enable socio-economic development and growth (Ding 2013:312; Zhang 2013:24; Ng *et al.* 2018:292; Cigu *et al.* 2019:I-22) through provision of effective and efficient movement of freight and people (Ng *et al.* 2018:292). This in turn, acts as a catalyst for poverty alleviation and striving towards the realisation of global development goals (The World Bank 2014). It follows that monitoring the performance of R&D investment into transport and transport infrastructure research is of importance in developing economies, particularly in South Africa, due to the relatively low level of investment into R&D (CeSTII 2019:6).

Rust (2010:87) argued that the result of R&D in the transport sector (including infrastructure) yields a variety of solutions including new materials and products, but more often new methodologies and processes such as new design methods, new methodologies for enhancing transport system performance and free software for the use of professionals in the industry. This is an increasing trend (Spieth *et al.* 2014:237). Measuring the performance of such an R&D programme is therefore complex and a classical return on investment calculation does not suffice (Rust and Sampson 2019:547). Proposals have been made, for example, to measure social impact in addition to financial impact of activities through an External Rate of Return platform that will take into account the full impact of a company or activity (Florman *et al.* 2016:5).

SANRAL initiated an R&D programme in 2019. It adopted a systems-based research management model and a BSC with a set of indicators across the full innovation value chain to assess the benefit and impact of the R&D programme (Rust and Van Dijk 2020:41). This article relates the work conducted to validate the indicator set based on its balance, how well it addresses SANRAL's overall strategic objectives and through a survey among stakeholders and researchers.

LITERATURE REVIEW AND BACKGROUND

Assessment of the performance of R&D has a number of objectives (Deeming *et al.* 2017:15):

- Top-down accountability, to allow for aggregation of impact at a national level;
- Bottom-up accountability, and transparency to allow for transparency of research activity along the pathway to impact;
- Advocacy, that demonstrated research capability to stakeholders;
- Steering, that allows for the aligning of the research agenda with specific objectives;
- Value for money, that addresses monetised benefits;
- Management, learning, feedback and allocation, that allows for the information of strategic management decisions;
- Prospective orientation, that allows for planning the pathway to the end impact goal; and
- Speed of translation, that allows for setting targets for researchers using a logic model to address the time that research takes to move towards final impact.

There are a number of models for benefit and impact assessment (Brady 1995:252), however, the applicability of these models and processes to management of R&D and innovation in diverse R&D programmes is doubtful (Brady 1995). These models and techniques have been developed for managing the development of hard products mostly for the consumer market and do not deal with the wider benefit associated with R&D that also has social and environmental impacts such as the SANRAL R&D programme.

A BSC is a system for measuring programme performance to facilitate strategy implementation (Bremser and Barsky 2004:229; Kaplan and Norton 2001:95). A BSC comprises indicators of performance that deal with tangible, financial aspects as well as non-financial aspects of a programme or company. Kaplan and Norton (1992:71) provided four perspectives for a BSC within which the indicators are grouped:

- How shareholders view the company (financial perspective);
- How customers see the company (customers/stakeholders);
- What the company must do to excel (internal processes); and

- How the company should innovate and learn (learning and growth).

Some authors have added a fifth perspective: Strategy (Malbasic and Marimon 2019:38; Sen *et al*. 2017:97).

BSC indicators can be used as key performance indicators at division level and even at employee level. The benefits of using a BSC approach are (Bremser and Barsky 2004:229):

- "*The BSC utilises causal sets of performance measures to monitor results. Variance analysis of metrics provides insight into deviation from objectives.*
- *The primary purpose of the BSC is to highlight strategy and its impact on operating decisions. Utilising the BSC over multiple periods provides the basis for feedback (strategic learning loop and management control loop) and planning.*
- *The BSC provides a common framework and reference point for employees across levels and functions. The cascading process provides for alignment.*
- *Most BSC organisations link objectives to personal rewards to guide employee decision-making.*
- *The requirement to use causal linkages throughout the BSC forces employees to analyse performance deviations and to identify, assess and manage drivers of outcomes and results.*
- *BSC objectives guide employee decision-making and provide a common framework with which to evaluate decision alternatives.*
- *The BSC requires frequent monitoring and routine feedback of operating measures to employees across organisation levels. Target setting and budget goals are intended to provide motivation for employee actions.*"

The BSC approach has been used to measure performance in a number of fields including, for example:

- Evaluating knowledge management practices (Gupta and Chopra 2017:84);
- Measuring non-profit incubator performance (Messeghem *et al*. 2018:658);
- To improve sustainable development (Rafiq *et al*. 2020:1365);
- Measuring the performance of library services (De la Mano and Creaser 2016:191; Urquhart 2017:121);
- To evaluate social impact (Grijalva *et al*. 2016:168);
- For environmental investment decision-making (Jassem *et al*. 2018:541) and environmental performance of companies (Al-Zwyalif 2017:118);
- To evaluate the performance of the water, energy and food sector (Ribeiro *et al*. 2020);
- The evaluating of Enterprise Resource Planning systems (Chand *et al*. 2005:558; Shena *et al*. 2016:127); and
- To evaluate construction and construction services (Salim 2018:320; Augusti-Juana *et al*. 2019; Sen *et al*. 2017:97).

Most notably a number of the use cases above pertain to monitoring of "softer" outcomes such as social impact. In most cases a BSC is used to assess more than just financial performance and includes, for example, customer satisfaction, human resource and employee development (Shibani and Gherbal 2018:1; Perramon *et al*. 2016:1121) as well as safety, equality and environmental aspects (Agusti-Juana *et al*. 2019). This is achieved through numerical or quantitative indicators as well as qualitative measures.

Spano *et al*. (2016:194) discuss the use of a modified BSC to measure the performance of a research network in the Bioscience field. They incorporated innovation metrics into a standard BSC and concluded that the tool is useful in strategic decision-making. The indicators should be monitored over time to provide a trend that can be used as input into strategic planning (Chand *et al*. 2005:558).

Although technology and knowledge generation are important for innovation in the roads and transport sector it is difficult to measure the impact thereof using only traditional financial metrics (Bremser and Barsky 2004:229; Coombs and Bierly 2006:421). A BSC can, however, utilise indicators across the full innovation value chain and incorporate both financial and non-financial measures metrics.

Although R&D investment is vital for long-term sustainability, the expense is often scrutinised especially in low-margin sectors such as construction, as well as in roads and transport. It is therefore vital to assess the benefit and impact achieved from such investment, particularly in public sector R&D programmes where tax-payers' money is spent. Such assessments can be used to motivate for the R&D investment but can also be used to identify areas in the R&D programme that require improvement (Bozeman and Melkers 1993; Jyoti *et al*. 2006:879).

The public sector SANRAL R&D programme discussed above is diverse and deals with areas from road materials and design to network management and road safety. For such programmes, benefit/impact assessment through economic return on investment only is not suitable (Bloch and Brugge 2013:133). The outcomes from such R&D programmes are equally diverse, ranging from human capital development, transformation and social impact to technological advances, therefore assessing the benefit and impact is challenging (Link 1993:15). This is further exacerbated by the diversity of the people that have to execute the process of development through the full innovation value chain. An alternative approach should therefore be designed specifically for the R&D performance assessment of the SANRAL R&D programme.

THE SANRAL RESEARCH AND DEVELOPMENT PROGRAMME

SANRAL was established in 1998 in terms of The South African National Roads Agency Limited and National Roads Act, 1998 (South African Government 1998).

SANRAL's main mandate is "*to manage and control the Republic's national roads system and take charge, amongst others, of the development, maintenance and rehabilitation of national roads within the framework of government policy*" (South African Government 1998).

In 2019 SANRAL embarked on an R&D programme to address various elements of its new strategy, Horizon 2030 (SANRAL 2017:3). This strategy focuses, among others, on skills development, as well as the use of technology and innovation to improve network capacity, mobility and road safety. It is important to SANRAL to ensure maximum benefit from the R&D expenditure.

The R&D programme comprises a number of focus areas associated with roads and transport. These are:

- Future transportation and technical innovation;
- Transportation planning, public administration, management and economics;
- Pavements;
- Asset management;
- Traffic;
- Road safety; and
- Geotechnical, structures, drainage and hydraulics and the environment.

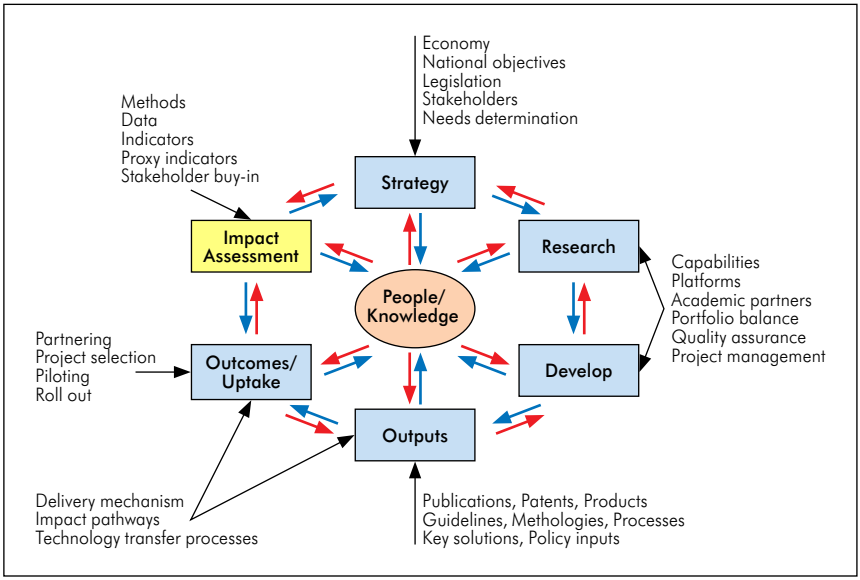
The nature of the R&D in the above seven focus areas, varies from product development such as new materials, to social sciences related to road safety and it is therefore complex to measure its benefit and end-impact. Based on a preliminary study in 2019 SANRAL adopted a number of principles for the evaluation of its R&D programme (Rust and Van Dijk 2020:41):

- That a systems approach be followed for the management of the R&D programme of which benefit/impact assessment is a vital element;
- That a BSC approach be followed in the framework for benefit/impact assessment; and
- That a set of associated indicators be developed that will assist in the assessment of the benefit/ impact of the R&D programme.

The systems-based model adopted by SANRAL is depicted in Figure 1 (Rust and Van Dijk 2020:41; Rust and Sampson 2019:547).

The model above contains a process for benefit/impact assessment that is a "sensor" monitoring the performance of the R&D programme. It contains multi-directional feedback loops that allow for "self-correction" of the system. The management of the R&D programme thus takes into account all the elements of the model including benefit/ impact assessment which is integral and not a stand-alone activity. "Back-casting" is used to plan research themes and projects by first establishing the planned impact, then uptake channels required (outcomes); the characteristics of the deliverable and only then the nature of the R&D activities required.

Figure 1: A systems-based model for R&D and innovation management



Source: (Rust and Van Dijk 2020:41)

A basic set of indicators was developed to address benefit/impact assessment across the full innovation value chain as depicted in Figure1. This process involved case studies of similar programmes, discussions with SANRAL's focus group for R&D and a rating process by SANRAL employees (Rust and Van Dijk 2020:41). The main objective of this article is to discuss the validation of the indicators through a survey among stakeholders and researchers in the roads and transport sector in South Africa.

The model is an enhancement of the innovation value chain that includes the following aspects: (The National Research Council of the National Academies 2005:17):

- *"Input–tangible quantities put into a process to achieve a goal.*
- *Output–products and services delivered.*
- *Outcome/uptake–results that stem from the use of the outputs.*
- *Impact–the effect that an outcome has on something else."*

METHODS

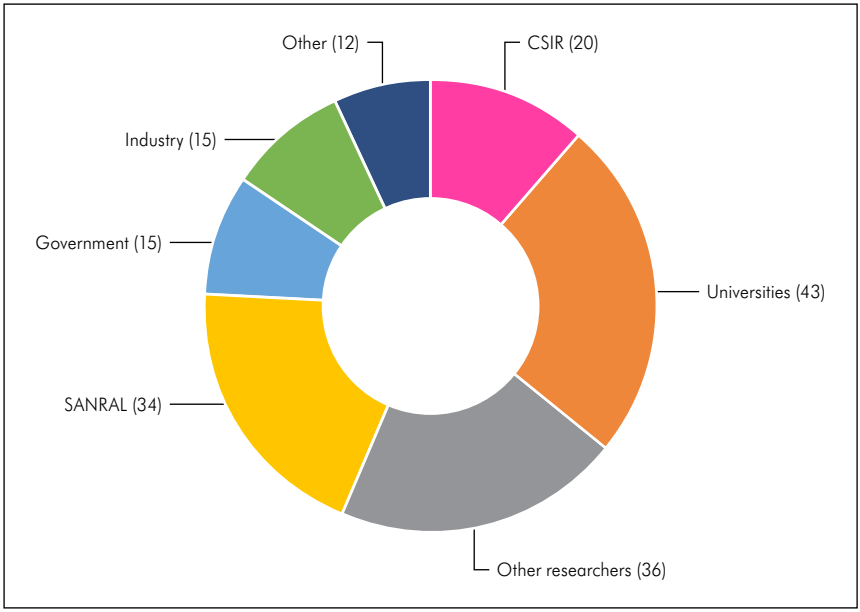
The SANRAL BSC and associated indicator set (Rust and Van Dijk 2020:41) was evaluated by:

- Assessing the balance in the indicator set by transposing the indicators on the R&D management model in Figure 1;
- Evaluating the degree to which the indicators address the SANRAL strategic objectives (SANRAL 2017:3); and
- The rating of indicators through a survey, using a structured 5-point Likert rating scale completed by SANRAL staff, stakeholders and self-identified researchers participating in seven research focus area workshops of the SANRAL R&D programme (a total of 175 attendees).

The workshop attendees originated from the following organisations or groups:
- Researchers from Universities;
- Other, individual researchers;
- The Council for Scientific and Industrial Research of South Africa (CSIR);
- SANRAL staff;
- Invited attendees from national and provincial government departments;
- Invited attendees from industry; and
- Others.

The distribution of the attendees is shown in Figure 2.

Figure 2: Distribution of SANRAL workshop attendees



Source: (Authors' own construction)

IMPACT/BENEFIT ASSESSMENT FRAMEWORK FOR THE SANRAL RESEARCH AND DEVELOPMENT PROGRAMME

In developing the BSC for SANRAL, it was taken into account that the final impact to road users and other stakeholders is very important to SANRAL. Thus, the indicators associated with the BSC had to span the full innovation value chain. In addition, the BSC and indicators had to be linked strongly to the overall SANRAL business strategy. In line with others, a "strategy" element was therefore added to the traditional four BSC perspectives (Malbasic and Marimon 2019:38; Sen *et al.* 2017:97).

As mentioned above, long-term impact is difficult to measure, especially in the case of a diverse R&D programme with significant non-financial benefit (Coombs and Brierly 2006:421). The use of proxy indicators for impact was adopted. The indicators cover financial and cost benefits as well as the "softer", non-financial benefits of research such as human capital development and the impact on communities and the environment.

The indicators for the SANRAL programme were developed from desktop research, case studies, discussions with SANRAL executives and a rating process by SANRAL employees (Rust and Van Dijk 2020:41). The identified indicators are presented below (Rust and Van Dijk 2020:41).

Process indicators

The R&D management process ensures that objectives are met within the allocated time frame and at the right quality. The process therefore requires strategic planning and governance. The following were proposed as indicators to assess these processes:

1. Number of needs determination processes;
2. Number of foresight studies;
3. Establishment of a Research Advisory Panel;
4. Establish research focus area steering committees;
5. Number of SANRAL staff and researchers trained in research methodology;
6. Number of SANRAL staff and researchers trained in research ethics; and
7. Number of Research Focus Area technology development strategies (R&D plans) developed.

Input indicators

The monitoring of inputs into an R&D process is important to allow for the assessment of the "return", both monetary (for example, savings) and in "soft" benefits. The proposed indicators in this instance were:

8. Number of researchers active in SANRAL research programme;
9. Number of black researchers active in SANRAL research programme;
10. Number of black research project leaders;
11. Number of female researchers active in the SANRAL research programme;
12. Number of active researchers with a PhD;
13. Frascati distribution of research funding (basic, applied, experimental development, piloting and implementation);
14. The amount of funding employed for research infrastructure;
15. The amount of research funding spent; and
16. The number and size of collaborative partnerships.

Output indicators

R&D outputs can be monitored at a strategic level by reviewing the volume, the quality and the implementability of these outputs. The proposed output indicators were:

17. Number of publication equivalents;
18. Number of new technology/knowledge packages;
19. Number of SANRAL endorsed national research reports;
20. Number of new or updated national guidelines;
21. Number of new Master's degrees completed;
22. Number of new PhDs completed; and
23. Quality assessment of publications (for example, journal impact factors).

Outcome indicators

Outcomes from the R&D process are defined as the effect it has on organisations outside of the R&D organisation and process (The National Research Council of the National Academies 2005). This can also be seen as the "uptake" of the outputs into industry. Monitoring uptake is vital because it is a precursor for eventual impact. The proposed indicators for this category were:

24. Number of technology demonstration projects where new knowledge/ technology was implemented;
25. Monetary value of demonstration projects;
26. Number and size of social impact projects;
27. Number of projects where positive environmental impact is made;
28. Number of practitioners trained in use of new technology or knowledge package;
29. Cumulative cost/benefit ratio; and
30. Number of small contractors involved in projects emanating from research programme.

Table 1: Matrix of indicators

BSC perspectives	Innovation value chain elements				
	Process	**Input**	**Output**	**Outcomes**	**Impact**
Financial		14. Funding employed for research infrastructure 15. Research funding spent		29. Cumulative benefit cost ratio	
Customer/ Stakeholder		16. No and size of collaborative partnerships		24. No of technology demonstration projects implemented 25. Monetary value of demonstration projects 26. No and size of social impact projects	32. Fatalities / 100,000 trips 33. Traffic through-flow rate 35. Road condition index 36. Facility performance index 37. User satisfaction index 40. Freight flow rates
Internal business processes	3. Establish Research Advisory Panel 4. Establish Research Focus Area Steering Committees		17. No of publications 18. No of new technology packages 19. No of national research reports 20. No of national guidelines		
Learning and growth	5. No of SANRAL staff trained in research management 6. No of SANRAL staff trained in ethics	8. No of active researchers 12. No of active researchers with PhD	21. No of new Master's degrees 22. No of new PhDs 23. Quality assessment of publications	28. No of practitioners trained	
Strategy	1. Needs determination processes 7. Number of Focus Area technology development strategies	2. No of foresight studies 10. No of black SA researchers active 11. No of SA female researchers active 13. Frascati distribution		27. No of projects with positive environmental impact 30. No of small contractors involved	31. No of retrospective studies 34. No of job opportunities created 38. Number of community projects 29. Cumulative monetary value of involvement in communities

Source: (Authors' own construction)

In addition, it was proposed that qualitative information such as success stories be recorded.

Impact proxy indicators

Impact can rarely be measured directly. It is therefore useful to define proxy indicators for impact. The following were proposed:

31. Number of retrospective studies to determine current impact resulting from past R&D;
32. Fatalities per 100 000 trips on roads where new solutions have been implemented;
33. Traffic through-flow rate at crucial bottlenecks;
34. Number of job opportunities created;
35. Road condition index;
36. Facility performance index;
37. User satisfaction index;
38. Number and nature of community involvement projects;
39. Cumulative monetary value of SANRAL's involvement in communities; and
40. Freight flow rates on road where new technology has been implemented.

The duality of the BSC addressing both the perspectives of a BSC as well as the elements of the innovation value chain was recognised. A matrix showing how the indicators are linked to both aspects is given in Table 1.

VALIDATION OF THE INDICATOR SET

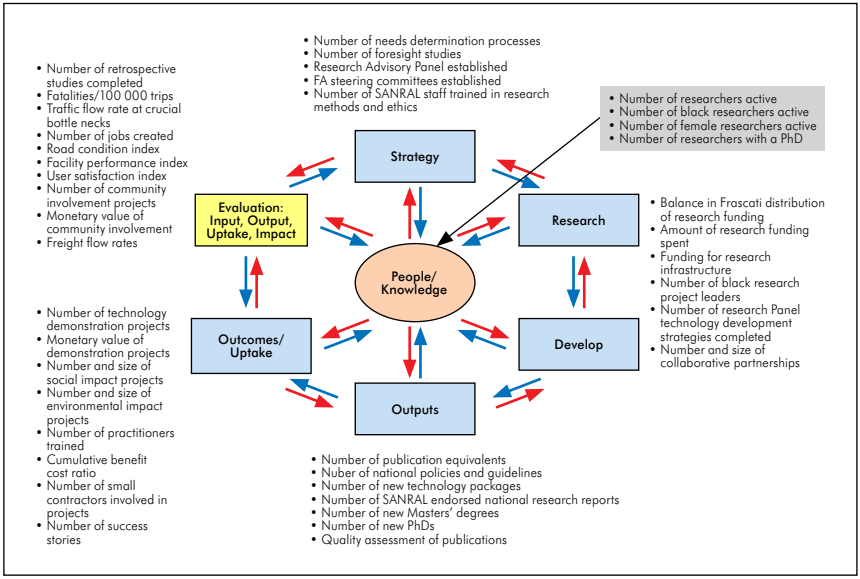
The indicator set evaluated in terms of the research model

To ensure that the set of indicators is balanced in relation to the research model, they were plotted on the model as depicted in Figure 3. The indicators cover all the elements of the research model and are well balanced in this respect.

The indicator set evaluated in terms of the SANRAL strategic objectives

The relevance of the indicator set to the SANRAL strategy, Horizon 2030 (SANRAL 2017:3), was evaluated using the matrix shown in Table 2. The top row of the matrix contains the strategic objectives in the SANRAL strategy. The first column contains the indicator set. A green block indicates that the indicator addresses the strategic objective well and an orange block indicates a partial contribution. All

Figure 3: The SANRAL indicator set plotted on the R&D and innovation management model

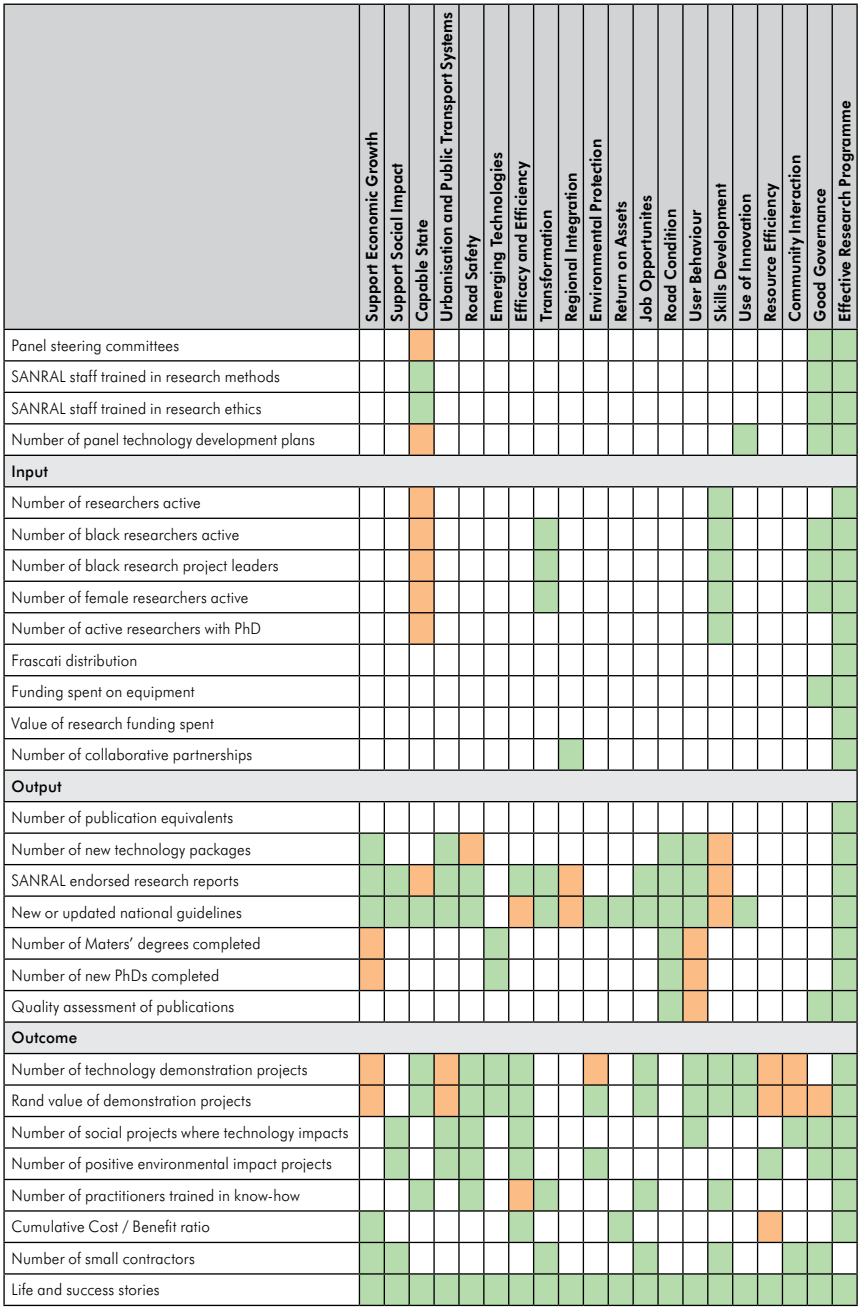


Source: (Authors' own construction)

the strategic objectives are covered by the indicator set which therefore is suitable to provide some input into SANRAL's strategic planning processes, particularly if trend analysis is conducted over time.

Table 2: Strategic objective evaluation matrix

Process	Support Economic Growth	Support Social Impact	Capable State	Urbanisation and Public Transport Systems	Road Safety	Emerging Technologies	Efficacy and Efficiency	Transformation	Regional Integration	Environmental Protection	Return on Assets	Job Opportunities	Road Condition	User Behaviour	Skills Development	Use of Innovation	Resource Efficiency	Community Interaction	Good Governance	Effective Research Programme
Needs determination processes																				
Foresight studies																				
Research Advisory Panel																				


Support Economic Growth
Support Social Impact
Capable State
Urbanisation and Public Transport Systems
Road Safety
Emerging Technologies
Efficacy and Efficiency
Transformation
Regional Integration
Environmental Protection
Return on Assets
Job Opportunites
Road Condition
User Behaviour
Skills Development
Use of Innovation
Resource Efficiency
Community Interaction
Good Governance
Effective Research Programme
Panel steering committees
SANRAL staff trained in research methods
SANRAL staff trained in research ethics
Number of panel technology development plans
Input
Number of researchers active
Number of black researchers active
Number of black research project leaders
Number of female researchers active
Number of active researchers with PhD
Frascati distribution
Funding spent on equipment
Value of research funding spent
Number of collaborative partnerships
Output
Number of publication equivalents
Number of new technology packages
SANRAL endorsed research reports
New or updated national guidelines
Number of Maters' degrees completed
Number of new PhDs completed
Quality assessment of publications
Outcome
Number of technology demonstration projects
Rand value of demonstration projects
Number of social projects where technology impacts
Number of positive environmental impact projects
Number of practitioners trained in know-how
Cumulative Cost / Benefit ratio
Number of small contractors
Life and success stories

Impact proxy	Support Economic Growth	Support Social Impact	Capable State	Urbanisation and Public Transport Systems	Road Safety	Emerging Technologies	Efficacy and Efficiency	Transformation	Regional Integration	Environmental Protection	Return on Assets	Job Opportunites	Road Condition	User Behaviour	Skills Development	Use of Innovation	Resource Efficiency	Community Interaction	Good Governance	Effective Research Programme
Number of retrospective studies																				
Fatalities per 100 000 trips																				
Traffic flow rate at bottlenecks																				
Number of job opportunities created																				
Road construction index																				
Facility performance index																				
User satisfaction index																				
Number of Community involvement projects																				
Rand value of community involvement																				
Freight flow rates																				

Source: (Authors' own construction)

Rating of the indicator set by researchers and stakeholders

The indicator set was evaluated through a survey among attendees of the seven workshops that SANRAL conducted to determine potential research needs. In addition to the indicator set above, SANRAL requested that the following potential indicators be added to the survey:

- Monetary value of indirect economic impact;
- Behavioural changes of drivers;
- Public perception of interventions;
- Effective communication measures;
- Network benefits of interventions;
- CO2 levels near roads;
- Energy footprint of operations; and
- Road safety index.

Some of these aspects cannot be measured (for example, behavioural changes of drivers) and some work will need to be done to develop indicators that can address these aspects. Nevertheless, the quantifiable proposed aspects were added to the survey.

The results of analysis of the ratings are shown in Table 3.

Table 3: Ratings Z indicators

	Avg	Std Dev
Process Indicators		
Number of needs determination processes	3.59	1.14
Number of foresight studies	3.49	1.02
Establishment of a Research Advisory Panel	4.16	0.98
Establish research focus area steering committees	4.20	0.93
Number of SANRAL staff and researchers trained in research methodology	3.40	1.06
Number of SANRAL staff and researchers trained in research ethics	3.29	1.15
Number of Research Panel technology development strategies developed	3.34	1.06
Input Indicators		
Number of researchers active in SANRAL research programme	3.81	1.04
Number of SA black researchers active in SANRAL research programme	3.72	1.11
Number of SA black research project leaders	3.63	1.12
Number of SA female researchers active in the SANRAL research programme	3.61	1.08
Number of active researchers with a PhD	3.63	1.03
Frascati distribution of research funding (basic, applied, experimental development, piloting and implementation)	3.55	1.02
The amount of funding employed for research infrastructure	3.90	1.07
The amount of research funding spent	3.88	1.05
The number and size of collaborative partnerships.	3.77	1.01
Output Indicators		
Number of publication equivalents (DoE formula)	3.70	0.99
Number of new technology/ knowledge packages	4.12	0.87
Number of SANRAL endorsed national research reports	3.83	0.99
Number of new or updated national guidelines	4.20	0.96
Number of new Master's degrees completed	3.62	1.00
Number of new PhDs completed	3.61	1.12
Quality assessment of publications (eg journal impact factors)	3.94	0.92
Outcomes (Uptake) Indicators		
Number of technology demonstration projects where new knowledge/ technology was implemented	4.25	0.93

	Avg	Std Dev
Rand value of demonstration projects	3.27	1.14
Number and size of social impact	3.91	1.02
Number of projects where positive environmental impact is made	3.84	0.92
Number of practitioners trained in use of new technology or knowledge package	3.87	0.96
Cumulative cost/benefit ratio	3.95	1.01
Number of small contractors involved in projects emanating from research programme	3.39	1.15
Public perception of interventions	3.61	1.13
Effective communication measures	3.91	1.05
Number of small contractors involved in projects emanating from research programme	3.37	1.18
Life stories and success stories of new technologies implemented	3.67	1.18
Impact Proxy Indicators		
Number of retrospective studies to determine current impact resulting from past R&D	3.52	1.01
Fatalities/ 100 000 trips on roads where new solutions have been implemented	3.90	1.15
Normalised accident rates	3.66	1.10
Rand value of indirect economic impact	3.93	1.00
Behavioural changes in drivers	3.97	1.13
Network benefits on interventions	3.90	1.01
Traffic through-flow rate at crucial bottlenecks	3.88	1.12
CO2 levels near roads	3.44	1.21
Energy footprint of operations	3.50	1.11
Road safety index	4.10	1.05
Number of job opportunities created	3.88	1.05
Road condition index	3.88	0.99
Facility performance index	3.66	0.94
User satisfaction index	3.74	1.03
Number and nature of community involvement projects	3.48	1.12
Cumulative Rand value of SANRAL's involvement in communities	3.41	1.13
Freight flow rates on road where new technology has been implemented (Netsafe statistics)	3.71	1.04

Source: (Authors' own construction)

The following can be noted from the results in Table 3:

- **Process indicators:**
  - High scores (>4) were achieved for the establishment of a Research Advisory panel and Focus Area Steering committees;
  - Low scores (<3.5) were achieved for research methodology training, ethics training and focus area strategies, the latter perhaps due to a lack of understanding.
- **Input Indicators:**
  - There were no particularly high (>4) or particularly low scores (<3.5).
- **Output Indicators:**
  - High scores (>4) were achieved for technology packages and national guidelines;
  - No particularly low scores were achieved (<3.5).
- **Outcomes Indicators:**
  - A high score (>4) was achieved for technology demonstration projects;
  - Low scores were achieved for monetary value of demonstration projects, and involvement of small contractors.
- **Impact proxy indicators:**
  - A high score was achieved for the road safety index (>4);
  - Low scores were achieved for CO2 levels near roads (<3.5); energy footprint of operations (= 3.5) and cumulative monetary value of SANRAL's involvement in community projects (<3.5).

CONCLUSION

The SANRAL R&D benefit indicators were validated by analysing the balance in the indicator set, comparing the indicators with SANRAL's strategic objectives and through ratings by 175 stakeholders and researchers. The indicator set addresses aspects of the full innovation value chain. The BSC and indicator set can be used to evaluate other roads and transport focused R&D programmes. Cognisance was taken of the complex systems-nature of R&D and the associated SANRAL R&D management model to develop and validate the indicator set. The indicator set can be adjusted to assess the benefit and impact of any roads and transport research programme that requires a broad assessment of benefits derived. SANRAL is in the process of developing a data- base and associated software to implement the BSC system.

NOTE

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