

Mauritius National Research Foresight Exercise

Synthesis Report

**Manchester Institute of Innovation
Research &**

Centre for Urban & Regional Ecology

University of Manchester

Version 0.5

Final version

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Note:

This Synthesis Report is the main output from the National Research Foresight Exercise. For further details, see the NRFE Summary Report, Technical Annex and Background Working Papers. These together with all data-files, are available on the MRC website at -

http://www.mrc.org.mu/in-house_projects/national_research_foresight_exercise

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PART I:

This Overview / executive summary provides a 5-page outline of the main features and findings of the NRFE. A more comprehensive 'Prospectus and Summary Report' is also available separately.

1 OVERVIEW

Mauritius is at a crucial stage in its development, on the trajectory towards a knowledge-based economy and society. Clearly Mauritius needs to enhance and extend its capacity for knowledge based enterprise, governance and society, through coordinated programmes of research and innovation, to build 'anticipatory intelligence for a knowledge based nation'.

This is the entry point for the Foresight approach. With a combination of futures thinking, capacity building, and creative strategy development, this is the most effective way to manage uncertainties, mobilize opportunities, and define common visions with strategic thinking.

The National Research Foresight Exercise (NRFE) aimed to map out a medium-longer term research & innovation (“R&I”)¹ strategy for Mauritius. Managed by the Mauritius Research Council, and delivered by the Manchester Institute for Innovation Research, it had three main tracks: futures outlook with projections and scenarios for 2020-2030: review and capacity building: and strategies for collaborative and policy or enterprise-related research

The overview of the NRFE process and result is shown in the slide here:

NRFE - Overview

- | | |
|--|---|
| <ul style="list-style-type: none"> • We asked - what lies in the future for Mauritius and its development agenda? • We looked up to 2030, with 3 alternative scenarios: then worked on a roadmap to manage risks & mobilize the best opportunities. • In this, research & innovation (R&I) is not only about papers & patents – but a knowledge approach for added value across society & economy . | <ul style="list-style-type: none"> • So what is to be done, nationally, and in each of 6 clusters? a) Combine R&I excellence with national policy / business relevance b) Resources for R&I - must be adequate c) Culture of R&I - must be spread & cultivated d) Strategy for R&I – enabled by a continuing foresight & national intelligence capacity. |
|--|---|

¹ **NOTE: this report uses the abbreviation ‘R&I’ for ‘research and innovation’: this is the current shorthand for a range of activities including ‘R&D’ (research and development), RTD (research and technology development), or ‘S.T.I.’ (science, technology, innovation).**

1.1 Futures outlook

One of the main contributions of the foresight approach is a futures outlook. This is not to say that the future can be predicted – but rather, it can be anticipated and shaped.

Firstly, baseline data on recent trends was gathered, and current growth rates were projected forwards, as a guide to upcoming challenges. From the possible variations in these, three main scenarios were generated. Scenarios are an essential tool for longer range strategy and policy, in the public, private and civil sectors: these are the 3 which emerged:

- **‘Growth at all costs’**: or ‘Plan G’ trend scenario. This reflected what many participants saw as the current default or “business as usual” direction of national development. While economic growth rates were high, there was a perceived likelihood of increasing social divisions, environmental damage, and economic dependency or vulnerability.
- **‘Win-win’** or **‘Plan A’**: this summarized a general re-orientation towards long term goals of sustainable development, in which environment, society and economic growth all fitted together in a positive way.
- **‘Island’** or **‘Plan B’**: this was a fall-back position: in the event that the global economy did not grow as expected, meanwhile Mauritius should aim at resilience and self-reliance, to sustain social well being, human resources and environmental resources.

1.2 Priorities

The working groups and online consultations showed the top priority for R&I to be in areas where there is international level science and R&I capacity, combined with direct policy demand, which is unique to the situation of Mauritius. This is the primary goal of a R&I program which focuses on unique capabilities and research agendas, to build national centres of excellence where possible. International research centre status: combines global science network with national support & procurement policies. Themes of particular priority include marine / ocean resources: small island development issues:

tropical ecosystems-based material science, nano-technology and biological sciences.

Such priorities appear in each of the main themes of the 6 cluster working groups:

- **Marine / land-ocean industries:** R&I should follow an industrial ecology integrated systems approach: coupled with a human ecology approach for working with enterprises, employees, residents and visitors.
- **Agriculture / sugar / food / health:** holistic systems approach to the links between agriculture, landuse, food systems and public health: capacity building for the strategic conversion for social-ecological benefits.
- **Infrastructure resources,** (energy / water / transport / waste): again, R&I with an industrial ecology 'integrated systems' approach: the sustainable development agenda is the main imperative, and the USP of Mauritian R&I will be in applying theory to practice in a unique 'living laboratory'.
- **Social and cultural issues** (demographic change, cohesion, empowerment, citizenship): social science R&I which aims at multi-lateral, participative, co-production modes of knowledge gathering and mutual learning.
- **Enterprise resources:** (skills, firms, finance, entrepreneurs): innovation focused R&I programmes which look beyond conventional themes towards whole supply chains, investment models, entrepreneur models and innovation systems.
- **Global links and resources:** finance, ICT, tourism, trade, security, climate change: outward facing R&I programmes, which address the inter-connections and synergies between a wide range of challenges and opportunities. This should work with the internationalization of R&I communities and networks: and a 'smart specialization' approach to the unique situation of Mauritius.

Each of these calls for new models of R&I, which are more suitable for the Grand Challenges in each area: complex, inter-connected, controversial problems. Such new models aim to be more participative and better linked with society and business: mobilizing new data sources and analytic methods: at the same time more responsive to complex policy-sensitive issues where present and future are all connected.

1.3 Outline roadmap

This roadmap is not fixed, but more of a rolling programme for ongoing review. It is set out with parallel tracks in the form of ‘3 horizons’:

- Horizon 1 focuses on direct actions in the near term of 1-3 years. General policies should look at getting immediate resources into top priority areas, relieving blockages, and continuing the study and knowledge development programme for Horizons 2 and 3.
- Horizon 2 focuses on strategic actions in the medium term of about 5-10 years. General policies can look ahead to strategic aims, for the building of a R&I and higher education community: spread of knowledge-based activities: strategic goals and programmes for each of the thematic clusters. Also this will look at enabling resources for R&I, such as large datasets, upskilling the education sector, and supporting knowledge-based enterprise communities.
- Horizon 3 is an outlook on more structural transitions in the longer term of over 10 years: although the foundations can be laid and seeds planted in the near term. General policies are aimed more at the transformation of public policy and public services: new kinds of integration of enterprises and communities: and transformational models for R&I with enabling structures. These will continue to explore opportunities in multi-disciplinary R&I: multi-sectoral applications: and multi-level knowledge developments.

1.4 Next steps

This report, following the final round of consultation, is now submitted to the Mauritius Research Council.

The overall recommendations are to work towards a National Research and Innovation Strategy, with 6 main next steps:

1. Identify priority actions to be carried out by the government, by MRC or by others, in the roadmap format: near term, medium and longer term.
2. Identify strategic goals for each of the thematic clusters in the roadmap format: near term, medium and longer term.
3. Establish a rolling work program & knowledge platform to mobilize and coordinate activity in each cluster theme.
4. Identify opportunities for new funding mechanisms as **input** for R&I: these may be national level or at the cluster / sector level.
5. Identify opportunities for uptake of **output** of R&I: not only dissemination of knowledge, but a culture of active learning, skills and innovation at all levels of all organizations.
6. Establish a continuing 'foresight and strategic intelligence unit', for ongoing development of the '3 horizon roadmap' for each of the cluster themes, and for the over-arching goals of the knowledge society.

PART II:

Outlook

In Part II – ‘outlook’, we first set the scene and the role of the foresight approach. There follows a review of the policy landscape, set against the future outlook using a scenario approach. An outline of the cluster themes provides more detail and depth.

2 INTRODUCTION

2.1 Anticipatory intelligence for a knowledge based nation

Mauritius is at a crucial stage in its development, well on the trajectory towards a knowledge-based economy and society.

The Ministry of Tertiary Education, Science, Research and Technology has set out a far-reaching vision – to “Transform Mauritius into a Regional Centre of Excellence in Higher Education” – and a practical mission: “to expand the Tertiary Education sector to further increase access, and through the development of a research culture and improve linkages between Universities and the world of work”.

Such visions can be challenging to turn into practice. This is all the more in the context of rapid change and development, which is seen by many stakeholders to be increasing pressures on physical support systems, social structures and divisions, and economic or financial vulnerability.

Such visions would ideally be based on clear evidence on future trends and opportunities, detailed knowledge of what policies work, and which stakeholders can do what. But in practice, we are surrounded by future uncertainty, controversy, inter-connections, moving pictures and fuzzy policy agendas.

This is the entry point for the Foresight approach. With a combination of futures thinking, capacity building, and creative strategy development, it is about the most practical of any approach to respond to such uncertainty, controversy etc.

This National Research Foresight Exercise (NRFE) has been initiated by the Mauritius Research Council, and carried out by the Manchester Institute of Innovation Research. In a participative dialogue with the NRFE Steering Group, the study has explored a range of questions – what are the emerging problems and opportunities for research and innovation? which research themes, and what kind of research models? how to promote these, and who should do what?

In reality such questions go a long way beyond a managerial approach to innovation indicators and policy analysis. These questions can be explored with a creative approach to bigger and more inter-connected problems and opportunities: and then responses (if not ‘answers’ as such), come through a creative design process, a mapping and development of synergistic collaborations and inter-connections.

One output is an outline ‘roadmap’, with practical combinations of research and innovation themes, policies and programmes, stakeholder resources and capacities. Meanwhile a higher level outcome aims to set up creative and unique and topical agendas, challenges, and research paradigms. Together these can rise to the challenge of ‘anticipatory intelligence for a knowledge based nation’.

2.2 Context: national development of Mauritius

The national policy framework has been set out in the ‘Government Programme 2010 – 2015’, particularly in clause 189:

“Government will organise a National Research Foresight Exercise with the participation of all scientists engaged in scientific research. The ultimate objective will be the preparation of a time-bound Action Plan on Research and Development with clearly defined deliverables.”

The main previous reference point for national innovation policy is the STIP (Science Technology & Innovation Plan) of 2009.

“The MRC was mandated by the Ministry of Industry, Science and Research to formulate a policy framework for the application of science, technology and innovation with a view to enhancing socio - economic development and improving quality of life in Mauritius.

In this fast moving national situation, together with severe financial constraints, many of the STIP recommendations have been superseded, and the Ministry, the MRC and many others have been developing forward looking responses to these agendas.

It is hoped that this NRFE can make a significant contribution by taking a longer view, with a mandate for creative innovation, and feeding back international experience of changing research paradigms, and methods of foresight to explore them.

2.2.1 Benefits and applications

Many of the benefits of foresight will be particularly focused on the wider national development objectives of Mauritius:

- Progress towards a knowledge society
- Focusing R&I capacity on policy needs
- Mobilization & coordination of research community
- Integration of sectors and academic disciplines.

As with most foresight processes, there is a focus on the ‘process’ as much as on the ‘product’: there is clearly a tangible value in bringing together stakeholders, to look creatively at the future and their role in shaping it. Too much focus on the product can divert attention from the process. However there will be also practical outputs (‘deliverables’) from the NRFE.

The practical outputs are summarized in this NRFE Report, which aims to provide the basis for the research strategies of MRC and other collaborating organizations. It would also aim to provide orientation and context for other related research activities: these might include new industrial ecology clusters, business models, social enterprises and policy inter-mediation.

2.3 Context: the scope and role of foresight

Foresight is a process which explores future trends and uncertainties: connects these to human resources and capacity in the present: and applies both to strategic planning. Foresight goes beyond normal research or policy planning, for agendas with high levels of uncertainty and controversy, and where there is potential to improve capacity of the stakeholders involved in a complex issue. There are many variations of Foresight around the world (see Georghiou et al, 2009):

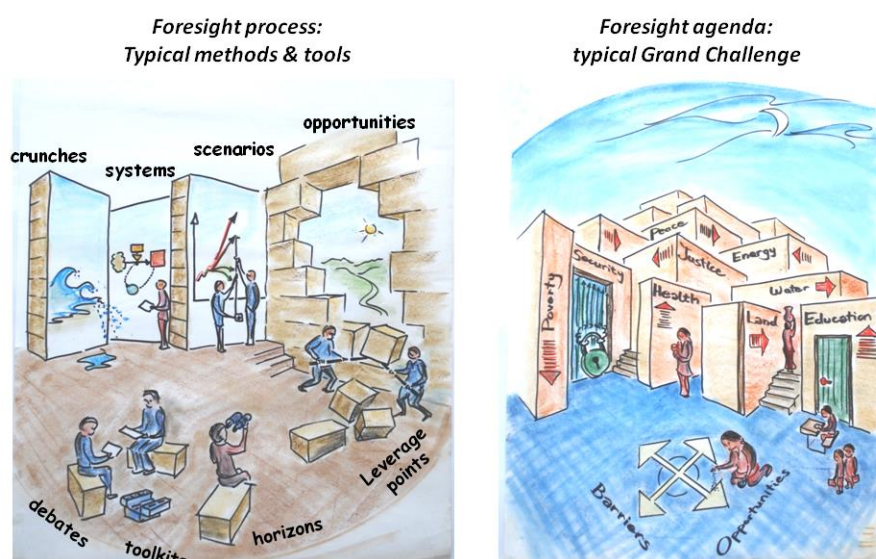
- Research focused foresight: has particular applications where issues are highly inter-connected, with high levels of uncertainty and controversy, with large gaps between academic disciplines and policy needs, where short term decisions are needed but bring long term consequences. It can be useful for specific sectors or themes, or an entire research community.
- Innovation focused foresight: this is the most typical application, looking at more applied features of the science / technology / innovation (STI) system. This includes the ecosystem of innovation stakeholders, innovation policies, and other factors such as IP regimes, human resources, physical infrastructures etc. Again it can operate on a national or trans-national scale, in specific sectors or technologies, or broadly in themes or clusters.
- Policy focused foresight applies the above principles to national or regional level sectors, organizations, policy themes etc. The focus may be sectoral or territorial.
- Corporate focused foresight applies the above principles to all kinds of firms, clusters, industrial sectors, finance or producer services.

The NRFE has followed a combination of the first two, for a comprehensive view of the R&I agenda.

2.3.1 Figure 1: Foresight process & content

Foresight: process & content

(Graphics by Joe Ravetz, reproduced courtesy of Rockefeller Foundation and Institute of Alternative Futures)



2.3.2 The foresight process

A typical Foresight process includes 3 main strands (Miles & Keenan, 2003): figure xxx

- Futures strand (*'when'*): systematic exploration of trends, projections, scenarios, wild cards, and policy responses:
- Capacity building strand (*'who'*): a systematic development of shared learning, networking, collaboration and intelligence between all stakeholders involved:
- Strategic planning strand (*'how'*): a systematic application to longer term policy, in the context of uncertainty, complexity and controversy of the issue.

One current application is the 'synergistic foresight' approach, which brings in some further levels: these are based on experience of questions which typically come up in discussion (Ravetz, 2011):

- *'Which'*?: specific areas in sectors or technologies as the focus of enquiry;
- *'What'*?: factors in the regimes or institutions of STI, that are also relevant.
- *'Why'*?: the values, worldviews and discourses between different stakeholders;

The Systemic Foresight Method is similar in many ways: this looks at the key stages in the cognitive learning process, in the form of a 5 stage process model (Saritas, 2010). A typical range of Foresight methods are shown in the table below, in the general arrangement of the 'Systemic / Synergy' approach.

It should be noted that selection of appropriate methods is not like that of a simple menu. Rather it depends on the internal logic of the process, and the social learning capacity of the stakeholders involved. So each WP uses a selection of methods, which are arranged around a process of building evidence and shared intelligence.

2.3.3 Table1: Foresight stages, methods & tools

SYNERGISTIC FORESIGHT	Relational thinking	Divergent thinking	Emergent thinking	Convergent thinking	Applications	
SYSTEMIC FORESIGHT	INTELLIGENCE	IMAGINATION	INTEGRATION	INTER PRETATION	INTER VENTION	
	<i>scope phase</i>	<i>creative phase</i>	<i>ordering phase</i>	<i>application phase</i>	<i>dissemination</i>	
Worldviews / goals (why)	Res alliance delphi	Vision mtg				
Futures strand (when)	Global trend / risk analysis	National STI scenarios	Success scenario			
Capacity strand (who)	Res. alliance delphi	Stakeholder networking	final consultation			
Strategy strand (how)	Policy analysis	Policy scenarios	Policy structuring	STI roadmap		
Theme strand (which)	STI mapping	Key theme 1	Theme scenario analysis	Theme roadmap	Theme programme	
		Key theme 2	Theme scenario analysis	Theme roadmap	Theme programme	

The main objective of the contribution from Manchester is to facilitate the Foresight capacity of stakeholders in the Mauritius community, (rather than to construct a Foresight exercise on their behalf). In the event, resource constraints at MRC led to more of the desk work being carried out in Manchester.

Also, the Foresight approach is seen as most effective where it is embedded and continuous in the R&I (research and innovation) or STI (science, technology, innovation) community. So, major effort would be focused on the building of capacity at various levels – personal, organizational, institutional and governmental. This involves both specific techniques, and also general knowledge, comparisons, and the kind of confidence and ‘know-how’ which comes with experience.

2.3.4 What is ‘research’ / R&I / R&D / S.T.I.?

One of the first issues is to scope ‘what is the nature of research’ to be covered in this foresight exercise. There are different combinations of ‘research and innovation’ (R&I): research and development (R&D): science / technology / innovation (STI). We use the first term “R&I” throughout this report, in the context of formal and practical definitions (but recognizing in practice there are overlaps with these and other definition). To summarize the standard definitions (OECD, 2006):

- “Research and experimental development (R&D) comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications.
- **Basic research** is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view.
- **Applied research** is also original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective.
- **Experimental development** is systematic work, drawing on existing knowledge gained from research and/or practical experience, which is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed.

Furthermore there is a question of R&I scope and boundaries:

- Conventional focus – innovation in physical science & engineering, high technology: innovation with direct applications to enterprise & economic development.
- Broader scope – innovation in service models, social enterprise, cultural innovation, policy and governance innovation: wider applications to society, governance, ecological and cultural activities.

This corresponds to current thinking in the shift from ‘Mode 1’ towards ‘Mode 2’ science (Gibbons, 1994):

“Mode 1 is discipline-based and carries a distinction between what is fundamental and what is applied; this implies an operational distinction between a theoretical core and other areas of knowledge such as the engineering sciences, where the theoretical insights are translated into applications. By contrast, Mode 2 knowledge production is trans-disciplinary. It is characterised by a constant flow back and forth between the fundamental and the applied, between the theoretical and the practical. Typically, discovery occurs in contexts where knowledge is developed or put to use, while results - which would have been traditionally characterised as applied - fuel further theoretical advances.”

The application of such concepts are demonstrated in Part III of this report.

3 CONTEXT

3.1 Policy context

Generally there is a huge amount of activity and forward thinking relative to the size of Mauritius, not least from the Ministry and the MRC. However from the NRFE workshop discussions, there is also some perceived risk of duplication, too many initiatives, which can easily overload a small community of participants. The implication is that the NRFE needs to be carefully targeted to be of best value: not repeating what is already known: and providing new insights on current challenges.

One example of a long running initiative is the 'Ocean Economy' (Government Programme 2012-2015, pp8-9). The overall case for this is clear: there is much expertise and R&I capacity: a unique innovation case for integrated systems: and major opportunities for the private sector. At the same time there are also barriers – investment risk, fragmentation of interests, complex I.P. structures, political uncertainties, deployment gaps (i.e. the so-called 'valley of death' between prototype and near-to-market). The foresight approach – beyond the NRFE, the proposed continuing program – has the potential to contribute: by looking ahead at projections and scenarios: looking across at inter-connections between sectors and themes: and looking around at the engagement of different parts of society.

3.1.1 Ministry of Tertiary Education, Science, Research and Technology

The vision of the Ministry is to “transform Mauritius into a Regional Centre of Excellence in Higher Education”. The mission is to “expand the Tertiary Education sector to further increase access and through the development of a research culture and the setting up of Science Parks improve linkages between Universities and the world of work”. The goals include:

- Extend the 24/7 concept to tertiary education
- Attract renowned Tertiary Educational Institutions
- Reach an objective of one graduate per family
- Set up a one-stop-shop for tertiary education
- Review the Tertiary Education Loans Scheme
- Review existing legal framework for intellectual property rights
- Prepare an Action Plan on Research and Development
- Give a new drive to science popularization and sensitization
- Develop programmes in new emerging areas, e.g Nanotechnology, Renewable Energy, Marine and Life Sciences

- Promote a new culture of open and distance learning through the setting up of the Open University of Mauritius

3.1.2 Key policy initiatives

Current initiative which are directly relevant:

- Maurice Ile Durable (sustainable development) working groups: related to the national MID strategy & participative process (in progress). Topics include – energy: Biodiversity & Natural Resources: Pollution, Waste: employment : education: equity
- National Research Groups, which are coordinated by the Mauritius Research Council (MRC), operate through a wide consultative process, including the Mauritian Diaspora. Topics include energy, human resources, food quality, water resources, transportation. Each has launched its programme in 2012.

Past policy initiatives include:

- The “Competitiveness Foresight: What orientations for Mauritius?” study was commissioned by the National Productivity & Competitiveness Council in the 2004-2005 period. Previously there were 9 thematic working groups set up by the Mauritius Research Council (MRC) in 2001, to elaborate on each of the following themes: land and land use, water resources, energy and energy efficiency, marine resources, biomedical research, biotechnology, manufacturing technology, science and technology education, information and communications technology.
- “Vision 2020” was a large consultation programme in 1997, with some similarities to a foresight process. It was part of a regional exercise carried out by the African Futures and was referred to as the National Long Term Perspective Studies” (NLTPS).

3.1.3 STIP recommendations 2009

The Science Technology Innovation Programme (STIP) 2009 was the result of consultation with a wide range from the public, private and academic sectors. A major recommendation is the setting up of a National Innovation Fund (not implemented as yet). 10 other key policies were recommended, some of which are finding their way through the system.

- Policy 1: Increasing Investment in R&D: proposed to increase to 1% of GDP. (this is not yet implemented.)
- Policy 2: Promoting Science and Technology Education
- Policy 3: Upgrading Human Competencies in the STI Sector
- Policy 4: Enhancing the Public Research and Development System
- Policy 5: Empowerment of Women in the STI Sector
- Policy 6: Recognition of the Scientist
- Policy 7: Public Understanding of Science in the Society
- Policy 8: Strengthening the IPR Framework
- Policy 9: Enhancing Competitiveness of SMEs by supporting compliance to standards
- Policy 10: Promoting Innovation in Enterprises
- Policy 11: Setting up of the National Innovation Fund

3.1.4 The Mauritius Research Council:

The (MRC) coordinates research in the scientific, technological, social and economic areas for societal benefit and to act as an agent of Government, advising on science and technology issues.

Priority Areas of Research include:

- Biomedical and Pharmaceutical Research Based on Indigenous Resources
- Information and Communication Technologies
- Land and Land Use
- Manufacturing Technology
- Ocean Technology and Marine Resources
- Social and Economic
- Water Resources
- Waste Management
- Science and Technology Education
- Energy Efficiency and Renewable Energy

The MRC also conducts social research through its Centre for Applied Social Research (CASR).

Besides funding and managing research projects as listed under the previously-mentioned section, the MRC also undertakes projects of national importance in-house, as per its internal expertise.

These projects are carried out in collaboration with stakeholders made up of ministries, the private sector, tertiary education institutions, NGOs and international organisations. Ongoing initiatives/projects include, in addition to the NRFE:

Sectoral programmes include:

- Development of a Seaweed Farming and Processing Industry
- E-Waste Research Programme
- Geothermal Energy Prospection in Mauritius
- Wind modelling
- Investigating Natural Fibres and their industrial applications

Strategic programmes include:

- Research Innovation and Industry Linkage
- National Research Groups in Priority Areas
- Collaborative Mauritius

3.2 International context:

3.2.1 Foresight for small nations & islands

Typical features of small nations & islands include:

- Lack of critical mass in research & STI capacity

- Small markets for public procurement and product innovation
- Vulnerable to changes in external markets & political conditions
- Culture of conservatism and in-grown networks
- Internal pressures on resources & finances.

These issues are explored in a rationale of response to ‘market or system failure’ in the small nation context: (Georghiou & Cassingena-Harper, 2009)

“Governments typically intervene in the national innovation (eco)system when there are market or system failures in the innovation process. Market failures generally arise through firms being unable to capture all of the benefits of their investments in innovation or to deal with uncertainty. There is a significant point here for small economies. Most of the knowledge used will originate outside the country but to exploit these knowledge spillovers a domestic investment in R&D and a highly connected research and innovation system is essential.”

“System failures seek to remedy inadequacies in the physical or knowledge infrastructures and the ability of innovation actors to coordinate effectively. A further source of systems failure occurs because firms may be unaware of new technologies outside their normal sphere of activity and risk being displaced by disruptive innovations. This poses a particular threat to small countries, both because their firms may be less well placed to monitor developments and because loss of a firm may not be balanced by the emergence of new players. Another system failure in a small country could be that innovation support mechanisms such as technological, business or export advice may not be economic for the private sector to provide in a small and intermittent market for specialised consultancy. Importing such advice may be impractical because of lack of knowledge of local conditions and hence the government may need to remedy the deficiency.”

Most of these issues apply to Mauritius, as raised in the NRFE consultations:

- Knowledge spill-over effects need to be supported by government, in order to mobilize a wider community of stakeholders: education and R&I: domestic supply chains and demand side: other parts of civil society.
- Need for ‘internationalization’ of supply chains and SME communities, particularly in knowledge-based industries (some sectors in Mauritius are more advanced than others, for instance financial services / ICT systems appears to be well-placed).
- Need for ‘specialization’ which generates USP and value-added, rather than simple competition on the global open market.
- Need for targeted government support, which may be different to that of a larger country, to overcome the system failure of critical knowledge resources.

3.2.2 R&I in small nations: the ERAPRISM study

The ERA –PRISM is the largest single project to date focusing on the R&I agenda for small nations and islands, in the European Union. Materials and the final synthesis report are on www.eraprism.eu/documents/del_2_6_Final_Publication.pdf

The project focused efforts on a number of specific policy concerns:

- In-depth focus on improving and refining R&I indicators
- In-depth focus on public procurement for innovation
- In-depth focus on research funding frameworks for small countries.
- A broader coverage of a range of R&I policy issues which provide the context for the ERA-PRISM work. These include: peer review and evaluation, mobility, international cooperation and other European issues which may emerge over the lifetime of the project.

Conclusions: the ERA-PRISM Project has highlighted not only the diversity of European countries as a whole but also the diversity among the small country group in terms of their national R&I ecosystem, its maturity, size and related capacity and performance. Among the key project findings is the fact that, despite the diversity in R&I policies, funding systems and performance, small countries share a dependence on international collaboration evident in co-publications and joint projects. They share a good record of participation in the EU Framework Programme, although parts of the programme are still inaccessible due to a range of reasons including lack of critical mass.

There are also significant areas of common concern and interest shared by small countries and areas of opportunity for sharing know how on R&I policy approaches as well as actual areas of cooperation. National context influences and shapes a country's performance in R&D investment and innovation outputs and this restricts the level of applicability and transferability of policy approaches from one country to the other. Indeed small countries face certain constraints in implementing EU policies which are designed from a large country perspective. From a national perspective the project has been useful in providing a sounder basis for policy. This has been done by understanding better each other's systems, through more detailed analysis of different indicators, comparing with countries of similar size and scale.

The analysis on the use of public procurement to leverage research and innovation activity, which has been carried out in the small partner countries highlights the fact that there are good examples of its effective use and identifies ways of promoting an ongoing exchange of experiences. A Manual for small country use of public procurement for research and innovation has been produced targeting specific small country concerns and niche opportunities.

(<http://www.eraprism.eu/documents/4.2%20del%20Best%20Practice%20Case%20Studies.pdf>)

This focus on public procurement has great relevance to Mauritius. As in any other country, procurement for public goods and services is subject to many pressures – cost, quality standards, employment and risk avoidance. However the priority for innovation and the R&I process should be high up on that list. The implication is that all strategic plans and major contracts on the 'demand side' would be coordinated with the framework for R&I on the 'supply side', to ensure that public procurement is delivering the best long term value to the nation.

3.2.3 Experience from developing country studies

UNESCO runs a programme of Science Policy and Capacity-Building country studies on R&I related indicators and policies. While Mauritius is not covered directly, there are near equivalents in the Seychelles, Tanzania and other east / southern African countries. A common template is used, and

this has been adapted for use in later sections of this NRFE. This template of issues is similar to those of country reviews, e.g. the Cyprus: Peer Review Outcome Report (Cunningham et al, 2009).

- Contextualization of the science system within broader political, economic, educational and social systems
- History of science in the (country, region) under review
- The governance of science and policies (especially S&T, R&D and higher education)
- Informal S&T structures
- Knowledge and R&D performers
- S&T Human Resources (Profession of researchers etc)
- Research Funding (Public or private; National and international; Trends)
- Scientific co-operation and agreements
- Tensions, dynamics and challenges

3.3 Examples & best practices

While Mauritius is clearly unique, it is useful to look around for parallel examples from small island nations, from Indian Ocean, African and Asian emerging and developing nations. Firstly some examples of foresight for strategy and capacity building:

- Singapore has a history of strategic National Science and Technology Plans, including a foresight activities in futures and capacity building, which contributes to their position as one of the most innovative of any small island nation. The plan is now taken forward by the Agency for Science, Technology and Research (A*STAR): through this the government is committed to a 5-year R&I investment programme of 1% of GDP, with leverage for GERD of 3.5% of GDP. (www.a-star.edu.sg/portals/0/media/otherpubs/step2015_1jun.pdf)
- The largest study anywhere on R&I for small nations and island states was the recent ERAPRISM project, which looked at Iceland, Slovenia, Luxembourg, Latvia, Cyprus and Malta: (www.eraprism.eu). There was a particular focus on public procurement: and on specialization and internationalization in R&I policy.
- Malta's national strategy is a good demonstration of R&I policy in small nations and island states: (www.mcst.gov.mt/page.aspx?id=48). Luxembourg carried out a first national foresight exercise, for a micro-state with concentrations of advanced financial services and medical technology (<http://fnrforesight.lu/>).
- The Trinidad & Tobago Foresight and Innovation Network is another small island initiative: this provides a portal to enable inter-connections, and thereby economic competitiveness and social prosperity, through active use of foresight and innovation. (www.ttfi.net/index.php)
- For a developing country overview, see the paper 'Foresighting and Technology Choice': this refers to a tourism sector 'F4D' (Foresighting for Development) initiative in the Seychelles: (<http://foresight.jrc.ec.europa.eu/fta/papers/Session%204%20What%27s%20the%20Use/Fo>

[resighting%20and%20Technology%20Choice.pdf](#)); and also a tourism sector 'Vision 21': (http://www.sey-tess.com/other_items/Extract%20from%20VISION%2021.pdf)

- For a continental overview, see the Foresight Africa 2013 report (www.brookings.edu/research/reports/2013/01/foresight-africa-2013)
- parallel initiatives in other African nations include Uganda: <http://sverigesradio.se/diverse/appdata/isidor/files/406/12817.pdf> : Botswana: <http://www.researchictafrica.net/countries/botswana/BNRST%20Final%20Report%20December%202005.pdf> : South African Benchmark 2020: <http://www.foresight-platform.eu/wp-content/uploads/2011/04/EFMN-Brief-No.-63-South-African-Benchmark-2020.pdf>

There are also many examples of new forms of policy-research linkages in foresight and integrated sustainable development:

- The APEC Center for Technology Foresight, based in Bangkok, aims to develop and diffuse foresight capability and leading edge planning tools to prepare APEC economies for rapid change and major societal challenges (www.apecforesight.org)
- Malmo, Sweden: the Institute for Sustainable Urban Development is a good example of active policy-research linkage and facilitation in a small nation: (<http://www.isumalmo.se/isu/>)
- British Columbia, Canada: the Georgia Basin futures project was an integrated cross-sectoral sustainable development program, linking R&I, policy, business and civil society (http://journals.sfu.ca/int_assess/index.php/iaj/article/view/252/227)
- European Union: one example of many is the Smart Cities Platform, which promotes active inter-connections between users, producers and researchers on advanced digital solutions for urban infrastructure (<http://eu-smartcities.eu/>).

3.3.1

4 FUTURES OUTLOOK

This section is at the core of the foresight approach: looking ahead to an uncertain future, firstly by projecting forwards based on current trends: then by exploring the range of possibilities, testing common assumptions and thinking through alternative scenarios.

4.1 Current trends and projections

Clearly Mauritius has changed rapidly since its independence in 1962. It is now one of the most advanced of any nation in the global South, with a successful mixed economy, diverse and tolerant society, and open democratic governance. To map this out, a range of current statistics was charted (figure xxx): with 10-20 year historic trends, then projected at the same rate of growth towards 2025. There is a large note of caution here: faster growth trends are unlikely to continue for long without meeting some kind of limit, physical or human. However, pending further detail, such projections are a guide to what kind of issues can be expected:

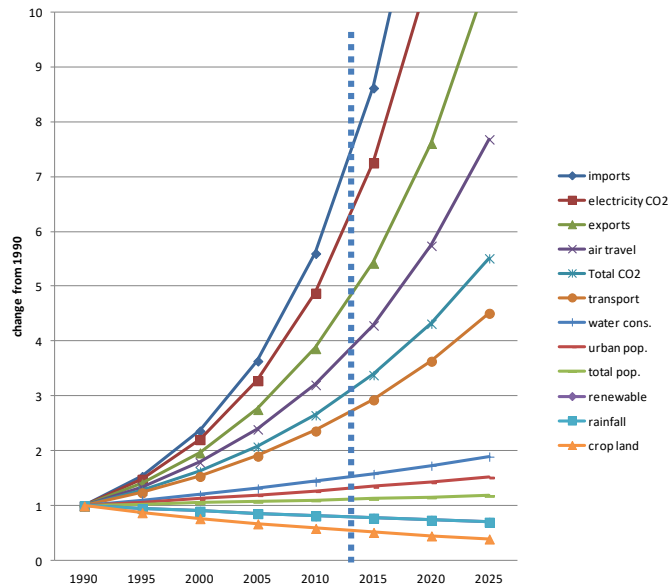
- Very high growth: imports, exports, CO2 from electricity generation, visitor numbers and air travel
- High growth: total CO2 and surface transport
- Moderate growth: water consumption, and urban / total population
- Moderate decline: average rainfall, local renewable energy, and land in export crops (sugar / tobacco / tea).

Further detail is in the 'Futures analysis' chapter. Here we flag up some of the most critical points where opposing trends seem to point towards major challenges in the near future:

4.1.1 Figure 2: comparison of trends and projections

Trend projections

various time-series & growth rates for Mauritius projected to 2025: Source MRC working papers



4.1.2 Urbanization and landuse.

The overall national population density in 2030 will be approx 7 persons per hectare. If spatial development (including both urban and rural areas) continues to average EU standards of density and form, urban areas would occupy 35000 hectares or 17% of the total. If the general affluence increases so that the resources and the aspiration were there to develop at typical North American standards, the urbanized areas would be over 1/3 of the total land area. Tourism is another fast growing landuse: data is not easily available, but a rough estimate would be for 10% of total land area in tourism related uses (IRS areas, commercial centres, beach areas, golf courses, leisure and scenic routes etc). Recent growth rates in tourism are very high, although whether these continue is arguable. The overall combination of extensive development for residential and commercial tourism purposes could occupy up to half the total island area, leaving a dwindling stock of land for food, energy, water landscape and nature conservation purposes.

4.1.3 Climate emissions, impacts, energy and water:

Total climate emissions have grown recently by 5% per year: due mainly to imported coal for power generation, and imported fuel oil for transport and buildings. Local energy production (mainly bagasse) has meanwhile reduced at the rate of 1.5% per year, which seems almost perverse. The future of international level climate / energy policy is the subject of huge debate: but it seems likely that caps or other kinds of constraints could be put on carbon intensive activities such as coal

burning. The implication is that Mauritius has a challenge – to develop a modern industrial and knowledge-based economy, which bypasses the fossil fuel stage, and moves directly to power from renewable energy sources on a limited land area. The national energy strategy aims to “achieve by 2025 about 35% self sufficiency in terms of electricity supply through use of renewable sources of energy”: but there are few visible totals, and meanwhile new coal-fired power stations are being opened.

This coincides with a parallel water resource challenge, with rising demand and reducing supply, which again have to be found on a limited land area, with many other pressures and demands. The implication is that the MID agenda of sustainable development, is not an optional extra but a necessity.

4.1.4 Inequality in Mauritian society:

In many meetings there was discussion on the trends of social segmentation, possibly accelerated by current economic trends and policies. Large parts of the coastal strip are taken by IRS developments, inaccessible to local people, and offering mainly low-skill manual work with few advancements.

Many desirable plots in high-ground areas meanwhile are sold for elite housing developments to rich expatriates. Town centres are rapidly rearranged to suit affluent tourists and the new middle classes, with a visible ‘mushrooming’ of shopping malls. Seeing this prospect many less advantaged young people naturally tend to feel alienated, dropping out of formal education, and turning to drugs or other self-destructive or anti-social behaviour.

4.1.5 Global-local tensions:

The particular role of Mauritius as a remote island was also very topical, dependent on overseas trade, communications, finance and visitors. The theme of the divided society above, seems to magnify a certain tension between global and local. Businesses are set up in Export Processing Zones as branch plants with cheap labour: land values are pushed up by the global leisure and tourism market. At the same time the globalized financial sector is a major generator of wealth and connections. The scenarios below brought these tensions to the surface, not to solve the problem, but to explore the possibilities.

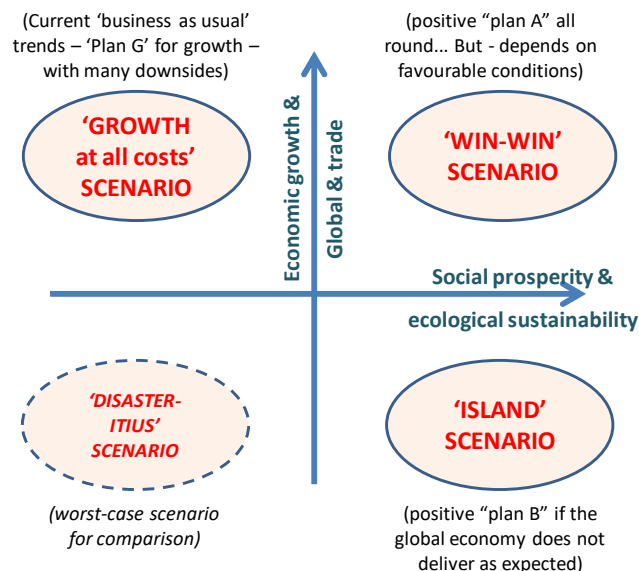
4.2 Scenario development process

Scenarios are an essential tool for longer range strategy and policy development. They are used by many organizations in the public, private and civil sectors. **Scenarios are not forecasts**, rather they explore the range of possibilities, in the form of structured ‘what-if’ questions, which test assumptions and ranges of uncertainty.

The scenario outlines here were developed rapidly through two workshops with the Steering Group and the Cluster working groups. The results are in the form of outlines, which could be taken to further detail, including for verification with technical and policy sources. The scenario structure has also been designed to be compatible with the IPCC global ‘SRES’ climate change scenarios: this enables detailed climate change projections to be attached to each one. The time horizon for these is set at 2025-2030: this is quite approximate, but realistic, as for most questions it is almost impossible to forecast whether the rate of change in 18 years will be positive or negative, faster or slower. (The detail of the scenario framework, and the longer list of possible scenarios is shown in the Technical Annex.)

4.2.1 Figure 3: scenario framework

Scenario framework



The selected scenarios turned out to be a very useful way to bring to the surface some very topical choices and contradictions in the national development path. These are the key concepts behind them:

- **‘Growth at all costs’:** or ‘Plan G’ trend scenario. This reflected what many participants saw as the current default or “business as usual” direction of national development. While economic growth rates were high, there was a perceived likelihood of increasing social divisions, environmental damage, and economic dependency or vulnerability.
- **‘Win-win’ or ‘Plan A’:** this summarized a general re-orientation towards long term goals of sustainable development, in which environment, society and economic growth all fitted together in a positive way.
- **‘Island’ or ‘Plan B’:** this was a fall-back position: in the event that the global economy did not grow as expected, meanwhile Mauritius should aim at resilience and self-reliance, to sustain social well being, human resources and environmental resources.

- There is also a 'Lose-lose' or 'disaster-itiius' scenario, where everything goes wrong: this was used only for reference.

Each of these scenarios was also cross-linked into the IPPC global scenarios and modelling results, for global development, climate emissions and climate impacts. Overall they represent the perceived tensions and possible conflicts, between - expectations of 'business-as-usual' trends: the aspirations for national development: and the assumptions on global conditions.

The main features of the scenarios are summed up here: following that are outlines of each alternative scenario, including narratives and newspaper headlines from the future:

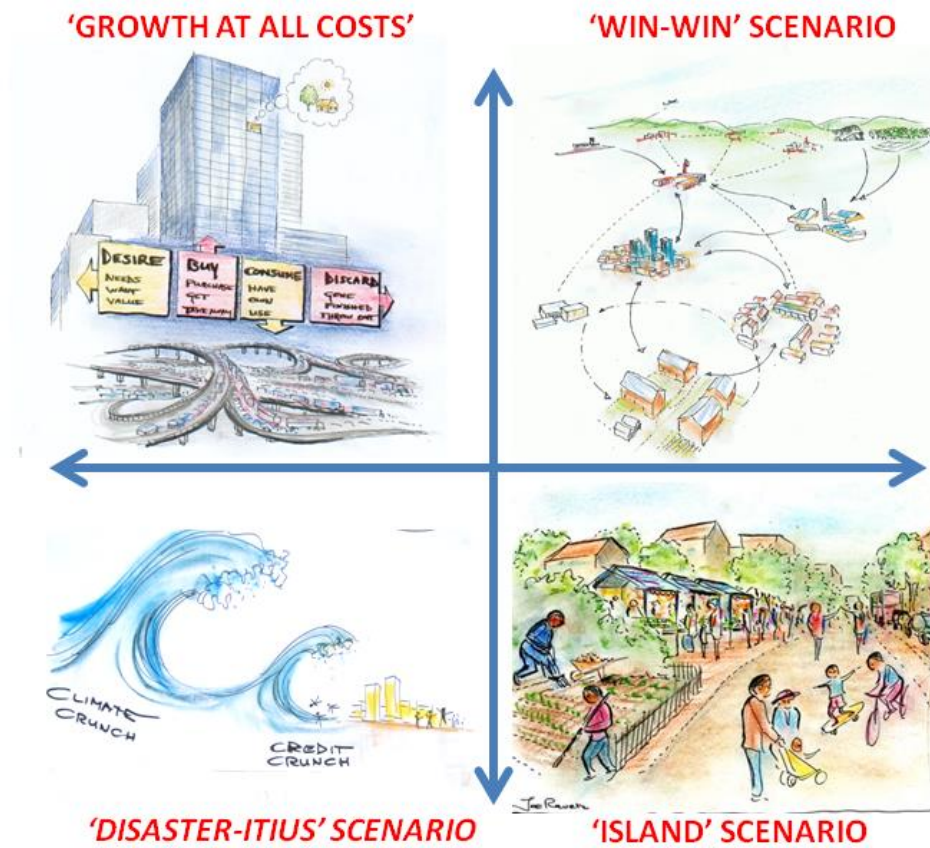
4.2.2 Table 2: summary of scenarios

	'Growth at all costs'	'Win-win' scenario	'Island' scenario	('Lose-lose / Disaster-itiius')
	<i>'Trend' /Plan G</i>	<i>Plan A</i>	<i>Plan B</i>	
Economic growth / technology	High	High	Low	<i>Low</i>
Social prosperity & governance	Negative	Positive	Positive	<i>Negative</i>
Environment & resources	Negative	Positive	Positive	<i>Negative</i>
Globalization / global trade & links	High	High	Low	<i>Low</i>

4.2.3 Figure 4: scenario images

Scenario images

(Graphics by Joe Ravetz, various sources)



4.3 ‘GROWTH AT ALL COSTS’ scenario: (‘Plan G’)

“What-if....” Mauritius continues with a high rate of economic growth and a GDP of US\$ 20,000 by the year 2030 (i.e, a 5.5% rate of growth). Such progress in economic and technological development have been achieved in Mauritius as a global hub. However, the MNEs mainly came to the island due to its low cost labour, low rate of tax and flexible regulations. Natural resources are exhausted irresponsibly, water and air are polluted, waste piles up in landfills, and biodiversity struggles. The economic and technological advancement is enjoyed only by a small portion of the society, and many other islanders suffer from poor education and health services. Much of the land is sold to foreign investors, and new ‘gated communities’ are set up for the holiday homes of millionaires and billionaires. While the island is apparently wealthy, it is also more dependent and more vulnerable to shifts in the global economy, and sudden shortages of resources such as food, oil, finance and tourists.

In relation to the ‘baseline’ trends: it is generally seen that this scenario is the most closely related to current trends: many participants see this as the almost inevitable result of current developments. The main scenario axes can be summarized:

- Economy and technology (+)
- Social stability and governance (-)
- Environment and resources (-)
- Global / outward looking focus.

4.3.1 Implications for R&I activities and policies:

- Research agenda for the private sector is driven by foreign investors and their mother companies
- International-isation of research activity: most researchers are overseas much of the time, working for MNEs or other global scientific networks.
- R&I activity will be imported – little or no knowledge transfer or technology transfer.
- R&I activity doesn’t address local issues, or local opportunities, as it is geared up for global markets.
- R&I activity steers towards new technology for global consumer markets, and has little interest in social or cultural issues.
- Local issues and challenges are not appropriately researched

4.3.2 A day in the life...

“... Sheila woke up in a hurry – she had to get to Port Louis for an 8.00 meeting with the director of finance, and the roads could be really bad on a Monday. Her BMW 3.0i (bought on a mortgage for only 60,000 USD) had the latest google-plex info-tainment, but actually she hated sitting there in the motorway jams in a cloud of fumes – especially when the ‘heli-cars’ of the millionaires sailed overhead.

She was making very good money working for the Mauritius branch of Tech-Global Inc, but there was a feeling that somehow things weren’t right – for instance she hardly saw her partner, who also had massive project deadlines almost every evening and weekend. And then there was their 3 year old son. He had to go to the nursery for 10 or 12 hours a day, and then at home he seemed more interested in the new smart-kid-cyber-phones than in his parents, surrounded by luxuries in their cramped apartment which cost over half of their incomes. Hitting the first of many traffic jams ahead, Sheila wondered about the path that Mauritius had followed, and whether 20 years back some other choices might have been made...

4.3.3 And the newspapers said...

- (November 28th 2030)

- SLUMDOGS BUT NO MILLIONAIRES !!
- RIOTS ARE EARLY THIS YEAR (is it due to climate change?)
- NO MORE DOGS ... (the other dogs ate them)
- RIOTS COST 1% of Mauritius GDP - says National Bank of China.
- TRICKLE UP + UP: that’s our message to the ‘high-net-worth’ community to invest in our high value / low tax luxury plots on the beautiful coast of Mauritius (labour costs are minimal, high speed airport shuttle is included).

4.4 ‘WIN-WIN’ Scenario: ‘Plan A’

What if..... Mauritius is internationally recognised as a model of integrated sustainable development, and as an advanced techno-economic hub. The island has developed a highly stable, tolerant and prosperous society, with good governance and public services. High technology enables the sustainable use of land and marine resources across the whole 200,000 hectares of the island. It is also famous for its efficient financial services, ease of doing business, and highly advanced ICT sector: inward investments for integrated resorts and other tourism has been contained so that local communities benefit. The competition between MNEs to manage their operations from the island

provided rapid increases in the country's net wealth, which has been reinvested in infrastructure, education and health, and more equally distributed among the citizens.

The island produces its energy from tidal waves, solar energy and wind, and is continuously striving for improvements to export to other countries. Drinkable water is provided by de-salinisation of deep ocean water, and this cold resource is bottled and exported, used for air conditioning, reducing the energy use dramatically. All the cars in the island are electric cars, assembled locally, and traffic problems have been solved with smart 'responsive' integrated transport technologies. Mauritius is also a vital hub of the global aviation network, and was the first in the world to achieve 'zero-carbon' for all flights to the island.

- Social stability and governance (+)
- Environment and resources (+)
- Economy and technology (+)
- Global / outward looking focus.

4.4.1 Science / technology / innovation / research implications:

- A 'tech-savvy' population has emerged, where social technologies are used from primary school onwards, and help to coordinate the green economic system;
- Many innovations in infrastructure came from an active government procurement program, to encourage lead technologies, integrated supply-demand chains, and new social markets;
- Pro-active financial / fiscal policy which attracts entrepreneurs and investors in innovative technologies and business models: where benefits always come to local people;
- New scientific directions, such as complexity studies and neural networks, were encouraged by the government to help develop the green economy strategy;
- Innovations in economic-social research and knowledge systems, for a green economy which is as much about human resources and quality of life, as technology;

4.4.2 A day in the life...

Rashid surveyed his mailbox over breakfast with his family. Soon he would walk the kids to the local community school – this was a fascinating hub of teaching and technology and creative arts, where business-people, philosophers, artists and politicians often dropped in, to learn from the kids and help them work on the community gardens.

After that, Rashid thought his day could be quite interesting – a bunch of investors from Moscow and Kiev were coming over to look at the green portfolio. Although these people had more money than they knew how to spend, they also knew that Mauritius could not be bought or sold like any commodity – it had a national agenda for re-investment that was the envy of the world.

People everywhere asked – how could this one island generate such funds, to re-engineer its entire infrastructure, to educate its entire population to the highest

levels, and to sustain its unique biodiversity. Moreover, it had developed a system of economic exchange that combined financial, social and ecological values – this alone was an intellectual export of the highest order. Naturally such a path had not always been smooth and predictable. There were many intensive think-tank sessions, right across the community, but there were also intense arguments – for instance the squatter communities demanding justice and land rights, clashed head-on with investors looking for larger and larger integrated resorts. Luckily there seemed to be a clear pathway of ‘developpement durable’, which everyone could see would benefit everyone....

4.4.3 And the newspapers said....

- (November 28th 2030)

-
- NEW MASSIVE INVESTMENT OPPORTUNITIES ARE ANNOUNCED (green technology, electric cars, renewable – all are available in the M.I.D. portfolio for 2030)
- MORE BUSES LESS HEDGES (10 billion rupees are at stake)
- IT’S NOT WHAT YOU THINK, IT’S HOW YOU THINK: *join the green economy policy network and learn how to share your resources...*
- IS 20 YEARS ENOUGH?? or will this transformation need 35, 50, or 100 years?
- HOW DEEP IS YOUR GREEN? Some NGOs say Mauritius is too successful
- H.D.I. TOP 10 AWARD FOR MAURITIUS

4.5 ‘ISLAND’ Scenario: ‘Plan B’

“What-if....” The global economic system dominated by neo-liberal financial capitalism has more or less collapsed, and the developed world is still seeking for solutions to ongoing social and economic disturbance. Like many other countries, Mauritius could be badly affected by this mayhem. However, the citizens of Mauritius were timely in spotting the dilemmas of sustaining growth in existing economic systems, given the additional challenge of severe climate change impacts. The answer to the question of development was a more sustainable ‘alternative economy’ for Mauritius. The alternative economy is characterised by smaller, highly self-sufficient local economies, largely independent of the global economy. It engenders a safer and more pleasant environment for both individuals and families to live within. Mauritius develops innovative ways to use its existing resources and industries, with core competences such as land-based ocean, tourism and agriculture. Mauritius is now the pioneer as a first fully ‘sustainable nation’ in the world. The alternative economy in Mauritius helped the country to generate 100% of its electricity from renewables. Thanks to access to education through public schools supported by voluntary teachers, food through the home-grown vegetables and fruits, and practices such as social solidarity and

sustainable consumption, the gap between the rich and poor has been reduced to a large extent. The island's external income mainly benefits from the tourism sector. Handicrafts such as jewellery and also smart phone apps, provide income for poor families, who then have access to basic goods and services.

In relation to the 'baseline' trends: it is generally seen that this scenario suggests a different development pathway than other scenarios in the set. There are a number of opportunities in this scenario and at the same time a number of transformations may be needed in socio-economic systems. However if the global economy cannot be assumed, then this scenario may be the most practical and realistic of all. The main scenario axes can be summarized:

- Social stability and governance (+)
- Environment and resources (+)
- Economy and technology (-)
- Local / inward looking focus

4.5.1 Implications for the R&I activities and policies:

- Primary use of national R&I capacity; most researchers are from Mauritius, with international teams collaborating on research such as on sustainability, responsible consumption, Corporate Social Responsibility and so on.
- R&I activity is produced locally - little knowledge transfer or technology transfer
- R&I activity addresses primarily local issues and local opportunities in a new socio-economic order
- New models of undertaking research (e.g. community modes of participative, ICT enabled..)

4.5.2 A day in the life...

Thamara, 35, is an entrepreneur in the new local socio-economy. She works in a Mauritian IT company, which creates smart electronic tags for plants to ensure quality home-grown food. Thamara has achieved a high level of creativity in her work, which is much more than just earning a living. All around there is less pressure on jobs for material wealth, so Thamara's work has become a more intellectual and creative activity – in fact it's a calling, and part of her quest for personal and spiritual realization.

She now has more time for things she loves such as making jewellery with Mauritian semi-precious stones. And thanks to her domestic solar tiles, her energy bills are low: public schools provide excellent education, and most of their food is grown in the neighbourhood or close by. On the way back from work, Thamara stopped by a kids clothing 'resale hub' and swapped a tee-shirt for her daughter, in exchange for her outgrown items and hand-made jewellery. Roshan's Organic Food in Port Louis is her family's favourite place for weekend breakfast where they enjoy incredible home baked sandwiches and juices to eat on the patio – and then they can mingle in to this or that circle, on themes such as gender philosophy, smart technology, cultural history or global futures.

4.5.3 And the newspapers said....

(November 28th 2030)

- SIMPLE LIVING, HIGH THINKING!!
- DEMOCRACY – IT STARTS WITH PIPES IN THE GROUND
- LESS MONEY → MORE COOPERATION? ENOUGH MONEY → A whole load more cooperation?
- GROSS HAPPINESS INDEX UP 5% TODAY!!
- PLAN B: PEOPLE HELP PEOPLE
- MAURITIUS AS A HUB OF SOCIAL INNOVATION
- NOBEL PEACE PRIZE GOES TO MAURITIUS (but how will they spend it???)

4.5.4 Scenario D: LOSE-LOSE... 'Disaster-itus'

(This scenario is not explored in detail here: it provides a useful comparison to the others).

“Mauritius by 2030 is a forgotten piece of polluted and wasted land in the middle of the Indian Ocean. The island suffers from chronic socio-economic crises, while the surrounding global economy also fell to pieces. The economy is mainly based on low technology production of sugar cane and a few other tropical fruits. The product portfolio is extremely limited and far from meeting the island’s needs: poverty is endemic and the population is lacking even basic skills. Climate change and other natural disasters are increasing: tourism and migration are limited due to the rising price of oil and pandemic health risks.”

- Social stability and governance (-)
- Environment and resources (-)
- Economy and technology (-)
- Local focus by default

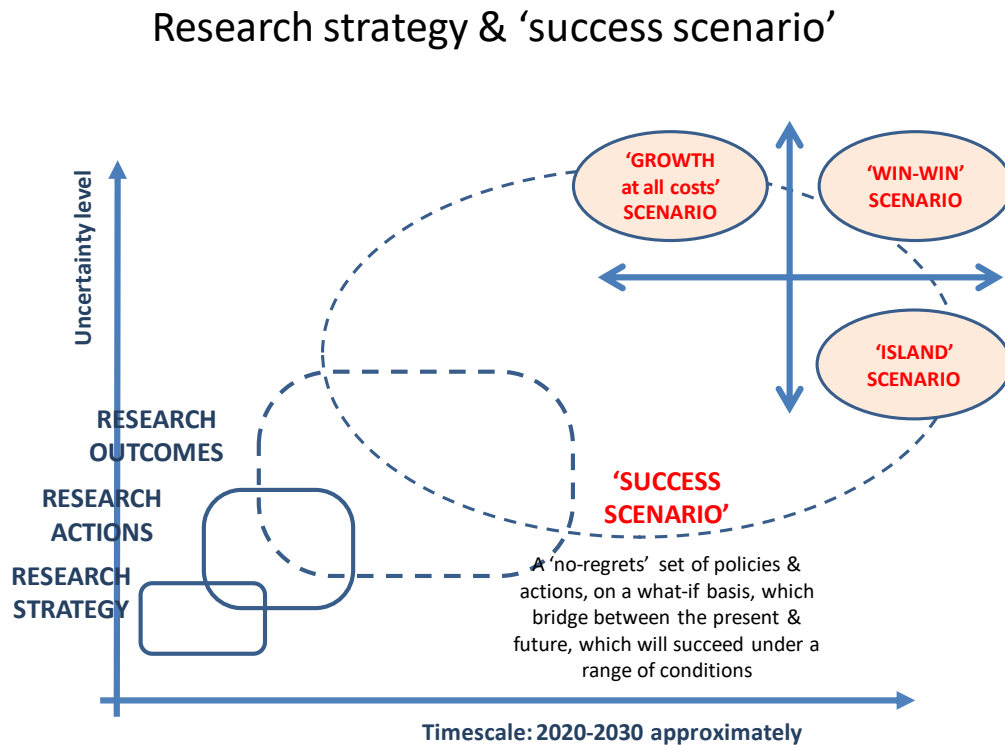
4.6 'Success' scenario

There is also a 'Success scenario' which emerges from discussion on the implications of the 3 main scenarios above. This is basically a 'no-regrets' set of policies & actions which bridge between the present & future uncertainty, i.e. hedging bets on which of the 3 main scenarios would eventually turn out. However there is also some degree of aspiration, in moving from the 'default' scenario towards what is perceived as the 'Plan A / win-win', or the fall-back 'Plan B / simple living' variations. There is also a linkage with the sustainable development agenda of MID, (although this is more short term practical than strategic in focus).

The implication of such a 'success' scenario for the NRFE and national R&I agenda:

- That research and innovation (R&I) can play an active part in the national policy goals for integrated sustainable development, rather than being a passive add-on to an agenda which follows current trends of economic growth and private wealth. The NRFE can bring-up trends/issues to the surface and the resulting research agenda should interalia aspire to contribute towards reaching a desired scenario/mix of favourable ones

4.6.1 Figure 5: research strategy & success scenario



The graphic (Figure 5) shows a ‘no-regrets’ scenario, on a what-if basis, which bridge between the present strategy and resources, and the future uncertainty of alternative scenarios. In other words a ‘Success scenario’ is a set of responses and actions which are likely to achieve ‘success’ (as defined by the stakeholders), under a range of feasible conditions, as represented by each of the context scenarios. In this case the success scenario aims at the following:

- ‘Plan G’: to enable the positive outcomes of this, while being aware that many of the drivers are for external private profit at the expense of local social / ecological goals.
- Plan A: to promote the win-win outcome, but having regard to the possibility that external conditions may change.
- Plan B: to allow for the possibility that the track of global trade, visitor numbers and economic development may reduce or even collapse, in which case there is a strong need for self-sufficiency as a backup.

In this way, a success scenario is a kind of precursor to a strategy outlook or roadmap; the key features of a ‘success’ scenario would be likely to include:

- Uses foresight approach to evidence, uncertainty, strategic thinking
- Focuses on interconnections & capacity building
- Balances local & global interests & opportunities
- Generally normative & ethical orientation to social & environmental issues.
- Holistic style of bringing together different forms of knowledge
- Tends to advocate innovation (social, economic, governmental) to work with multiple values & perspectives, in solving grand challenges and wicked problems.

The success scenario also picks up from current trends and developments, as shown in the diagram above:

- Research foresight – leads towards a national research strategy:
- This sets up research actions, which in due course produce research outcomes. At each stage the uncertainties increase.

The scope of this is explored further in Part III and IV.

5 CLUSTER THEME OUTLOOK

5.1 Development of cluster working groups

It was decided at the start of the NRFE to get closer to the detail of the research community and R&I supply / demand system, by forming a set of cluster themes with working groups. These have some similarities to the current National Research Groups: but these NRFE cluster themes aim to look more widely and deeply: integrating aspects from other themes: to take on the futures and foresight dimension: to look at interconnections and innovations in the way that research is done.

Following a scoping session, 6 themes were identified: 6 half-day working groups were held over 4 days, with the number of participants from each group between 6 to 18 representatives of all major stakeholders. Briefing papers with a common template, were discussed and explored.

- The response from each working group was very positive (after some initial warm-up time in some cases). The futures focus was thought to be very valuable for strategic thinking.
- The discussion and subgroup sessions focused mainly on the scenarios: in particular the difference between default or 'baseline' trend projections ("business as usual"); and the 'national development goals', as represented by 2 alternative scenarios.
- **Proposed research topics were based also mainly on the differences between the scenarios, and the 'baseline' and 'oriented' versions**
- The question of alternative modes of research (i.e. not just what to research, but 'how' to research) was also discussed.

These are the groups which were formed from the results of the Inception meeting:

- **Marine / land-ocean industries** (building on existing LBOI initiatives): with linkages to tourism: bio-medical: seaweed: energy:
- **Agriculture / sugar / food** / other land-based industries: with linkage to public health: ecological & biodiversity: energy: water: overseas trade:
- **Infrastructure**, including energy / water / transport / waste / urban planning: with linkages to economic development: sustainable development: social policy: overseas trade.
- **Human resources**: education, empowerment, citizenship, workplace conditions, quality of life, etc: (with linkage to governance, cultural issues, social policy etc.
- **Enterprise resources**: i.e. knowledge-based enterprise: physical science / manufacturing / supply chains, and the mainstream STI (science, technology, innovation) agenda.

- **Global resources:** finance, ICT, tourism, trade & transport links, climate change, security, etc. (a very wide range of themes with links to national policy, international cooperation etc)

Following that, cluster working groups were formed and met in late 2011, with 3 main aims:

- Apply the results of national studies to each Cluster theme
- Develop a mini-foresight process with stakeholders, including futures and capacities strands.
- Set up a continuing process for the NRFE, depending on the stakeholder commitments and interests.

5.1.1 Comparison with other classifications

It was important to link the cluster groups with other science and research classifications. From the Delphi survey of 2011, linkages were made between existing global Grand Challenges: R&I science classifications: and sectoral industrial classifications. Matrix 1 maps and compares these different classifications. For each there are results on the perceived 'importance' (national research demand), and the level of feasibility (quality of research supply).

5.1.2 Matrix 1: Baseline: cluster theme / survey results

CLUSTER WORKING GROUP CHALLENGES	GRAND CHALLENGES (European Commission)		SCIENCE CLASSIFICATION		APPLICATIONS & END USERS	
	Importance	Feasibility & capacity	Importance	Feasibility & capacity	STI applications	Policy & business applications
Social & cultural issues	Education standards & investments	Medium			Education	Higher
Agri-food-health	Food security, diet & culture	Higher	Clinical medicine	Lower	Health & social work	Lower
Infrastructure resources: & Marine & land resources	Water security: Energy security	Higher: Lower	Environmental engineering	Lower	Transport, communication	Higher
					Electricity, gas & water	Higher
Agri-food-health	Food security, diet & culture	Higher	Agriculture forestry & fisheries	Higher	Agriculture forestry & fisheries	Lower
Enterprise resources			Economics & business	Higher		
			Computing & informatics	Higher		
Global links & resources	Sustainability & climate change	Medium				

5.2 The role of Grand Challenges

The European Research Area (ERA) developed the notion of Grand Challenges, as an organizing device for large scale research programming. There are currently 21 global Grand Challenges which form the basis of an online library (outlines are at <http://community.iknowfutures.eu/news/toolkit.php>). The set of 21 was also ‘borrowed’ as one of the inputs to the NRFE consultation.

Such Grand Challenges aim to address so-called ‘wicked’ problems: highly inter-connected issues with high uncertainties, without fixed boundaries or definitions, without clear methods or scientific evidence, and lacking consensus on policy responses. Each of these extends from conventional or inter-disciplinary scientific approaches, towards other parts of society: policy and governance: finance and business: media and culture: community and civil society. For each it is clear that conventional research methods are generally not enough. To explore a world which is increasingly

complex, inter-connected, multi-level and vulnerable, new approaches are needed, which can respond both to systemic risks and to creative opportunities.

The Grand Challenge approach is both a creative stimulus and a practical way to explore and collaborate on R&I programmes, and the policy, business or social innovations which may spring from it. A short list of potential Grand Challenges relevant to the NRFE has been identified from the ERA 21 and from the NRFE cluster themes, and it is recommended that these could be used as discussion 'seeds' for the next stage of development of the cluster themes. These are selected as the most relevant to the NRFE:

- The research agenda for water brings many challenges. There are many positive achievements: on the technical side, the use of remote sensing, GIS and hydrological modelling: and on the policy side, the emergence of ecosystems services (ESS) and related markets and fiscal policies. However it is fair to say that with the impacts of climate change, economic growth, urbanization and landuse change, alongside the larger scale of infrastructure and water transfers, the political and economic (and socio-cultural) problems are now in the centre of the stage.
- energy security covers the whole picture – technology and innovation, markets and finance, infrastructure and urbanization, environment and climate, consumption and social behaviour. Current research programmes are beginning to shift from a conventional technology-engineering focus, towards a more holistic view, and in some cases a critical perspective on the political economy dominance of technologies, intermediaries and transnational firms.
- Food security and culture (maps on to the cluster theme of 'agriculture / health'). Many foresights have looked at the agriculture and food question, and will continue to do so, with a topical combination of science, public policy, environment and landuse, and global politics. However there is a risk firstly that the research process is full up with all the inter-connections, and doesn't have much room for the more wild frontiers of surprises, threats and opportunities. Secondly there is often a disconnection between the problems and the levers of change in policy or business.
- Health, illness, well-being: (maps on to the cluster theme of 'agriculture / health'): The health agenda across emerging nations is under increasing pressure: rising costs, increasing lifespan, growing expectations, and at the same time, public sector deficits and shrinking budgets. And behind the service agenda is a wider awareness of positive health, rather than simply treatment of illness. This involves many other policy areas, in workplaces, housing, cultural patterns, addictive behaviours, gender relations and so on. Above all there is a realization that many of these problems are in-built to the syndromes of affluence and the socio-political model of consumption, where institutions such as food companies and media channels are responsible as much as individuals.
- Governance, democracy and citizenship: (maps on to the cluster theme of 'social issues'). Governance is not only about national or supra-national institutions which can appear very remote to the majority of citizens. It is also about the configuration of identity and accountability at every level – national, regional, municipal, local community, to the household and personal level. Even more interesting is the apparent divergence of 'function' and 'territory', and the dislocation of 'governance' from many other forms of activity.
- Education and skills: (maps on to the cluster theme of 'enterprise resources'). The role of the education system is crucial: but there are many dilemmas and questions. What kind of

knowledge is needed in the global knowledge economy – more technical skills, people skills, entrepreneurial skills, or transferable skills? And surrounded by pervasive information, should we pursue knowledge as a ‘tacit’ process of inter-personal relationships, rather than simple data? There are practical policy issues on the organization and management of schools, universities, professional training, or lifelong learning programs. These also point towards new opportunities, such as edu-tainment, niche tourism, and virtual learning systems.

- Globalization and localization: (maps on to the cluster theme of ‘global links’). To frame such a challenge as a research agenda, raises questions about the scope and nature of research. To study globalization should we talk to global elites, to policy-makers, or the victims of side-effects? And to study localization, working with ‘local’ communities could be a process without end. Thinking more widely, a creative foresight process is better able to respond to such unbounded and multi-layer kinds of problems, where subjects are all mixed up with objects, and theory mixed up with practice.

5.3 ‘Ocean & island resources’ cluster

The ocean is possibly the single greatest resource and greatest challenge for Mauritius. Already there is a highly innovative LBOI cluster in development by MRC. This cluster working group could start from there and explore some wider links and creative opportunities, for the interface of research, policy and business.

At the same time there are challenges and pressures, particularly the impacts of climate change on sea level and ocean chemistry. Within this medium-long term agenda, water resources, agriculture and tourism development, all intersect at the coastline. This is an issue especially for outlying dependencies.

There are various ways to scope a wide ranging policy-research agenda: here we use the ‘STEEPvU’ scheme, in common with many future studies:

- Social issues – i.e. stakeholders involved: coastal residents, businesses, landowners, tourists
- Technology issues: innovation in energy and water: bio-medical and pharmaceutical: marine engineering
- Economic development – the clear opportunities and investment cases for LBOI industrial ecology schemes, depending on collaboration
- Environmental issues – local environments and biodiversity, marine quality, climate change
- Political and policy issues: property rights, regulation, governance for collaborative schemes
- Values and ethical issues: natural vs human rights
- Urban and infrastructure – water, energy, transport etc.

5.4 ‘Agriculture / food / health’ cluster

For Mauritius, food supply and food security is more critical than in most other countries. There are urgent issues in the conversion of landuse, urbanization and demographic change, overseas trade / shipping / aviation, prospects for energy and water in the context of climate change and 'peak oil'. There is the legacy of the sugar-cane industry, now looking for a future role in a different trading and supply chain context. Also there are issues for the food & drink industry as a vital economic sector, landowning system and major employment sector, which is also topical in relation to tourism. There are also emerging issues for public health and safety, the role of food in the local economy, and the 'food-health gap' between rich and poor, or old / young.

The scope of this cluster can be framed as a series of interfaces:

- Supply chain interfaces, e.g. where production meets consumption: or, in trade policy, the balance between domestic markets and self-sufficiency: or, export for global markets?
- Landuse and resource interfaces: should land in agriculture, (and particularly in sugar cane), be allowed for conversion to urban development / ecological / tourism uses?
- Food supply and public health interface: with concerns on lifestyle, new chronic syndromes (e.g. Diabetes): food availability to different social / ethnic groups, risky or addictive food / drink consumption types.

There are very practical benefits in doing this: for businesses, industrial sectors, investors / landowners, and especially for policy-makers concerned with the integrated development of the nation. There are also wider benefits at more of the knowledge level: STI activity and policy: together with education, research, social policy, financial / technology intelligence, etc.

5.5 'Social & cultural resources' cluster

Social and cultural issues firstly are 'relational' and inter-connected: while health, education, social security and other public services are managed in separate organizations, the problems and opportunities of real people and communities are highly inter-dependent. Another point is about change, transition and transformation, where social issues rarely stand still – there is continuous movement between one field and another. For instance, many public health syndromes arise through consumption habits, which can be generated by kinship and cultural change, and also by migration: to respond effectively needs not just 'more public services' but innovation in the public service model.

- Social issues include a wide range of linkages: including Demographic change: social policy: poverty and equity and exclusion issues: ethnic & cultural diversity, quality of life, empowerment and citizenship,
- Technology developments can have profound implications on social life, often in the name of progress.

- Economic development and resources: a focus on ‘growth’ alone also can have high impacts on social and cultural resources.
- Environment is clearly not just a technical issue, but related to health, education, security: and wider issues of prosperity and quality of life.
- Politics and policy: the quality of the governance system, public services and public participation, is crucial for the empowerment and citizenship of the people.
- Values and ethics: the role of ethnic and religious communities: other systems of morality: new challenges such as with the young, the old, visitors and migrants.

5.6 ‘Infrastructure resources’ cluster

In most modern infrastructures – water / energy / transport / waste – there is a crucial combination: rising demand and population: diminishing natural resources: technology innovation and financial centralization: political tensions and social changes. The Mauritius agenda for infrastructure is more crucial than most, with high dependency on energy imports, and vulnerability in the face of ‘peak oil’, and climate change in both impacts and in policy.

Technology innovations often depend on parallel innovations, in governance, social and economic systems. Such innovation might look at the inter-dependency of suppliers and users: investors and consumers: upstream and downstream parties: uncertainties and risks of many kinds: or the political economy of infrastructure and regulation. Over-arching this is the concept of ‘sustainable development’, where the island of Mauritius has a unique opportunity as an international demonstration. For example – the transport sector could continue its current trends towards energy intensive, land consuming and polluting modes: or – it could look for transformational technologies, new urban planning models, business models, public services and communications networks, based on accessibility rather than mobility.

To scope this broad agenda we can use the ‘STEEP VU’ framework:

- **Social issues** – suppliers, inter-mediaries, consumers: businesses, landowners, tourists.
- **Technology innovation**: new possibilities in water / energy / transport, with new risks and dependencies
- **Economic development** – need for infrastructure on the supply side: new consumers on the demand side: opportunities through collaboration and clusters
- **Environmental issues** – local air / water pollution, land and biodiversity, climate change
- **Political and policy issues**: property rights, regulation, governance for collaborative schemes
- **Values and ethical issues**: sustainability versus free markets?
- **Urban development** – patterns of spatial planning, network configuration, centralization vs decentralization.

5.7 ‘Enterprise & human resources’ cluster

This agenda is highly inter-connected - business and micro-economics, industrial sectors and supply chains, product design and markets, applied science and technology. These raise important cross-cutting questions: what are the conditions for growth and competitiveness? How to improve human resources and organizational capacity? Which policies are the most effective to stimulate business investment and enterprise? How does this reflect on the Mauritian diaspora, and the internationalization of STI, investment, trade, media and markets. Overall, is the 'knowledge society' an end in itself: is it about economic growth, or a wider view of prosperity and well-being?

Using the the 'STEEP-VU' framework as a structure:

- **Social issues**: human resources, education and training, organizational change and management: workplace conditions and health issues: social entrepreneurship
- **Technology**: the central agenda here would look across the range of sectors at the national supply side, demand side, STI capacity, niches, specializations and key technologies.
- **Economic** development: this starts with a mainstream agenda of business studies and fiscal policy: it should also look at some wider factors of productivity and competitiveness
- **Environment**: a key constraint and key opportunity for many business sectors, as above.
- **Politics** and governance: starts with a mainstream agenda on regulation, procurement and STI support: also looks widely to civil society and its relation to business.
- **Values** and ethics: the value agenda is increasingly important for business enterprise, both on supply and demand sides.
- **Urban** and infrastructure: in Mauritius, often seen as a brake on growth and competitiveness.

5.8 'Global resources & links' cluster

Mauritius is almost by definition a global hub. But the world around is changing rapidly, in ways which are not predictable. At the top of the geo-political agenda is the changing shape of global powers, and the rise of China, India, the Gulf States and Africa. There are security issues across the Indian Ocean: and from the post-colonial legacy, there are implications for the social model and cultural identity of Mauritius.

The 'global resources and links' theme focuses on what is most relevant to Mauritius: finance and trade: energy and food security: tourism and communications: and climate change. In each of these there are mounting pressures and potential disruptions, together with new opportunities.

This theme is very wide: so here we can use the STEEP-VU framework as a structure:

- **Social** issues: internationalization, migration and the diaspora: tourism and visitor economy
- **Technology**: international networks, transfers, ICT, product supply chains
- **Economic** development and resources: finance sectors, FDI, business networks and consortia
- **Environment**: global climate change: global environmental regulation in policy / business

- **Politics & policy**: international relations, security, trade and investment
- **Values & ethics**: cultural identities, reason for leaving or staying.

PART III:

Analysis

In Part III – Analysis, we take the previous sections on policy context, futures outlook, and cluster themes, and look systematically with a matrix framework, at all relevant combinations and inter-connections. This starts with the baseline analysis: then applies the scenarios in a framework: and then moves toward a synthesis of strategy and policy development.

6) BASELINE ANALYSIS

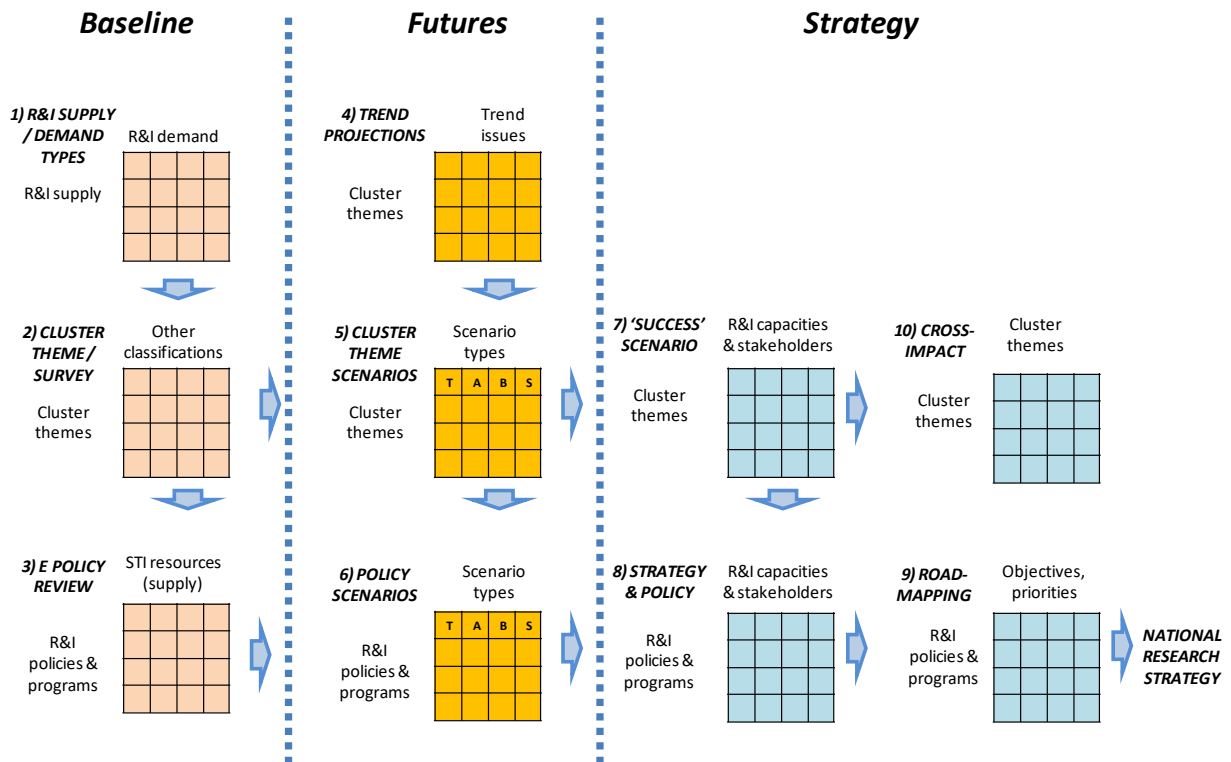
6.1 Methodology for analysis

The core of the methodology for both analysis and synthesis, is a structured set of inter-connected matrices. This works with qualitative information, so that a mathematical approach is not generally effective: the only practical approach being that of systematic cross-reference. The conceptual layout of the matrices is in Figure xxx below.

The 10 core matrices are grouped into three types: baseline information: futures (i.e. scenarios): strategy (i.e. roadmap).

- 2) **Baseline: Cluster theme / survey results:** from the results of the 1st Delphi survey, this maps the cluster themes against Grand Challenges, science & industry classifications.
- 3) **Baseline: R&I supply / R&I demand type:** this matches national policy 'research demand', with STI capacity for 'research supply'.
- 4) **Baseline: R&I policy / R&I capacity:** this takes the various studies, interview and workshop results, in summary matrix format.
- 5) **Futures: Cluster theme / trend projection:** this takes the MRC work on the baselines, put into simple matrix form in the cluster theme format.
- 6) **Futures: Cluster theme / scenario:** a simple summary of the cluster workshop outputs: and also includes the beginning concepts for a 'success scenario', or 'strategy'.
- 7) **Futures: R&I policy / scenario:** this analyses across the clusters, to identify R&I policies, and also broader approaches, which were raised in the cluster meetings.
- 8) **Strategy: Cluster theme / R&I capacity:** this analyses the content of the thematic approach relevant to various actors.
- 9) **Strategy: R&I policy / R&I capacity:** the core of the strategy or roadmap, which matches policy to resources and capacity.
- 10) **Strategy: R&I policy / time & resources:** a concept outline of a national strategy, with practical constraints: this will guide and inform the national 5-year Research Strategy.
- 11) **Strategy: Cross-impact cluster theme:** this tracks the potential linkages or conflicts between each of the cluster themes and their contents.

6.1.1 Figure 6: Foresight methodology with matrix analysis



6.2 Research typology: capacities & applications

The first issue is to categorize different research themes and topics, against the particular features of the national profile (small island, remote location, tropical climate, emerging economy, etc). This draws on the results of the online Delphi survey, with further interpolation from the workshop discussions. Matrix 2a below matches national policy 'research demand', with R&I capacity for 'research supply'.

- this uses a matrix of possibilities to identify different levels of priority,
- this is shown as combinations of 'national policy and strategy' (research demand): and 'national research / STI capacity' (research supply).

This matrix can be repeated to look in more detail at each of the cluster themes.

The results are not unknown to researchers in Mauritius, but interesting to map out clearly.

- The priority issues include those with strong or global level R&I capacity, and a direct / unique policy agenda: Marine / ocean resources: Small island development issues: Ecosystems-based material & life science.
- Somewhere in the middle are themes with Regional level R&I capacity, and Indirect & non-unique national policy agenda: for instance, Tropical medicine: Tropical agriculture & development: Sugar cane technology: Climate science.

- Otherwise there are themes with national level or applied research R&I, with policy applications which could be in any location. Examples could include economics, business & management studies. Such themes can be of equal importance overall, but have a different role to play to those in the opposite corner.

6.2.1 Matrix 2a: Baseline supply / demand: by R&I theme

National policy & strategy agenda (research demand)	non-specific applications	Indirect & non-unique national policy agenda	Direct & unique national policy agenda
National research / STI capacity (supply)	<i>Could be anywhere</i>	<i>Could be in other similar locations</i>	<i>(i.e. USP is only in Mauritius)</i>
Strong / global level R&I capacity	'Pure' natural sciences, social sciences	Tropical country sustainable development studies. Coastal resources, aquaculture.	Small tropical island nation sustainable development models. Tropical ecosystems / material & life science. Marine science / ocean resources:
Regional level R&I	Astronomy facilities: Mathematics, engineering. Humanities, social sciences	Tropical medicine: Tropical agriculture & development: Sugar technology & industry. Climate science. Textile science & technology	Food systems & public health syndromes. Social enterprise & development models.
National policy / applied R&I	Other knowledge based professional & consultancy activities	Urban planning & development Tourism studies. Policy studies, education, social etc.	Industrial ecology systems in water, energy, transport, waste etc. Applied social, cultural, economic research

6.3 Research policy typology

The thematic typology above can then be explored in terms of specific R&I strategies and policies.

Generally, there is a priority for research which supports the national goals for sustainable development: and which also takes an independent role from either government or business: and which contributes generally to a knowledge-based society. There are different categories, based on a range of research 'supply' and research 'demand':

- **Global level capacity / direct policy demand:** Strong international research capacity, with unique national applications: this is the primary goal of research which focuses on unique

capabilities and research agendas, to build national centres of excellence where possible.
International research centre status: . Combines global science network with national support & procurement policies.

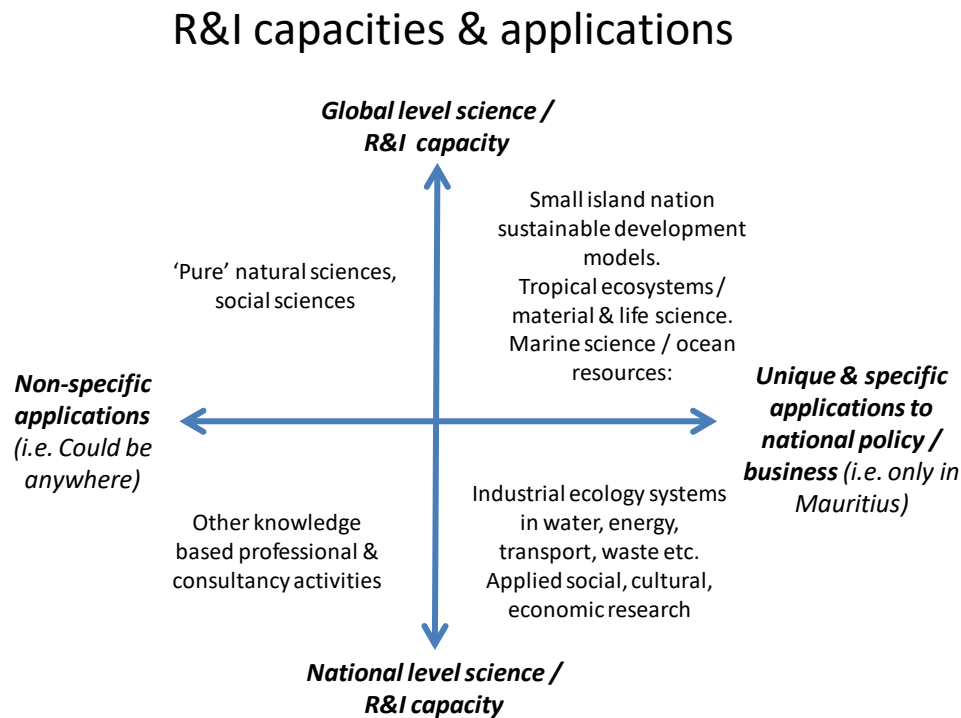
- **Global level capacity / indirect policy demand:** Strong international research capacity, with few direct national applications: this shows a more traditional research excellence & scholarship model, in all areas.
- **Local level capacity / direct policy demand:** National level applied research capacity, with unique national applications: the result is a focus on unique Mauritius issues & opportunities.
- **Local level capacity / indirect policy demand:** National level applied research capacity, with few direct national applications: Build technical capacity & skills for typical knowledge-based consultancy & applied research.

6.3.1 Matrix 2b: Baseline supply / demand: by R&I activity

National policy & strategy agenda ('research demand')	Direct & unique national policy agenda	Indirect & shared national policy agenda	No direct national policy agenda
	Focus on unique Mauritius issues & opportunities.	Research agendas relevant to policy but not unique to Mauritius	Other basic science & research (physical / life / social sciences)
National research / STI capacity ('research supply')			
Strong / global level STI capacity	International research centre status. Combines global science network with national support & procurement policies.		Global quality traditional research excellence & scholarship model, in all areas.
Regional level STI	Priority issues for tropical / emerging countries. Network around Africa / IOC region.	Research fields of some relevance to tropical / emerging / IOC countries.	Traditional research excellence & scholarship model, networked to the situation of a tropical / emerging / small island state scientific community.
National policy / applied STI	Focus on unique Mauritius issues & opportunities.		Build technical capacity & skills for typical knowledge-based consultancy & applied research.

The broader picture is shown in Figure 7:

6.3.2 Figure 7: R&I capacities & applications



6.4 Research policy - capacity analysis

The next step is to look in more detail at the results of various studies, interview and workshop discussions, on two axes:

- Research policy areas (arranged in a combination of the Mauritius STIP report and the generic structure used by UNESCO):
- Research stakeholders, including government and agencies: higher education and related: private sector business and finance: civil society organizations (CSOs): and the MRC itself with related organizations, i.e. those whose main remit is to facilitate and coordinate R&I in various sectors.

The results can be summarized broadly as in Matrix 3:

- **Government and agencies:** dominated by election cycles, risking capture by corporate interests, lacking funds to invest in R&I.
- **Higher education and related:** often traditional in outlook, divided into historic disciplines, not well connected to the needs of business.
- **Private sector business and finance:** often short termist and profit focused, under-valuing R&I, and lacking human resources and skills to move forwards.

- **Civil society organizations (CSOs):** numerous and lacking critical mass, not always fully connected to policy and business.
- **MRC with related organizations:** potential for a creative facilitation role, but generally underfunded, lacking some of the required skills and connections.

6.4.1 Matrix 3: Baseline: R&I policy / R&I capacity

	Government & public agencies	Higher education & related	Private sector industry, finance	Civil Society Organizations	MRC & related
					<i>(To be filled)</i>
Science Base & higher education issues	R&I is underfunded	Universities have traditional outlook	Business doesn't value R&I	too many & too small organizations	Insufficient funds to fund research
Human Resources & training issues	HR incentives don't always line up	Universities have traditional outlook	Skills gap & 2-tier society	Social, cultural, educational could fill gaps	MRC conducting training in research methodology & research grant application course
Business Enterprise R&D / Innovation focus	ease of doing business is low No incentive for the private sector to conduct research.	Need to change culture	Business culture often slow & stuck	Not always well connected	Almost non-existent
SME & firm clusters & networks issues	Focus on science parks, but is this needed?	Should focus outwards on clusters	Potential for reverse innovation	Not always well connected	To be developed...
Technology / Knowledge Transfer focus	Critical technologies & infrastructures to be identified	More incentives needed	Potential for reverse innovation	Not always well connected	A TTO has been set up at the MRC
Innovation governance, IP & related issues	No proper IP facilities yet	More incentives needed	Business doesn't value R&I	CSO could act as intermediaries	IP unit at MRC
Finance, access & equity issues	Need to spread equity ownership	More incentives needed	Gap in SME needs / finance supply	CSO could act as intermediaries	To be developed...
Policy interventions & public procurement	Trend to sub-contract to overseas	Universities not well connected	Need more strategic procurement	CSO could act as intermediaries	To be developed...
Globalisation & International issues	Migration & immigration policies are critical.	Many global science networks & collaborations	Risk of branch-plant mentality.	Social & cultural agencies need links to business	
Sectoral disparities and distribution issues	Trend towards privatized & divided society	Various schemes for inclusion	Ethical / social business is still a minority	Social & cultural agencies need links to business	

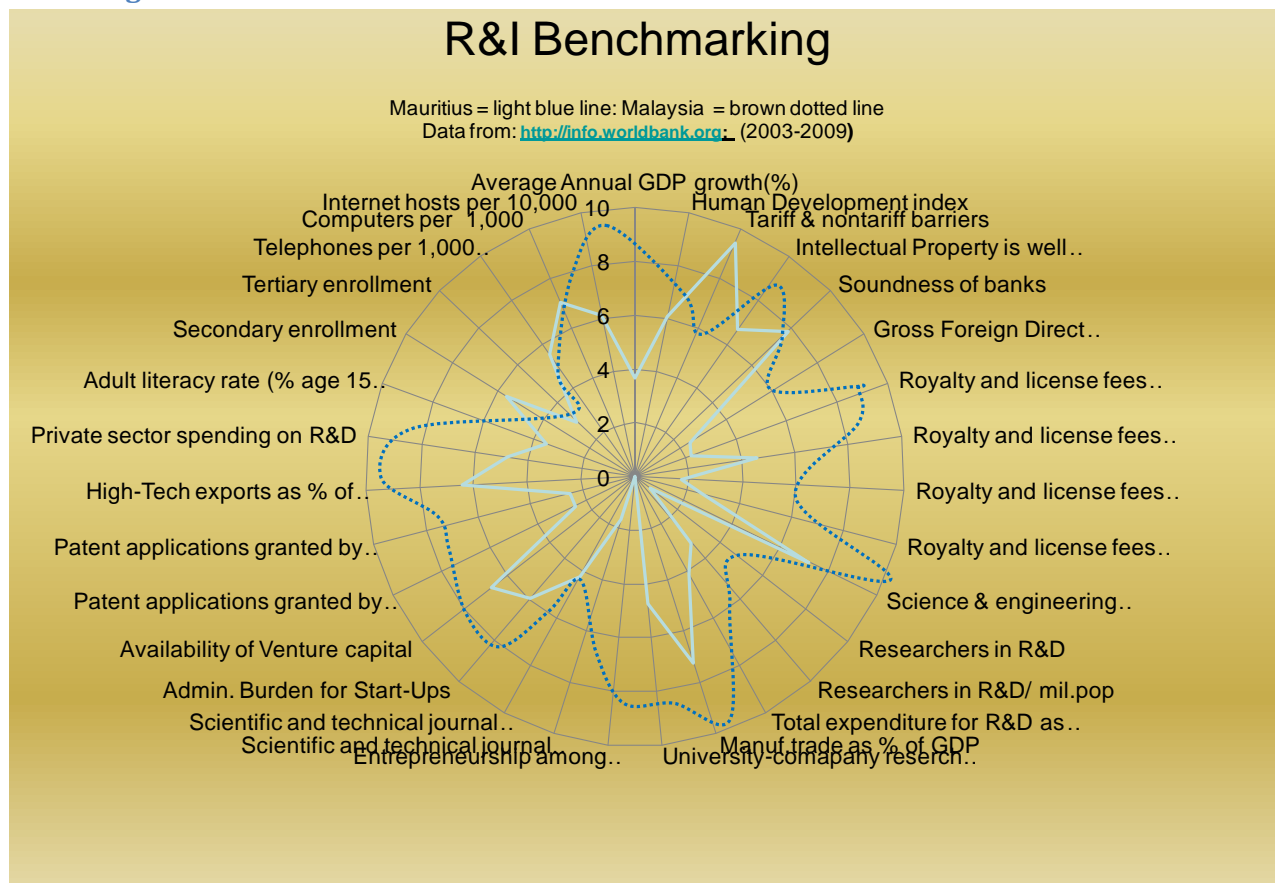
6.5 Benchmark analysis

Due to the unique combination of size, location and history, it was decided in the NRFE that a conventional STI / R&I analysis of indicators, and benchmarks was probably less useful to the overall purpose. However for the record, we include some basic comparisons. These are summarized here as between Mauritius and Malaysia, as a not too distant emerging economy (data tables are in the Technical Annex, and the MRC Working Papers).

(extract from NRFE Working Paper 12 from MRC)

“Mauritius is classified as an upper middle income country with a per capita income of US\$ 7250 in 2009. To keep upgrading, Mauritius needs to innovate; it is thus important to assess the current state of the innovation environment. The methodology adopted here takes this aspect into consideration and draws on existing secondary data to map the innovation space. We have borrowed from the World Bank’s Knowledge Economy Index (KEI) and Knowledge Indexes (KI) and adopted the definition of National Productivity and Competitiveness Council (NPCC) to define an innovation landscape. For this reason, data from World Bank notably on knowledge based index was assessed to benchmark Mauritius with the innovation performance system of two countries namely; Malaysia (ranked just before Mauritius) and Finland (ranked 1st on innovation performance). The knowledge based index (<http://info.worldbank.org/>) is built on four pillars and these are Economic Incentive regime, Innovation system, education and information Infrastructure (see figure xxx).”

6.5.1 Figure 8: R&I benchmarks



Some observations on the comparison:

- Overall GDP is higher in Malaysia: HDI levels are similar.
- Of the innovation system, IP is better protected in Malaysia, with higher royalties and licence ratios: however, banks are slightly better rated in Mauritius
- Larger proportion of STEM graduates (37% vs 24%), and researchers in R&D, in Malaysia;

- Much larger expenditure on GERD and BERD, and larger proportion of university-company research;
- Hi-tech exports are nearly 10% in Malaysia, and patents granted are much larger;
- Higher literacy rates in Malaysia, while secondary & tertiary enrolments are similar;
- Telephones and computers per head are similar, but Malaysia has twice the ratio of internet hosts.

7 SCENARIO ANALYSIS

The main purpose of this section, is to link the current trends and alternative future scenarios, with their implications for cluster themes and R&I policies.

A series of 3 key matrices set out the main connections between the following:

- **Futures: Cluster theme / trend projection:** this takes the MRC work on the baselines, put into simple matrix form in the cluster theme format.
- **Futures: Cluster theme / scenario:** a simple summary of the cluster workshop outputs: and also includes the beginning concepts for a 'success scenario', or 'strategy'.
- **Futures: R&I policy / scenario:** this analyses across the clusters, to identify R&I policies, and also broader approaches, which were raised in the cluster meetings.

7.1 Trends and projections

The 'Futures outlook' section showed a range of current statistics): with 10-20 year historic trends, then projected at the same rate of growth towards 2025. There is a large note of caution here: faster growth trends are unlikely to continue for long without meeting some kind of limit, physical or human. However, pending further detail, such projections are a guide to what kind of issues can be expected:

- Very high growth: imports, exports, CO2 from electricity generation, visitor numbers and air travel
- High growth: total CO2 and surface transport
- Moderate growth: water consumption, and urban / total population
- Moderate decline: average rainfall, local renewable energy, and land in export crops (sugar / tobacco / tea).

7.1.1 Matrix 4: Futures: Cluster theme / trend projection

(Percentages refer to year on year change, averaged over 10-20 years data where available: some fields are left empty pending further data gathering).

	Trend to 2010 – totals	Trend to 2010 - details	Projection to 2030	Implications
Marine / land				
Ocean & coastal	Lagoon health:			
Inland	Urbanization:			
Biodiversity				
Climate change	Rainfall: -1% reduction	Cyclones:		Water resources?
Climate emissions	Total CO2: 5%	Power generation: 8.25% Other incl tourism: 4.95%		Emissions trend? (note)
Agriculture / health				
Agriculture	Total cash crop: -2.6%	Tea area: -4.75% reduction		
Sugar industries	Sugar area: -1.1% reduction		Development of the cane industry	
Food sector		Increased dependency on imports		Increased food import bill
Public health	HDI: 0.82% increase	NCDs increasing		
Infrastructure				
Energy	Total energy cons 1.44% Commercial / hotels 7.4%	Imported coal 17% Imported diesel 3.5% Bagasse: -1% reduction		Energy demand rise Coal dependency?
Water	Total consumption treated water m3: 1.84%	Commercial 5.2%: hotels 4.5% households per cap: 1%		Water resource?
Waste				
Transport	Total energy: 3.75%	Diesel 4.4%: DPK 4.9%		
Social & cultural				
Demographic change	Population: 0.39%	Urban pop: 0.30%	Total 0.48%: urban 1.18%	Urbanization issues (note)
Poverty issues				
Gender issues				
Empowerment, etc				
Enterprise resources				
Skills & careers				
SMEs & innovation				
Trade	Total exports: 7%	Total imports: 9%		Trade balance
Social enterprises				
Global resources				
Communications	Internet users: 10%	90% have mobiles. Air travel: 6%		Air travel saturation?
Finance	Total GDP 4.65% (1995-10)	Growth rates decreasing over the last years		
Tourism	Total visitors / rooms: 6%	Tourism income: 14% Hotels: 2%		Tourism saturation?
Networks				

7.2 Scenarios for cluster themes

This shows a summary of the cluster workshop outputs: and also the beginning concepts for a 'success scenario', or 'strategy development concept'.

To summarize these, with a focus on the success scenarios

- **Marine / land-ocean industries.** The success agenda includes - Ocean & coastal diversification: Adaptive environmental management: Integrated hi-tech / low-tech conservation: Integrated climate management
- **Agriculture / sugar / food / other land-based industries.** The success agenda includes - Multi-level farming & land management: Balanced technical innovation: Multi-level food systems: Global-local food health policy.
- **Infrastructure,** including energy / water / transport / waste / urban planning: The success agenda includes - - diversified energy systems: water resilience: resource diversification: transport & access paradigm shift.
- **Social & cultural issues:** education, empowerment, citizenship, workplace conditions, quality of life, etc. The success agenda includes – Increased equity across society
- **Enterprise resources:** i.e. knowledge-based enterprise: physical science / manufacturing / supply chains. The success agenda includes – improving the environment to increase innovation at enterprise level.
- **Global resources:** finance, ICT, tourism, trade & transport links, climate change, security, etc: The success agenda includes - multi-level communications & knowledge management: diversified global / local financial sector: multi-level integrated visitor hospitality system: collaborative knowledge via global networks.

7.2.1 Matrix 5: Futures: Cluster theme / scenarios

Note: the table has been interpolated across 3 scenarios for each cluster theme, plus further interpretation of the 'success' scenario.

	'GROWTH AT ALL COSTS'	'WIN-WIN'	'ISLAND'	'SUCCESS'
KEY THEMES & TOPICS	'trend'	'Plan A'	'Plan B'	'no regrets' – agenda for R&I
Marine / land				
Ocean & coastal	Private investment in ocean resources	Partnership management of oceans	Local resources in ocean industries	Sustainable ocean & coastal diversification
Inland	Privatization of land & coastal strip	Collaborative land management	Local community land resources	Adaptive environmental management
Biodiversity	Rapid urbanization Pressure on biodiversity	Balanced urban-rural devt / conservation management	Indigenous ecological knowledge	Integrated hi-tech / low-tech conservation
Climate change	Climate emissions & impacts increase	Renewable energy & rapid climate adaptation	Local self-sufficiency & resilience	Integrated climate management
Agriculture / health				
Agriculture	Industrialized intensive farming	Sustainable farming with global / local balance	localized diversification in farming	Multi-level farming & land management
Sugar	Rapid restructuring	New products for global markets	Local products for local markets	Balanced technical innovation
Food industries	Globalized food chains	Sustainable global chains	Food self sufficiency	Multi-level food systems
Public health	Industrial diets, glucotoxic & allergenic syndromes	Sustainable balanced diets	Sustainable local diets	Global-local food health
Infrastructure				
Energy	Fossil fuel dependency	Balanced energy systems	Island self-sufficiency	Diversified energy system
Water	Intensive water systems	Balanced water systems	Autonomous water system	Water resilience
Waste	Material & waste intensive	Waste reuse & recycling	Total resource recovery	Resource diversification
Transport	Rising private car mobility	Multi mode & travel demand management	Local travel & accessibility	Transport & access paradigm shift
Social & cultural				
Demographic change	Rise of affluent classes	Balanced population	Income redistribution	Integrated society concepts
Poverty issues	Growth creates divisions	Growth out of poverty	Non-material prosperity	Holistic poverty reduction
Gender & generation	Roles are more polarized	Inclusion through development	Full equality of genders & generations	Socio-cultural transitions
Empowerment etc	Consumer choice designed by MNEs	Active global-oriented citizenship	Active local citizenship	Empowerment agenda
Enterprise resources				
Skills & careers	Shaped by MNEs	Holistic skills are valued	non-material skillsets	New skill / learning systems
SMEs & innovation	Profit is the only incentive	Smart networks for SMEs	Social-eco- innovation	SME dynamics
Finance	Low-tax hub & global flows	Integrated smart finance	Social-ecological finance	Integrated financial models
Social enterprises	Picking up the pieces of a privatized state	Integrated to mainstream economy	Combined social-economic-ecological enterprises	Dynamics of social-cultural-ecological enterprise
Global resources				
Communications	Air travel growth 5% p.a.	ICT speed & bandwidth	Shift to localized interactions	Multi-level communications & knowledge management
Finance	Financial flow growth 5%	Diversified & value added financial sectors	Global finance flows shift to local eco-social resources	Diversified global / local financial sector
Tourism	Tourism doubles in 15 years	long stay eco-tourism with social integration	Tourism reduces, long stay	Multi-level integrated visitor hospitality system.
Networks	Diaspora in the service of private MNEs	Diversified social & cultural networks	Shift to virtual networks	Collaborative knowledge via global networks

7.3 Scenarios for policy responses

This analysis looks across the clusters, to identify R&I policies, and also broader approaches, which were discussed in the cluster meetings. The scenarios include a wide range of possibilities:

- Science Base & higher education issues: short or long term: public or private focus:
- Human Resources & training issues: narrow or wide scope: local or global:
- Business Enterprise R&D / Innovation focus: shorter or long term:
- SME & firm clusters & networks issues: profit focused or society focused:
- Technology / Knowledge Transfer focus: private or public agenda:
- Innovation governance, IP & related issues: traditional IP or co-production paradigm:
- Finance, access & equity issues: narrow or diversified concepts of finance & equity:
- Policy interventions & public procurement: cost saving or lead market thinking:
- Globalisation & International issues: tension or diversification:
- Sectoral disparities and distribution issues: social-economic division or integration.

To follow this through, we chart the implications of each scenario for the type of R&I policy responses which can be anticipated:

7.3.1 Matrix 6: Futures: R&I policy / scenario

	'GROWTH AT ALL COSTS'	'WIN-WIN'	'ISLAND'	'SUCCESS'
<i>R&STI policy</i>	<i>'trend'</i>	<i>'Plan A'</i>	<i>'Plan B'</i>	<i>'no regrets'</i>
Science Base & higher education issues	HE to service private & global enterprise	HE integral to successful knowledge society	HE by & for service of the local community	HE priority for transition to sustainable knowledge society.
Human Resources & training issues	Training branch plant workers in 2-tier society	HR is diversified for global & local value added.	HR for social & economic cohesion	HR for multi-level global-local community
Business Enterprise R&D / Innovation focus	focus on short term near market returns	R&D for collaborative ethical business	R&D for local sustainable business	transition to sustainable knowledge society
SME & firm clusters & networks issues	global investor science park as strategic hub	SMEs are co-owned with crowd investment.	Clusters for socio-ecological values	Balanced local-global clusters & networks
Technology / Knowledge Transfer focus	Knowledge is private & profit focused.	Knowledge is firstly a public resource	Knowledge is more local & indigenous	Diversification of knowledge types
Innovation governance, IP & related issues	Innovation system run by & for global investors.	Shift to a multi-level global-local exchange hub	Collaborative IP is open to the community	Focus on local added value with global links
Finance, access & equity issues	Finance is global & focused on short term	Multi-level finance to match global & local	Finance diversified into social & ecological	Multi-level finance to match global & local
Policy interventions & public procurement	Most public services become privatized.	Public procurement for global-local exchange	Procurement incentives for local lead markets.	Diversified economic drivers of innovation
Globalisation & International issues	Island is a global hub with small backyard.	Successful balance of global & local added value	Global links shift to virtual, visitors stay longer	Multi-level adaptive strategy for global-local
Sectoral disparities and distribution issues	Result - social divisions & ecological breakdown	Result: public-private & global-local exchanges	Result: focus on social goals of equality & inclusion	Result: strategic & normative orientation for R&I.

7.4 General implications of the scenarios

7.4.1 Implications of 'Trend scenario':

- In the 'Growth at all costs' future, the R&I system becomes more of a tool for increasing private profit for the MNEs and overseas investors. It seems likely that the unique assets of Mauritius, would see the internationalization of scientific networks and use of a desirable tourist friendly location. This in turn would steer development towards a 2-tier society: the knowledge-based classes enabled by the R&I system, would be focused on short term material gain: while others would be excluded. Key themes here cover: HE (higher education) to service private & global enterprise:
- Training branch plant workers in 2-tier society
- focus on short term near market returns
- global investor science park as strategic hub
- Knowledge is private & profit focused.
- Innovation system run by & for global investors.
- Finance is global & focused on short term

- Most public services become privatized.
- Island is a global hub with small backyard.
- Result - social divisions & ecological breakdown

7.4.2 Implications of 'Win-win' 'Plan A' scenario

In the win-win scenario, we can anticipate how the R&I system is integral to a high-value, innovative, knowledge based society and economy. And to achieve broader goals than simply 'growth', such knowledge is more than simply technology and business – it includes social, cultural, ecological, and ethical dimensions. It is also not reserved for 'experts' but rather spread and embedded in all parts of society. In this scenario Mauritius continues to develop as a highly internationalized hub, so the knowledge society mobilizes this to best advantage, with global networks of science, social and cultural exchange. To summarize:

- HE integral to successful knowledge society
- HR (human resources) is diversified for global & local value added.
- R&D for collaborative ethical business
- SMEs are co-owned with crowd investment.
- Knowledge is firstly a public resource
- Shift to a multi-level global-local exchange hub
- Multi-level finance to match global & local
- Public procurement for global-local exchange
- Successful balance of global & local added value
- Result: public-private & global-local exchanges

7.4.3 Implications of 'Island' or 'Plan B' scenario

On the other hand, the global economic development path should not be assumed, and there is a strong case for a 'Plan B'. This aims at social and ecological resilience, non-material forms of prosperity, and a more diverse set of knowledge and practice, than only physical science and technology. While global trade, finance, exchange and tourism is reduced, it would still continue to generate a flow of innovations, which would be more directed to creative thinking on sustainable development models. Some R&I issues include:

- HE by & for service of the local community
- HR for social & economic cohesion
- R&D for local sustainable business
- Clusters for socio-ecological values
- Knowledge is more local & indigenous
- Collaborative IP is open to the community
- Finance diversified into social & ecological
- Procurement incentives for local lead markets.
- Global links shift to virtual, visitors stay longer
- Result: focus on social goals of equality & inclusion

7.4.4 Implications for R&I of 'success scenario'

The primary focus of the R&I system, and the ultimate goal of all the themes and clusters, is the knowledge needed for the transition towards sustainable development. The USP is the situation of Mauritius as the 'living laboratory' of a small island tropical emerging nation. Some key themes include:

- HE priority for transition to sustainable knowledge society.
- HR for multi-level global-local community
- transition to sustainable knowledge society
- Balanced local-global clusters & networks
- Diversification of knowledge types
- Focus on local added value with global links
- Multi-level finance to match global & local
- Diversified economic drivers of innovation
- Multi-level adaptive strategy for global-local
- Result: strategic & normative orientation for R&I.

8 STRATEGY DEVELOPMENT

The purpose of this section on strategy development, AKA ‘road-mapping’, is to link the emerging objectives of a research strategy, with stakeholders, activities, measures, resources and priorities.

A series of 4 key matrices set out the main connections between the following:

- **7) Strategy: Cluster theme / R&I capacity:** this analyses the content of the thematic approach relevant to various actors.
- **8) Strategy: R&I policy / R&I capacity:** the core of the strategy or roadmap, which matches policy to resources and capacity.
- **9) Strategy: R&I policy / time & resources:** a concept outline of a national strategy, with practical constraints: this will guide and inform the national 5-year Research Strategy.
- **10) Strategy: Cross-impact cluster theme:** this tracks the potential linkages or conflicts between each of the cluster themes and their contents.

8.1 Cluster themes and R&I capacities

The first question is for each of the cluster themes, what are the roles of the various stakeholders, and what are their capacities for positive action to support R&I?

Matrix 7 below analyses the content of the thematic approach relevant to various actors. (*MRC actions are to be discussed*). In summary this includes in general terms:

- **Government and public agencies:** integrated strategies which put R&I in the lead role as the catalyst for new business models, to be facilitated by a combination of procurement, regulation, fiscal incentives and other public facing policies.
- **Higher education and related organisations:** new concepts of inter-disciplinary education and skills development, which focus on integrated systems in industrial ecology and social enterprise, and using new paradigms for learning and knowledge co-production.
- **Private sector business and finance:** accelerating R&I to look for new business models, linked to social & ecological agendas, raising the knowledge & skill base of employees.
- **Civil society organizations (CSOs):** catalysts, facilitators and and coordinators of integrated systems models for production, consumption and civil society.
- **MRC with related organizations:** catalysts, facilitators and and coordinators of the knowledge and intelligence required for the above.

8.1.1 Matrix 7: Strategy: cluster theme / R&I capacity

	Government & public agencies	Higher education & related	Private sector industry, finance	Civil Society Organizations	MRC & collaborators
Marine / land					
Ocean economy	strategy leaders	Priority for oceanic studies	Major long term investments	Safeguards of social & ecological issues	<i>Main facilitators & coordinators</i>
Island environment	Strong policy regime	Environment science	Eco-enterprise	Stewardship & lobby	<i>R&I programs</i>
Biodiversity	Strategic landuse	Ecosystems science	Eco-enterprise	Stewardship & lobby	<i>R&I programs</i>
Climate change	Climate priorities in all policy areas	International links	Carbon enterprise potential	Stewardship & lobby	<i>Main facilitators & coordinators</i>
Agriculture / health					
Agriculture	Integrated production / consumption policy	Systems perspective on food / agri studies	New business opportunities	Farming support networks	<i>Coordinate R&I on synergistic agenda</i>
Sugar	Conversion of sugar sector	Links to institute	New business opportunities	Support for restructuring	<i>Coordinate R&I on synergistic agenda</i>
Food industries	Regulation of food industry	holistic food / health patterns & pathways	New markets & social businesses	Social enterprise in food industry	<i>Coordinate R&I on synergistic agenda</i>
Public health	Health service links	holistic food / health patterns & pathways	Lifestyle / health / food business model	Community health education/ enterprise	<i>Coordinate R&I on synergistic agenda</i>
Infrastructure					
Energy	Integrated policy / procurement	Systems level studies for sustainability	Integrated models for sustainable utilities	Enabling integrated energy systems	<i>Coordinate R&I on synergistic systems</i>
Water	Integrated policy / procurement	Systems level studies for sustainability	Integrated models for sustainable utilities	Enabling integrated water systems	<i>Coordinate R&I on synergistic systems</i>
Waste	Integrated policy / procurement	Integrated supply-demand systems	Business models for integrated resources	Enabling integrated material systems	<i>Coordinate R&I on synergistic systems</i>
Transport	Urban planning for new transport models	Integrated supply-demand systems	Business models for sustainable transport	Enabling integrated travel / accessibility	<i>Coordinate R&I on synergistic systems</i>
Social & cultural					
Demographic change	Third age & youth as innovation resources	Lifelong learning networks	Third age & youth as economic resource	Social enterprise networks & resources	<i>Coordinate R&I on new social models</i>
Poverty issues	Anti-poverty as social innovation agenda	Widen access & scope of education	Ethical business for anti-poverty agenda	Social enterprise networks & resources	<i>Coordinate R&I on new social models</i>
Gender issues	Gender equality as social innovation	Widen access & scope of education	Ethical business for gender equality	Social enterprise networks & resources	<i>Coordinate R&I on new social models</i>
Empowerment etc	Active citizenship as social innovation	Education for active citizenship	Social business for active citizenship	Social enterprise networks & resources	<i>Coordinate R&I on new social models</i>
Enterprise resources					
Skills & careers	Incentives for up-skilling	Education / industry & finance links	Incentives for up-skilling	Lifelong skills & mentoring networks	<i>Enhanced tech transfer programs</i>
SMEs & innovation	regulation, funding, lead procurement	Education / industry & finance links	Incentives for R&I in SMEs	New models for social business & networks	<i>Enhanced tech transfer programs</i>
Finance	Financial access & ethical finance	Business training & mentoring	Financial sector incentives for R&I	New models for social & ecological finance	<i>Enhanced tech transfer programs</i>
Social enterprises	Facilitation for social enterprises	Social enterprise training & mentoring	New models for social business & networks	Social enterprise support functions	<i>Enhanced tech transfer programs</i>
Global resources					
Communications	National wireless coverage	ICT –enabled education	Online business communities	Online social & cultural communities	<i>Digital futures program</i>
Finance	Financial sector incentives for R&I	Education / industry & finance links	Access to investment & joint equity	New social & ecological finance	<i>Diversified finance program</i>
Tourism	Promote responsible eco-tourist activity	Enhance knowledge base for tourism	Incentives for skills & eco-tourism	Social enterprise for eco-tourism	<i>Enhanced tourism program</i>
Networks	reverse migration & active diaspora	Incentives for global science networks	joint equity / reverse innovation schemes	promote active diaspora	<i>Expand diaspora program</i>

8.2 Research & innovation policy & capacity

At this point we can see emerging the core of the strategy development, i.e. the actions which aim to combine R&I policy to resources and capacity of the stakeholders involved.

8.2.1 Matrix 8: Strategy: R&I policy / R&I capacity

	Government & public agencies	Higher education & related	Private sector industry, finance	Civil Society Organizations	MRC & related
Science Base & higher education issues	Raise total GERD funding to OECD level	Enterprise & innovation culture	Enterprise & innovation culture	Lifelong learning & knowledge sharing	<i>Pro-active linkages from science-public-private-CSOs.</i>
Human Resources & training issues	Transform public sector to knowledge based organization	Career structure & incentives	Career structure & incentives	Lifelong learning & knowledge sharing	<i>Pro-active HR development systems</i>
Business Enterprise R&D / Innovation focus	Lower barriers to startup	Incentives for world class R&D	Lowering barriers, changing attitudes	Social & ecological business models	<i>Managed R&D, lead market programs</i>
SME & firm clusters & networks issues	Enabling of clusters / science park	Active engagement with clusters	Finance for cluster & network schemes	Social & ecological business models	<i>Active clusters on integrated themes</i>
Technology / Knowledge Transfer focus	Up-skilling of public sector	Technology / academic interface	Finance for transfer, exchange schemes	Social & ecological forms of knowledge	<i>Business mentoring & incubation</i>
Innovation governance, IP & related issues	IP enabling in public system.	IP enabling in academic system.	IP enabling in business system	Social & ecological forms of knowledge	<i>IP services & intermediaries</i>
Finance, access & equity issues	Promote long term finance & equity	Active links from finance to HE	Promote long term finance & equity	Social & ecological forms of finance	<i>Venture capital & equity schemes</i>
Policy interventions & public procurement	Procurement as main driver of R&STI	Incentives for lead markets proc.	Strategic collaboration with regulators	Social & ecological objectives in procurement	<i>Manage public service R&D needs for lead markets</i>
Globalisation& International issues	Promote global scientific networks & collaborations	Global scientific networks & collaborations	Mobilize global science-business exchange	Mobilize global social & ecological networks	<i>Promote global scientific networks & collaborations</i>
Sectoral disparities and distribution issues	Focus on actions with possible negative outcomes	Address the knowledge divide through HE	Promote ethical & ecological finance & business.	Promote ethical forms of production & consumption	<i>Coordinate stakeholders for progressive agenda</i>

Here we summarize for each of the main stakeholder types, the typical roles to be played, and the main opportunities which can be anticipated through a National Research & Innovation Strategy:

8.2.2 Government & public agencies policies

The government has the major role to play in leading and enabling the transition to a more comprehensive knowledge based society. There are some 'hard' measures of progress: principally the raising of public GERD to the recommended OECD level of 1% of GRP. Almost more important, there is a wider range of measures, such as procurement, SME incentives, investment incentives, restructuring of higher education, etc. This is a summary of key issues:

- Raise total GERD funding to OECD level
- Transform public sector to knowledge based organization
- Lower barriers to startup
- Enabling of clusters / science park
- Upskilling of public sector
- IP enabling in public system.
- Promote long term finance & equity
- Procurement as main driver of R&STI
- Promote global scientific networks & collaborations
- Focus on actions with possible negative outcomes

8.2.3 Higher education & related organizations

The HE system was perceived in the consultations as needing structural change, in order to be more responsive and effective in a wider knowledge based society and economy. Key issues include:

- Enterprise & innovation culture
- Career structure & incentives
- Incentives for world class R&D
- Active engagement with clusters
- Technology / academic interface
- IP enabling in academic system.
- Active links from finance to HE
- Incentives for lead markets proc.
- Global scientific networks & collaborations
- Address the knowledge divide through HE.

8.2.4 Private sector industry, SMEs, finance

The industrial and finance sectors are the engines of growth: but they appeared in the consultation as too often short-termist, profit focused, risk-averse and innovation resistant, with increasing dependency on the MNEs. So the agenda here is not only 'how can the private sector help the R&I system' – but the other case of how the R&I system can help the private sector. Some key themes and actions include:

- Enterprise & innovation culture
- Career structure & incentives
- Lowering barriers, changing attitudes
- Finance for cluster & network schemes

- Finance for transfer, exchange schemes
- IP enabling in business system
- Promote long term finance & equity
- Strategic collaboration with regulators
- Mobilize global science-business exchange
- Promote ethical & ecological finance & business.

8.2.5 Civil Society Organizations

With many combinations of interest-group, lobby-group, professional association and others, the Civil Society Organizations (CSOs) are much more than the add-ons to mainstream economy and government. In each of the above scenarios, they have the potential as facilitators and ‘thought leaders’ for new kinds of sustainable development models, and the R&I knowledge systems which are needed. These are some of the roles they can play:

- Lifelong learning & knowledge sharing systems
- Social & ecological business model innovations
- Social & ecological forms of knowledge based enterprise
- Social & ecological forms of finance, capital and exchange systems
- Social & ecological objectives in procurement in all sectors
- Mobilize global and international social & ecological networks
- Promote ethical forms of production & consumption

8.2.6 MRC & related organizations

The MRC role and agenda in this is up for discussion following the results of the NRFE. Briefly this is a listing of some of the themes which have emerged.

- Pro-active linkages from science-public-private-CSOs.
- Pro-active HR development systems
- Managed R&D, lead market programs
- Active clusters on integrated themes
- Business mentoring & incubation
- IP services & intermediaries
- Venture capital & equity schemes
- Manage public service R&D needs for lead markets
- Promote global scientific networks & collaborations
- Coordinate stakeholders for progressive agenda

8.3 Towards a roadmap

Here we show a first outline of the components of a roadmap. Matrix 9 maps the R&I policy areas against the three horizons of the roadmap structure. This is elaborated and explained in the next section Part IV - Synthesis.

8.3.1 Matrix 9: Strategy: R&I policy / R&I capacity

	Horizon 1	Horizon 2	Horizon 3	
	Shorter term priorities	Medium term objectives	Longer term goals & transitions	Resource Issues
Science Base & higher education issues	Prioritize R&I actions in the cluster themes. Explore new R&I models for science participation, funding, dissemination.	R&I should be a primary focus of lifelong education for all social & business enterprise.	New models for R&I in society & economy, incl science participation, funding, dissemination.	Wider combinations of resources from public, education, business & CSO, need to be mobilized & coordinated.
Human Resources & training issues	skill development programs, coordinated with SME fiscal incentives.	HR & skills / training systems should be the focus of development in public & private sectors	continuous skill development across society & economy.	Added value through upskilling & shift to knowledge based activity.
Business Enterprise R&D / Innovation focus	Scoping studies on business R&I models, which can address wider policy agendas.	Business should orientate R&I activity towards new business models which address wider agendas in policy & society.	new social business R&I models, which can address wider policy needs.	Added value via strategic market opportunities: and via improved employee / customer relations.
SME & firm clusters & networks issues	Next stage of 'cluster themes' development, with focus on supply, demand & networking of R&I assets, for each cluster theme.	Clusters and R&I networks should be coordinated to address larger social business opportunities.	SMEs and firms linked into larger networks of shared intelligence & collaboration	Added value via strategic market opportunities: and via improved employee / customer relations.
Technology / Knowledge Transfer focus	Enhanced tech transfer services & engagement of SMEs & industry associations	Knowledge transfer as part of a broader strategy which includes for new social business models.	Knowledge transfer & shared learning is embedded into every sector & organization	Tech transfer professional services
Innovation governance, IP & related issues	Enhanced IP services & engagement of SMEs & industry associations	IP-related assets should be managed as part of a wider policy agenda for integrated R&I.	Innovation & creative IP is embedded into every sector & organization	IP professional services
Finance, access & equity issues	Scoping studies on financial & accounting framework, for social & ecological assets & values.	Finance for R&I should be freely accessible on suitable terms, incl. for social & ecological values and objectives.	Fully holistic financial models, including social & ecological assets & values.	Diversified forms of financial investment, combined with social & ecological assets.
Policy interventions & public procurement	Identify public service procurement profiles & processes in the context of wider strategic objectives.	Public sector policy & procurement should prioritize lead markets & critical technologies.	public procurement is the catalyst for enabling wider strategic objectives	Strategic procurement costs seen as investment in wider policy objectives.
Globalisation & international issues	Identify sources & flows of external finance into business R&I activity: Diaspora programme to be extended to a more active multi-level engagement.	Balanced diversification of global-local firm structures, equity, finance and human resources, should be the first priority of R&I policy.	Fully internationalized and smart specialized R&I community.	Diversification of investment & collateral inputs can be seen as enabling of wider policy objectives.

8.4 Inter-connecting the cluster themes

The issue here is that each of the cluster themes described above is not fixed into silos or boxes. Rather they are extremely open and fluid, and will increase significance by active exploration of the inter-connections. The matrix below tracks some key potential linkages or conflicts between each of the cluster themes and their main topics.

8.4.1 Matrix 10: Strategy: cross-impact by cluster theme

	Marine / land resources	Agriculture / sugar / food / health	Infrastructure resources	Social & cultural issues	Enterprise resources
Global resources					
Communications	ICT based conservation	ICT based agriculture	ICT based resource management	Global-local balance of communications	Digital upskilling of business & HR
Finance	Ecological finance models	Ecological finance models	Finance sustainable infrastructure	Global-local balance in finance & equity	Global-local balance in finance & equity
Tourism	Eco-tourism	Eco- & health tourism	Low energy/ water tourism models	Integrated eco& cultural tourism	New tourism HR & business models
Networks	International R&I networks	International R&I networks	International R&I networks	Global social-cultural networks	Global business / finance networks
Marine / land					
Ocean & coastal		Aquaculture & fish	Marine energy & water	Oceanic culture	Human resources & investment
Inland		Landuse change	Sustainable energy & water	Environmental sociology	SME & environment-business
Biodiversity		Ecology & health	Nature conservation under pressure	Ecology & society	Biodiversity & economic devt.
Climate change		Low carbon food & climate adaptation	Sustainable energy & water	Climate adaptation in the community	Climate business opportunities
Agri / health					
Agriculture			New food types	New types farming	Farm restructuring
Sugar			New bio-energy	Sugar restructure	Sector restructuring
Food industries			energy / water scarcity	Healthy food in the community	Sustainable business models
Public health			Sustainable diets	Health education	Sustainable business models
Infrastructure					
Energy				Social energy models	Social business model
Water				Social water models	Social business model
Waste				Social waste models	Social business model
Transport				Sustainable transport	New transport models
Social & cultural					
Demographics					Social business model
Poverty issues					Social business model
Gender issues					Social business model
Empowerment					Social business model

PART IV:

Synthesis

Part IV– Synthesis takes the results of the analysis and strategy development, and puts them together for an outline of a National Research Strategy. The recommendations then summarize the actions and priorities for the next 5-10 years.

9 PUTTING IT TOGETHER

A range of topical issues emerged from the NRFE programme of workshops, interviews and online consultations, and these have been mapped out in Part III - Analysis. In this section we take a broader overview, which is focused on the questions – which research themes: what kind of research models: how to promote these: and who should do what?

9.1 The situation of Mauritius

These are salient issues which have informed the NRFE objectives:

- International cooperation in Mauritius has a different prospect from that of many other small islands, due to its remote location, multiple history, and links with 3 continents.
- The large Mauritian diaspora is one of the most valuable resources for the R&I community (e.g. as in recent circular migration policies)
- Sustainable development is an over-arching and very practical theme, due to location on an island with limited area & natural resources, heavily dependent on imports of food, energy, products etc.
- There are already some very creative initiatives, with combinations of industrial ecology, international cooperation & markets, ‘triple helix’ partnerships of public / private / education sectors:
- Mauritius is one of the most advanced of African nations: but there are deep rooted structural problems, i.e. with under-supply of human resources with particular skills set, unemployment, existing infrastructure not necessarily keeping pace with the development trends, institutional rigidity
- There is a legacy of primary production e.g. sugar cane, which is now struggling to be competitive, and raises major questions about the future.
- The evolution of the economy towards services (e.g. financial, ICT, hospitality, knowledge,...) brings many opportunities but also external impacts on some parts of society, on many environmental resources, on the infrastructure, and not least in new forms of economic dependency.

9.1.1 General issues for R&I in Mauritius

These are issues raised by various stakeholders on the scope of R&I and the innovation system in Mauritius:

- R&I or STI policies often come with an assumed focus on economic development focus: where is there scope for social, cultural, governance innovation?
- At the inception meeting there was some tension between the science / technology communities, and the social-economic-humanities research communities.
- There are typical gaps in cooperation and communication between different types of stakeholders: e.g. entrepreneurial SMEs and investors: public procurement: state funded research & higher education: finance & FDI:

9.2 National Research Foresight: strategic directions

Based on experience so far, we can identify several over-arching strategic approaches for the direction and focus of this NRFE, and what it could aim to achieve.

a) STI system focus:

- following through the agenda of the STIP, exploring some potential for new linkages, but aiming basically at a mainstream agenda of policies & investments in STI activity.

b) Industrial ecology focus:

- This is more focused on the content and themes: i.e. wider range of opportunities in the economic & industrial sectors.
- Some of these are in process, e.g. land-based ocean industries,
- others are at the potential stage, e.g. new business models / social / environmental models for sugar cane & agric-food.

c) Human ecology focus:

- focus on the content and themes, with a wider context which extends beyond the economic to all other activities. For instance, looking at sustainable consumption and integrated supply-demand chains: human resources and governance innovation: arts & cultural innovation: alternative economic and business models.

d) Sustainable development focus

- this orientates as a showpiece for sustainable development, on an island with limited land area. E.g. transport sector could continue as highly energy intensive & polluting: or it could look for transforming technologies & social business models

e) Continuing process focus:

- this recognizes that a 5 year national research strategy is one possible output: but that the more important and bigger picture around this is a process model, more than a fixed output. The focus is then on the communications, collaborations, infrastructures to enable continuing development of synergy, collaborations, learning and shared intelligence between all stakeholders.

Each of these alternative directions could aim to -

- a) Continue in parallel, with the aim of enhancing collaboration and synergy between them

- b) Separate and then prioritize one or another.

9.3 Implications for the national R&I strategy

Previously a number of strategic options were set out in the ‘Summary Review’ of 14-11-11. Following the working groups and interviews, and the contributions of the majority of participants, the preferred direction is now more clearly normative, i.e. aiming towards broad societal goals.

- Research and the STI system ‘should be’ not just a means to an end, and not just to serve business and the economic development agenda. It should aim to contribute to the wider goals of social and ecological development, especially those involving the ‘knowledge society’, ‘high value enterprise’, ‘human resource development’, etc.
- So – the research and STI system should be a vital part of the national strategic agenda for ‘sustainable development’ agenda (i.e. beyond the shorter practical focus of the MID). This sees Mauritius as a model and showpiece for sustainable development, on an island with limited land area.
- This suggests a research agenda which is oriented towards such a sustainable development process, i.e. researching the model and the process of development of the model.

For instance: the transport sector could continue on its conventional path of increasing energy demand & pollution: or it could look for transforming technologies, infrastructures and social business models. This would involve technology and engineering which is likely to be imported or transferred: it also involves innovative social, economic and governance systems, which would be significant R&I themes and unique exports in themselves. Naturally there is not often one single agreed definition of what is ‘sustainable’, rather a contested zone of debate and social innovation.

9.3.1 USP of Mauritian R&I

The USP (unique selling point) of Mauritius and its R&I community should then include a wider scope:

- **The nation could and should be a ‘sustainable development model’ for the world** (in the words of the Prime Minister).
- In particular there are unique opportunities for industrial ecology research / STI development:
- On the human resource side, there is a potential for a highly mobilized research community, within a highly cohesive multi-cultural society.
- All this takes place at a very desirable location and geographical hub located between several continents: i.e this is part of the USP,
- This points towards the potential for mobilizing such resources. There could be potential in parallel to ‘medical tourism’, of advanced ‘scientific tourism’ with high quality conference venues, advanced on-site capacity building in sustainable development (governance, economic, social or ecological systems).

9.3.2 Strategic issues for the methodology

The workshops and interviews highlighted some very topical issues:

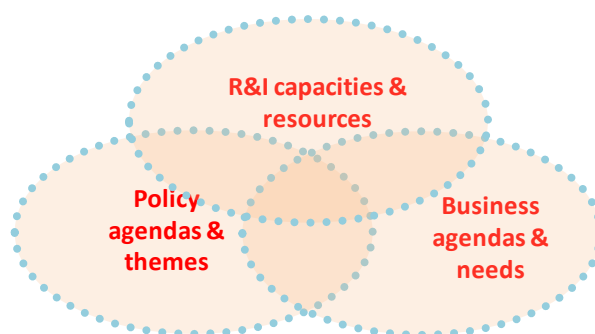
- Normative policy agenda: there is a tension between the role of STI as ‘neutral’ supplier of knowledge: and as active enabler of the national social-economic-environmental policy goals.
- Political economy agenda: within this, there may be differences between policy and business/ finance: in particular, the interests of business/ finance are likely to be externally based, and not always in complete alignment with the agenda of national policy.
- Each of the above then contributes to the ‘key priority matrix’ of supply and demand, as below

Firstly the concept can be shown in graphic form, as here:

- Policy agendas and themes has some direct needs which can be met by research / STI: other needs can be bought in from external sources
- Likewise with business / finance: with the added dimension that much business /finance is based overseas.
- Research / STI capacities and resources: some are directly overlapping with policy or business needs. Others are more indirect / independent, and networked across the international scientific community.
- The highest priority themes would be marked at the centre of the picture, where there is strong capacity, direct policy needs, combined with business engagement which would lead to STI investment.
- The lines between are quite fuzzy, and open to debate and negotiation.

9.3.3 Figure 9: overlapping agendas for R&I

R&I scope & sectoral linkages



9.4 Innovation in R&I models

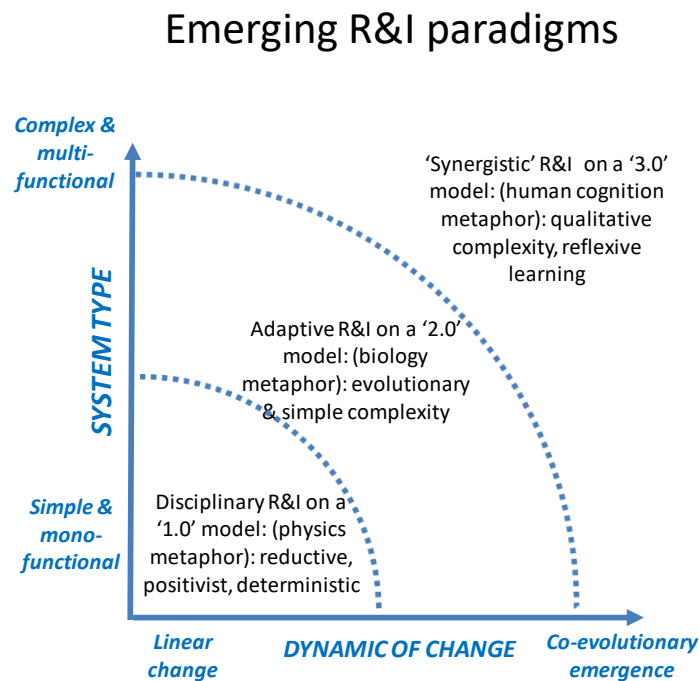
This agenda above calls up some very topical ideas and potential innovations in the R&I model: i.e. not just ‘what’ to research but ‘how’ to research: and how to set research agendas which are often beyond the scope of conventional R&I in order to respond to the Grand Challenges. These are some options and variations as discussed (these also reflect current developments in the European Research Area, the largest funded R&I programme in the world, and where Manchester is very active):

- Policy-engaged or enterprise-engaged, problem-oriented, action research models; this widens the scope of research towards the ‘applied’ side of the table: but also raises new kinds of inter-connections, for instance in industrial ecology combinations.
- Community-based research and data gathering, with techniques such as participatory visioning or deliberation, which bring a wider section of views and experiences, and also help to build capacity for a wider knowledge based society (Irwin, 2003).
- Big data science and applications, which mobilize on the current mushrooming of technical datasets, geo-location data, social media data, with intelligent and self-learning algorithms (Hudson-Smith, 2006).
- ‘Post-normal’ or ‘co-evolutionary’ science paradigms: especially to respond to problems or opportunities which are complex and controversial, emergent and indeterminant (Ravetz et al, 2011).
- Social technology applications, many of them very new, combined with pervasive remote sensing: for network-type problems which are suitable for ‘crowd-sourcing’ or ‘threaded discussions’, also combined with decentralized or mobile data sources, and geo-located applications (Tapscott & Williams, 2007).

The question is then not only ‘what’ to research, but ‘how’ to form and run R&I programmes which are more actively linked to policy and business, and to current trends in science and society. The Grand Challenges approach calls for new directions in R&I practice, with active debate in the world’s largest research programme. Here we just point out the difference between two extremes:

- a) ‘Disciplinary’ science on a linear so-called Mode 1 basis: the metaphor is that of classical physics or neo-classical economics, generally positivist, reductive and deterministic. This is more suitable where system variables are known and measurable, and the dynamics of change are linear and predictable.
- b) ‘Synergistic’ research on a more complex and co-evolutionary Mode 2 (or so-called ‘3.0’) model: (the metaphor is that of personal development). This is more suitable where the systems are complex and multi-functional, and the dynamic of change is emergent in qualitative and structural terms.

9.4.1 Figure 10: emerging R&I paradigms



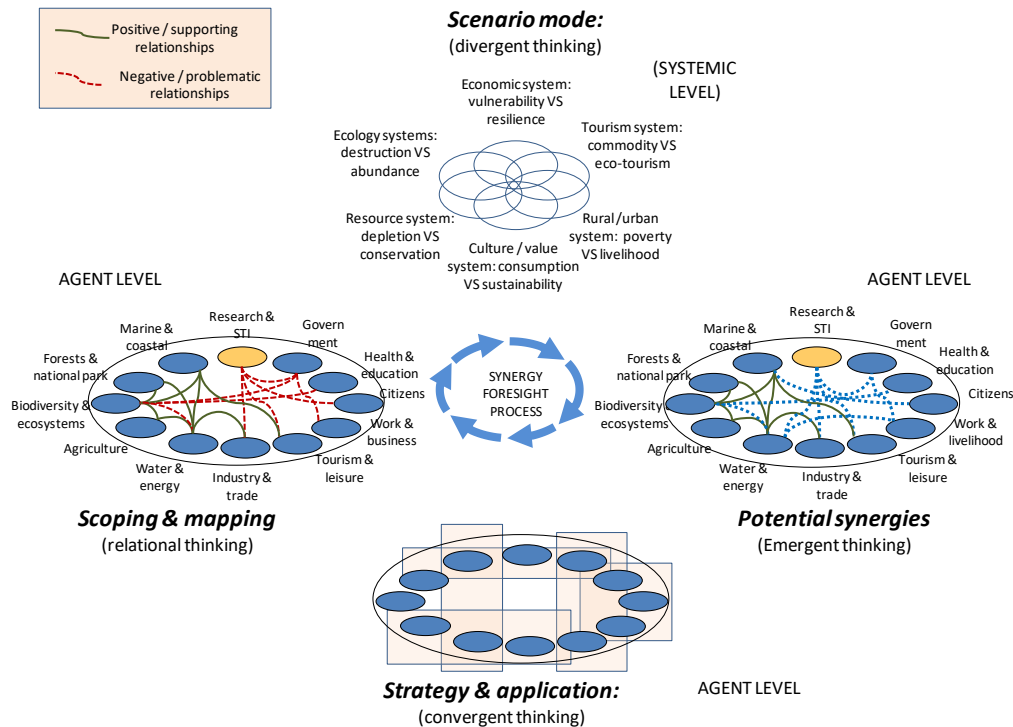
Such new R&I models as above may be better served by new methods, rather than conventional disciplinary boundaries. A method and toolkit for 'synergistic mapping', under development at Manchester was demonstrated in some of the cluster workshops (Ravetz, 2011).

As in figure xxx, this takes a simplified foresight cycle with four stages, and focuses on the 'synergistic' perspective on problems and opportunities. This includes:

- Relational mapping of inter-connections and
- Emergent mapping of co-evolution, mutual learning and collective intelligence.

One result from the marine/ environment working group is shown below. This and others have helped to identify the more holistic and innovative types of R&I models.

9.4.2 Figure 11: mapping inter-connected knowledge



9.5 Innovation & integration in R&I policy

At this point we can enlarge the field of view, and look at the links between the R&I system, and the national development agenda and economic profile. Three broad questions can be explored:

- What kind of socio-economic system could / should be the objective of the NRFE?
- What kind of knowledge activity is needed to enable this?
- What kind of R&I strategy and policy mix can facilitate such knowledge development?

A full study on this is beyond the scope of the NRFE. Here we explore the questions and provide a template to be applied in more detail to each cluster. This is recommended as the subject of further study and stakeholder debate, in a follow-on phase. This Synthesis report reviews the case and provides a template for policies & priorities for the CWGs. The Technical report contains further detail with extracts from relevant EU 'Policy Mix' reports.

9.5.1 What kind of socio-economic system?

The broad aspirations and goals for the national socio-economic system emerged from the Foresight process. To follow up in terms of sectoral structure, firm structure and financial structure, we can follow the direction of current innovation theory, and look for several features:

- An ‘innovation eco-system’: where each of the main actors and sectors, are in positive communication and collaboration:
- a wider ‘relational economy’, with both analysis and policy which puts priority on actors, networks, learning & collaboration:
- general level of diversity and self-reliance: avoiding the risks of financially driven FDI, large public sector projects, or MNC branch-plants.
- (for example there is evidence that the Mauritius EPZs contribute little directly to R&I investment or capacity).

These general points are then translated into the template below, with questions for each of the clusters.

9.5.2 What kind of knowledge is needed?

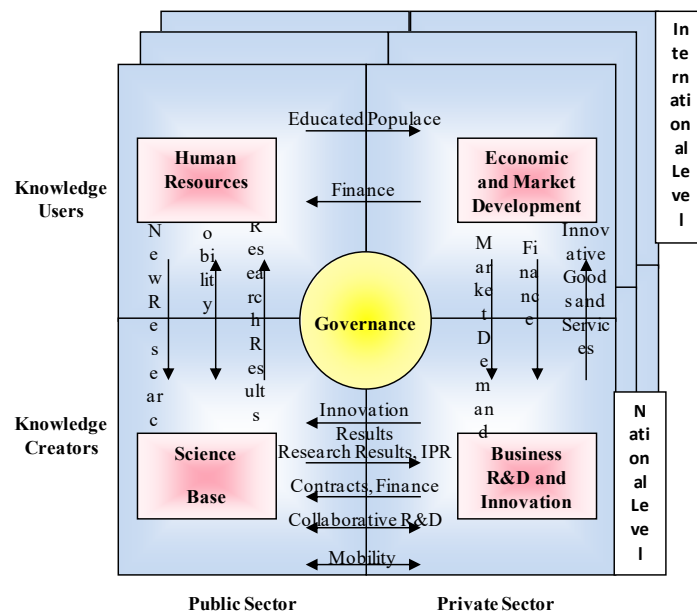
The previous section outlines some of the cross-cutting issues and paradigm changes for ‘what kind of knowledge’. This can then be made more specific, in terms of knowledge producers / users, and public policy / private business interests in such knowledge.

A very simple knowledge - policy domain model, shows some of the most relevant links and flows (e.g. flows of financial resources, human resources, R&D project results etc). It exploits the differences between knowledge creation and knowledge utilisation on the one hand, and between public and private sector actors on the other, to construct a four-quadrant model, with an additional ‘Governance’ sphere affecting activities in all quadrants. Within this model, for example, R&D actors populate an ‘R&D domain’ spread across the lower two quadrants, with public sector R&D performers in the ‘Science Base’ domain and industrial R&D performers located in the ‘Business R&D and Innovation’ quadrant.

9.5.3 Figure 12: Knowledge-Policy Domain Model

Knowledge-policy domains

Source: Adapted from CREST, “Policy Mix Peer Reviews: The Report of the CREST Policy Mix Expert Group—Third Cycle of the OMC in favour of the 3% Objective”, European Communities, 2008



9.5.4 Internationalization & specialization

The Mauritius case for R&I calls up the question of ‘internationalization’ of R&I networks, communications, collaborations and added value. Broadly, most forms of scientific R&I are increasingly internationalized. This takes place partly through mega-regional blocs such as the EU or ASEAN. As the location of Mauritius is between 3 continents, its international role and added value is likely also to be a hub or exchange point. This will be most effective where there is a clear added value in that role: this is likely to be one of the following:

- National capacity in niche areas, e.g. tropical or ocean studies: sustainable development models.
- National policy / business needs and demands, e.g. autonomous infrastructure
- Other national synergies and linkages: e.g. proximity of large financial sector to the above.
- Other national added value, e.g. desirable climate & lifestyle
- Other locational advantage, e.g. as Indian Ocean hub.

A good example of a full internationalization strategy is that of Germany (Federal Ministry of Education and Research, 2011). This states - “....the Internationalization of Science and Research will lead to the identification of the best available knowledge, optimum structures and the most suitable processes by means of continuous international comparison.... It will serve both as a guide and as a basis for improving coordination and increasing exchanges of information, thus promoting their goals and intended impact and exploiting hitherto unused synergy potential”. There are four main goals:

- 1. Strengthening research cooperation with global leaders:
- 2. International exploitation of innovation potentials:
- 3. Intensifying the cooperation with developing countries in education, research and development on a long-term basis:
- 4. Assuming international responsibility and mastering global challenges:

Smart specialisation looks at the counter case to the international: i.e. building the regional / national capacity and added value. It has been defined in the EU sense as “identifying the unique characteristics and assets of each country and region, highlighting each region’s competitive advantages, and rallying regional stakeholders and resources around an excellence-driven vision of their future. It also means strengthening regional innovation systems, maximising knowledge flows and spreading the benefits of innovation throughout the entire regional economy”. Details and materials are on - <http://s3platform.jrc.ec.europa.eu>

9.5.5 What kind of strategy and policy mix can help?

This Foresight has identified for each cluster theme, multiple actors, multiple objectives, and many possible policies and measures to achieve them. The question is then how to ensure that these are as far as possible, coordinated and working in synergy? For this the EU experience and research programme on ‘Policy Mix’ is very relevant (REF). This starts from the evidence on R&D investment versus R&D performance:

- Traditional R&D policy instruments such as direct grants and indirect R&D tax incentives were unlikely on their own to raise R&D investment levels sufficiently;
- A specific policy focus on raising R&D investment levels only made sense within broader policy efforts to stimulate performance improvements across innovation systems as a whole;
- Enhanced innovation system performance could both lead to, and be stimulated by, increased R&D investment;
- A concerted effort was thus needed to develop and promote the concept of policy mixes capable of both raising investment levels and improving innovation system performance.

The main features of the policy mix approach include, as in the model used by IPTS and the ERAWATCH Network, four main functions / processes:

- **Resource mobilisation.** The actors and institutions in the research system have to ensure and justify that adequate public and private financial and human resources are most appropriately mobilised for the operation of the system;
- **Knowledge demand.** The research system has to identify knowledge needs and how they can be met, thus determining priorities for the use of resources;
- **Knowledge production.** The creation and development of scientific and technological knowledge is clearly the fundamental role of any research system.
- **Knowledge circulation.** Ensuring appropriate flows and distribution of knowledge between actors is vital for its further use in the economy and society or as the basis for subsequent advances in knowledge production.

These domains can be elaborated into specific criteria:

Resource mobilisation

- Justifying resource provision for research activities
- Securing long-term investment in research
- Dealing with uncertain returns and other barriers to private R&D investment
- Providing qualified human resources

Knowledge demand

- Identifying the drivers of knowledge demand
- Coordinating and channelling knowledge demands
- Monitoring demand fulfilment (via evaluation)

Knowledge production

- Ensuring quality and excellence of knowledge production
- Ensuring exploitability of knowledge.

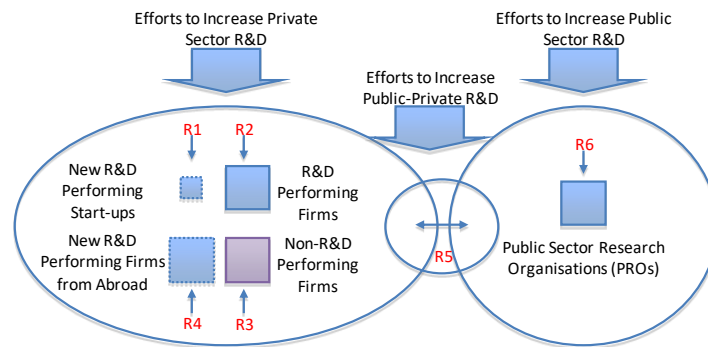
Knowledge circulation

- Facilitating knowledge circulation between university, PRO and business sectors
- Profiting from access to international knowledge access
- Enhancing absorptive capacity of knowledge users

A further question is the target for R&D / R&I investment and performance in different sectors and economic categories. Figure 13 shows separate routes that can be taken to raise R&D investment levels in these sectors via the deployment of a range of policy instruments.

9.5.6 Figure 13: routes to R&I investment

Routes to R&I investment



Route 1 – Efforts to promote the establishment of new, domestic R&D performing firms

Route 2 – Efforts to stimulate greater R&D investment by R&D-performing firms

Route 3 – Efforts to stimulate R&D investment by non-R&D performing firms

Route 4 – Efforts to attract R&D-performing firms from abroad

Route 5 – Efforts to increase private sector R&D carried out by or in cooperation with PROs

Route 6 – Efforts to increase R&D levels in public sector research organisations (PROs)

In practice, these routes are not mutually exclusive and are often taken in parallel: the policy priority can have very different implications for the nature of the resulting R&D activities, and the dynamics of public-private interactions and development paths:

- An emphasis on Route 2, for example, could help reinforce existing R&D strengths in the private sector;
- An emphasis on Routes 1 and 3, however, would be appropriate when the aim is to stimulate R&D activities in new technology areas or industrial sectors;
- An emphasis on Route 4 suggests itself within the broader context of industrial modernisation strategies where the aim is to upgrade existing low- to medium tech sectors via the intensification of knowledge-based activities;
- Emphasising Route 6 is necessary when the policy priority is to strengthen the science base, but following this route in parallel with Route 5 helps to ensure that the development paths of the public and private sectors remain linked and relevant to each other.

9.5.7 Table 12: Innovation & integration in R&I policy

SOCIO-ECONOMIC ISSUES	
Economic / enterprise profile	<ul style="list-style-type: none"> Implications of the cluster R&I agenda for broad economic and financial issues: e.g. sectoral shift: investment viability:
Firm structure & profile	<ul style="list-style-type: none"> Implications for firms / organizations: larger / smaller: national / international: horizontal / vertical integration.
Labour structure & profile	<ul style="list-style-type: none"> Implications for employees, skills & training, career paths, unions & professions
Public sector & civil society	<ul style="list-style-type: none"> Implications for government, public services, non-governmental organizations, other social & cultural networks
KNOWLEDGE ISSUES	
Internationalization of R&I	<ul style="list-style-type: none"> Priorities & added values for international R&I community
Smart Specialization of R&I	<ul style="list-style-type: none"> Role for national smart specialization programme
Clusters / networks of R&I.	<ul style="list-style-type: none"> Implications for the activity & organization of the R&I community
Innovation & deployment	<ul style="list-style-type: none"> Progress on innovation curve & deployment to market
POLICY MIX ISSUES	
Resource mobilisation	<ul style="list-style-type: none"> Justifying resource provision for research activities Securing long-term investment in research uncertain returns and other barriers to private R&D investment Providing qualified human resources
Knowledge demand	<ul style="list-style-type: none"> Identifying the drivers of knowledge demand Coordinating and channelling knowledge demands Monitoring demand fulfilment (via evaluation)
Knowledge production	<ul style="list-style-type: none"> Ensuring quality and excellence of knowledge production Ensuring exploitability of knowledge
Knowledge circulation	<ul style="list-style-type: none"> Facilitating knowledge circulation between university, public research organizations, and business sectors Profiting from access to international knowledge access Enhancing absorptive capacity of knowledge users

10 CLUSTER PROGRAMS

10.1 A framework for cluster themes & programs

This section sets out the main features of the integrated R&I approach, applied to the broad themes of the cluster working groups.

This report does not aim to identify specific projects in detail: it does look at the wider agenda, combining policy questions with R&I capacity, and mapping a 'R&I landscape'.

This 'R&I landscape' can locate individual projects as part of a larger whole, which includes activities from basic to applied science, and from global to local in scope (i.e. the 'quadrants' in the 'R&I capacities & applications' figure). Such a framework includes larger and more integrated programs: it also includes more specific 'foresight' programs or studies.

- 'Integrated Programs' ("I.P." as in the European Framework Programs): this is a multi-sector, multi-disciplinary strategic R&I framework. It generally combines basic with applied science: policy with action research: R&I with skills development: and a wider range of funding where possible.
- 'Foresight Programs' take a specific sector with a futures orientation: and include for creative 'path-finding' and blue-skies models: not only in technology but in economic, social, cultural, or political domains.

Each of these are described in the following 6 cluster programs, which in reality contain many overlaps and inter-connections. Each is likely to contain small targeted projects in basic research: more like academic 'science', likely to need public or foundation research funding. This will be combined with applied research, more focused on surveys, analysis, consultancy, near market technology, etc: could access wider public / private funding. Both will be enabled by programs for 'capacity building', i.e. horizontal activity such as infrastructure, databases, skills development etc, which enables further R&I to follow.

10.2 'Ocean & island resources' cluster

Generally this theme represents both established sciences (oceanography, ecology etc), but also a new and topical context of potential and threat. For instance there is huge potential in the Ocean Economy, with many possibilities for energy, food, bio-medical, chemicals and other resources.

Generally, R&I should follow an industrial ecology integrated systems approach, looking for inter-connections and synergies between different resources both physical and human. This can combine with a human ecology approach for working with enterprises, employees, residents and visitors. The scope and themes include:

- the Ocean Economy (as set out in the Government Programme):
- coastal and lagoons as vulnerable resources, with a science-policy-business agenda.
- tropical ecosystems, with potential for pharmaceuticals, textiles, material sciences of all kinds:
- sustainable multi-functional landuse systems: where new models are needed for integrating and enhancing social, economic, cultural and ecological assets.

This theme could draw on a range of studies and foresight methods for promoting creative collaboration.

- Technical studies on trends, problems, innovations: research capacities & collaborations
- Entrepreneurial studies on business cases, technology opportunities, international collaborations
- Policy & participative processes to explore the wider social / cultural / political implications of problems
- Cross-comparison methods to explore policy-research links and value chains

The likely R&I 'portfolio' includes the following:

- Basic science themes: ocean-related chemistry, biology, meteorology, hydrodynamics
- Applied science themes: industrial ecology approach to water systems, marine minerals & biotic resources: sustainable indigenous agriculture approach to bio-medical, pharmaceutical, textile engineering.
- R&TD themes: integrated engineering of ocean-related resources: applications of tropical agro-forestry products.

10.2.1 Table 13a: alternative futures: ocean & island resources

	'GROWTH AT ALL COSTS'	'WIN-WIN'	'ISLAND'	'SUCCESS'
KEY THEMES & TOPICS	'trend'	'Plan A'	'Plan B'	'no regrets' – agenda for R&I
Marine / land				
Ocean & coastal	Private investment in ocean resources	Partnership management of oceans	Local resources in ocean industries	Sustainable ocean & coastal diversification
Inland	Privatization of land & coastal strip	Collaborative land management	Local community land resources	Adaptive environmental management
Biodiversity	Rapid urbanization Pressure on biodiversity	Balanced urban-rural devt / conservation management	Indigenous ecological knowledge	Integrated hi-tech / low-tech conservation
Climate change	Climate emissions & impacts increase	Renewable energy & rapid climate adaptation	Local self-sufficiency & resilience	Integrated climate management

10.2.2 Recommended R&I programs

An Integrated Program could take the form - **'Ocean Economy phase 1 - offshore energy program'**: this looks at national capacity: skills, human resources, financial resources and infrastructure capacity, for offshore engineering, grid design, turbine innovation. This also includes methods and evidence base for assessments of environmental and total cost benefit, fully integrated with national energy and climate policies. The science agenda here is not so much the basic engineering, as the integration to an island nation context, and its role in the Ocean Economy.

There are other likely programs on a Foresight model. An **'Ecology and biodiversity'** program would bring together modelling of habitat under pressure: links to eco-tourism: multi-functional landuse: with indigenous medicinal / nutri-ceutical resources. A **'Climate Island'** program would research the projected national physical / economic / social impacts: options for adaptation strategies in the context of national development: innovations and opportunities for business and social enterprise:

To enable such programs, there are implications for socio-economic structures: for policies concerning knowledge and innovation system: and then for the 'policy mix': as in the table below.

10.2.3 Table 13b: R&I policy integration: ocean & island resources

SOCIO-ECONOMIC ISSUES	
Economic / enterprise profile	<ul style="list-style-type: none"> Mix of high capital intensive marine infrastructure / low capital SMEs on coastal & inland activities.
Firm structure & profile	<ul style="list-style-type: none"> International collaborations/ joint ventures for marine infrastructure. Possible cooperative or mutual financial structures are better suited to working with coastal & inland eco-systems.
Labour structure & profile	<ul style="list-style-type: none"> Skills development and training needed to spread the benefits of knowledge based enterprise (and avoid low-skill trap & dependency)
Public sector & civil society	<ul style="list-style-type: none"> Important role for public sector in both ocean, coastal and inland resources: resources and land are limited, communities & employees may be vulnerable,
KNOWLEDGE ISSUES	
Internationalization of R&I	<ul style="list-style-type: none"> Ocean economy studies will be highly internationalized: also can benefit from participation in larger projects, e.g. oceanography, climate change, astronomy
Smart Specialization of R&I	<ul style="list-style-type: none"> Specialization & added value of Mauritius will apply more to coastal and inland resources.
Clusters / networks of R&I.	<ul style="list-style-type: none"> Further knowledge / innovation mapping is required to identify the priority clusters, fields, cross-cutting linkages.
Innovation & deployment	<ul style="list-style-type: none"> Need a mix of early basic science / blue skies: pilots / prototypes: near to market deployment
POLICY MIX ISSUES	
Resource mobilisation	<ul style="list-style-type: none"> Ocean economy may require large scale technology & infrastructure, e.g. shipping, drilling, water engineering. this is likely to be specialized & capital intensive, high skill and international in scope.
Knowledge demand	<ul style="list-style-type: none"> For a high risk, high return ocean economy the state should be an active player. For island resources, other more indigenous and localized networks could be formed as knowledge users and brokers.
Knowledge production	<ul style="list-style-type: none"> Ocean economy should explore the question of institutional capacity, and what kind of roadmap could help to build it. Island resources should make active networks between all environment & ecological – related sciences
Knowledge circulation	<ul style="list-style-type: none"> A 'platform' both online & physical, is needed to bring together all stakeholders for ocean & island economy.

The likely roles of key actors and stakeholders in this challenging R&I landscape, is shown in the summary here:

10.2.4 Table 13c: stakeholder roles: ocean & island resources

	Government & public agencies	Higher education & related	Private sector industry, finance	Civil Society Organizations
Ocean / island				
Ocean economy	strategy leaders	Priority for oceanic studies	Major long term investments	Safeguards of social & ecological issues
Island environment	Strong policy regime	Environment science	Eco-enterprise	Stewardship & lobby
Biodiversity	Strategic landuse	Ecosystems science	Eco-enterprise	Stewardship & lobby
Climate change	Climate priorities in all policy areas	International links	Carbon enterprise potential	Stewardship & lobby

10.3 'Agriculture-sugar-food-health' cluster:

This theme is widespread and shared by almost every country in some way. For the Mauritius case there is a niche added value in terms of the tropical climate and eco-systems: the legacy of the sugar industry: and the very rapid spread of industrialized food imports, with mechanized distribution and consumption. This calls for an holistic systems approach to the links between agriculture, landuse, food systems and public health. It also calls for a policy and business-focused capacity building for the strategic conversion of production, for wider social-ecological benefits. Key themes include:

- agriculture under pressure and change
- the national food strategy and integrated food chain systems:
- industrial ecology approach for sugar industries and related products.
- nutrition health and personal development:

There are some very practical questions on R&I themes and activities: these also need linkages with other parts of society in creative engagement:

- What will the nation be eating in 2020 / 2030 ? (and how will this be different to today?)
- How will the nation produce or trade its food in 2020 / 2030?
- How should the land resource be used to the best advantage, (given the competing demands between food, sugar, energy crops, urban development, tourism, biodiversity, or other uses?)
- How can the marine / land-based ocean resource also be best used for food production?
- What forms of knowledge are most relevant to policy / business / civil society for integrated agri-food developments?
- How can STI and the research community best contribute to such practical questions?

The likely R&I profile and 'portfolio' includes the following:

- Basic science themes: agricultural, soil, forestry, sciences: hydrology, industrial ecology & ecosystems services analysis: nutritional science & medicine: glucotoxic medicine & psychology
- Applied science themes: alternative & indigenous cultivation systems, coastal food systems, organic food & diets: global food system analysis: agri-food economics & alternative economics: climate impacts & adaptation: land economics & policy: rural economic & social studies:
- R&TD themes: diabetic-related treatments: whole system local food chains:

10.3.1 Table 14a: alternative futures: agri-food-health

	'GROWTH AT ALL COSTS'	'WIN-WIN'	'ISLAND'	'SUCCESS'
KEY THEMES & TOPICS	'trend'	'Plan A'	'Plan B'	'no regrets' – agenda for R&I
Agriculture / health				
Agriculture	Industrialized intensive farming	Sustainable farming with global / local balance	localized diversification in farming	Multi-level farming & land management
Sugar	Rapid restructuring	New products for global markets	Local products for local markets	Balanced technical innovation
Food industries	Globalized food chains	Sustainable global chains	Food self sufficiency	Multi-level food systems
Public health	Industrial diets, glucotoxic & allergenic syndromes	Sustainable balanced diets	Sustainable local diets	Global-local food health

10.3.2 Recommended R&I programs

An Integrated Project could take the form of a **'Positive health & nutrition program'**, with links to national food / agriculture conversion strategy. This begins the major task of linking between the different parts of the picture – agriculture in flux: sugar industry conversion: the national food agenda: changing habits of consumption, the new glucotoxic syndromes and the public health / well-being agenda. The science agenda here focuses on the challenge of forming such links in an evidence-based and systemic way, which can then be mobilized for further R&I activity, and also for policy / business applications.

This would be supported by several Foresight type programs. A sector Foresight looks at **'Agricultural Conversion'** in the light of national food demand, drivers of change from demographic, lifestyle, economic and climate change, together with risks and vulnerabilities, and also opportunities.

A more specific study on the **'Sugar Ecology'** looks at industrial ecology pathways for conversion of the sugar cane sector. This links with other sectors and policy agendas such as energy, waste, water, landuse and soil, invasive species, and carbon sequestration. Both these would inform a policy-business Foresight on the food industry role in public health needs, and opportunities in a national food strategy.

To enable such programs, there are implications for socio-economic structures: for policies concerning knowledge and innovation system: and then for the 'policy mix': as in the table below.

10.3.3 Table 14b: R&I policy integration: agri-food

SOCIO-ECONOMIC ISSUES	
Economic / enterprise profile	<ul style="list-style-type: none"> • This cluster sees an opposition between MNE / large food producers / importers: and smaller scale indigenous growers • There is also possible opposition between 'big science' medical / health models, and small scale 'self-help' and 'lifestyle' models
Firm structure & profile	<ul style="list-style-type: none"> • As above
Labour structure & profile	<ul style="list-style-type: none"> • As above: e.g. the sugar cane industry is likely to go through radical changes in social-economic systems, and also landuse and the role of land-based labour.
Public sector & civil society	<ul style="list-style-type: none"> • The public sector will play an important role wherever there is perceived market failure: in agriculture or food production: or in healthy diet and food consumption.
KNOWLEDGE ISSUES	
Internationalization of R&I	<ul style="list-style-type: none"> • For international medical science, Mauritius offers special conditions and a living laboratory. For agri-food systems, similar.
Smart Specialization of R&I	<ul style="list-style-type: none"> • added value & Mauritius specialist niche: the tropical climate and eco-systems: the legacy of the sugar industry: and the very rapid spread of industrialized food imports, distribution & consumer habits.
Clusters / networks of R&I.	<ul style="list-style-type: none"> • Further knowledge / innovation mapping is required to identify the priority clusters, fields, cross-cutting linkages.
Innovation & deployment	<ul style="list-style-type: none"> • Need a mix of early basic science / blue skies: pilots / prototypes: near to market deployment
POLICY MIX ISSUES	
Resource mobilisation	For bio-medical and pharmaceutical, a possible role for MNE joint ventures with finance for advanced R&I 'living laboratories'.
Knowledge demand	<ul style="list-style-type: none"> • Government needs to act as client & sponsor for issues which are non-market value or external to market activities.
Knowledge production	<ul style="list-style-type: none"> • Role for alternative forms of agricultural R&I, training and skills development, which is better linked to rural communities
Knowledge circulation	<ul style="list-style-type: none"> • A 'platform' both online & physical, is needed to bring together all stakeholders for agri-sugar-food-health issues.

The likely roles of key actors and stakeholders is shown in the summary here:

10.3.4 Table 14c: stakeholder roles: agri-food-health cluster

	Government & public agencies	Higher education & related	Private sector industry, finance	Civil Society Organizations
Agriculture / health				
Agriculture	Integrated production / consumption policy	Systems perspective on food / agri studies	New business opportunities	Farming support networks
Sugar	Conversion of sugar sector	Links to institute	New business opportunities	Support for restructuring
Food industries	Regulation of food industry	holistic food / health patterns & pathways	New markets & social businesses	Social enterprise in food industry
Public health	Health service links	holistic food / health patterns & pathways	Lifestyle / health / food business model	Community health education/ enterprise

10.4 'Infrastructure resources' cluster:

This covers energy / water / transport / construction / waste, and potentially ICT: each area calls for R&I on the basis of an industrial ecology integrated systems approach. Overall the sustainable development agenda is the main imperative, and the USP of Mauritian R&I will be in applying theory to practice, in a unique 'living laboratory'. Key themes include:

- renewable energy /waste / water integrated system design, using indigenous resources wherever possible:
- sustainable transport systems, with both technology and social innovation working on both supply and demand sides
- linking infrastructure to climate change impacts and adaptation strategies.

Technology innovations often depend on a parallel innovation of governance, social and economic systems. Such innovation might look at the inter-dependency of suppliers and users: investors and consumers: upstream and downstream parties: uncertainties and risks of many kinds: or the political economy of infrastructure and regulation. The mainstream 'development' model of liberalized services is being revisited everywhere, but there are other structural questions. One is that of centralization versus de-centralization in networks and grids: another question is the paradigm of consumption which is locked into economic growth.

Over-arching this is the concept of 'sustainable development'. Mauritius has both the need and the opportunity to lead the way as a showpiece for sustainable development, on an island with limited land area. For instance, the (inland) transport sector could continue its current trends towards highly energy intensive, land consuming and polluting modes. But transport is closely linked with urban planning, urban design and building design. At present the majority of existing settlements are not designed with modern transport in mind: new buildings and settlements are more modern and automobile centred, but at the cost of social and environmental impacts, with extensive landuse on a modest sized island. So there is a strong and timely agenda for transport system to look for transformational technologies, new urban planning models, business models, public services, communications networks and social enterprises based around accessibility.

For instance, in water issues there are technical innovations such as remote sensing and hydrological modelling: and policy innovations such as ecosystems services (ESS) markets and fiscal policies. These can shift the agenda from centralized heavy engineering (reservoirs, dams etc), towards decentralized solutions (rainwater capture on buildings, separated supplies etc). However in the context of pressures from climate change, economic growth, urbanization and landuse change, the political, economic and socio-cultural issues are ever more central.

For energy, there is a topical research agenda, which covers technology and innovation, markets and finance, infrastructure and urbanization, environment and climate, consumption and social behaviour. Current programmes are expanding from a pure technology-engineering focus, towards a more holistic view and critical perspective on the political economy of new technologies and

transnational firms. Similar shifts can be seen in transport, waste management, communications, and the surrounding 'social infrastructure' of public services and community facilities.

The likely R&I profile and 'portfolio' includes the following:

- Basic science themes: material science: tropical ecology: molecular biology
- Applied science themes: mechanical / electrical / civil / chemical engineering: industrial systems design: applied / institutional / ecological / behavioural economics: urban planning & building design.
- R&TD themes: industrial ecology: infrastructure planning, cost-benefit & integrated assessment & modelling: transport system design.

This then generates a range of R&I types:

- **Technical studies** on trends, problems, innovations: research capacities & collaborations
- **Entrepreneurial studies** on business cases, technology opportunities, international collaborations
- **Policy & participative** processes to explore wider social / cultural / political implications
- policy-research links and value chains

10.4.1 Table 15a: alternative futures: infrastructure resources

	'GROWTH AT ALL COSTS'	'WIN-WIN'	'ISLAND'	'SUCCESS'
KEY THEMES & TOPICS	'trend'	'Plan A'	'Plan B'	'no regrets' – agenda for R&I
Infrastructure				
Energy	Fossil fuel dependency	Balanced energy systems	Island self-sufficiency	Diversified energy system
Water	Intensive water systems	Balanced water systems	Autonomous water system	Water resilience
Waste	Material & waste intensive	Waste reuse & recycling	Total resource recovery	Resource diversification
Transport	Rising private car mobility	Multi mode & travel demand management	Local travel & accessibility	Transport & access paradigm shift
Construction	High volume land intensive urban development	Optimization of sustainable construction	Low impact & local materials in construction	Value added approach to integrated supply/demand chain

10.4.2 Recommended R&I programs

One topical Integrated Project could be: '**Circular economy for integrated resource / waste /business**': this looks both at the total national resource flows, and focuses on key business supply chains. Priority areas can be examined for import supply chains, product types, packaging and logistics, waste management options and strategies for a 'circular economy' of re-use /recycling / re-

manufacture. This is not only a technical agenda, but one with major social science issues, in behavioural economics and psychology, cultural studies and human geography. Other foresight type projects would include:

- **Sustainable Transport:** innovative models for transport demand, supply and infrastructure, on a small island which now contains 400,000 cars. A foresight approach is needed to explore the intractable problems of growing mobility demand, space for vehicles, settlement sprawl: also looking at new technology potential for vehicles, demand management, smart networking, and the role of organizations which may lack capacity for innovation.
- **Sustainable Water:** foresight study of longer range water availability projections, vs water demand projections, in the context of drivers of change in areas such as technology, remote sensing, demand side behaviour, tourism development, etc.
- **Sustainable Construction:** the regenerative house / neighbourhood, and 'net positive energy' building: potential for renewable energy and materials, water harvesting, low impact construction & maintenance: together with behavioural issues, economic potential, and building design institutions.
- **Pervasive broadband:** the ICT Development Strategy envisages a national system with hardware, software and use-ware in parallel. However there are issues (from the consultations) with a lack of uptake, cultural inertia, locked in legacy systems, and monopolistic organizations: all of which need a pro-active action research programme.

To enable such programs, there are implications for socio-economic structures: for policies concerning knowledge and innovation system: and then for the 'policy mix': as in the table below.

10.4.3 Table 15b: R&I policy integration: infrastructure

SOCIO-ECONOMIC ISSUES	
Economic / enterprise profile	<ul style="list-style-type: none"> Current 'utilities' models based on centralized engineering may shift to more diverse innovative models, which would reflect a different kind of development path.
Firm structure & profile	<ul style="list-style-type: none"> this will need international expertise, consultancy & technology, but in collaboration with local and small scale providers
Labour structure & profile	<ul style="list-style-type: none"> different occupational structures & improved skills may be required for a transformed infrastructure
Public sector & civil society	<ul style="list-style-type: none"> infrastructure is by nature a public good, so it is crucial to keep a strong public interest, through ownership, management etc.
KNOWLEDGE ISSUES	
Internationalization of R&I	<ul style="list-style-type: none"> Much of the basic science / R&I is global by nature, so Mauritius researchers will need to network on a larger scale
Smart Specialization of R&I	<ul style="list-style-type: none"> Mauritius added value would be as a 'living laboratory' with advanced innovation in industrial ecology type engineering Also, innovation in political-social-economic models for sustainable infrastructure
Clusters / networks of R&I.	<ul style="list-style-type: none"> As each infrastructure is potentially inter-dependent (water / energy / waste) this calls for some kind of integrated organization or institute
Innovation & deployment	<ul style="list-style-type: none"> Need a mix of early basic science / blue skies: pilots / prototypes: near to market deployment
POLICY MIX ISSUES	
Resource mobilisation	<ul style="list-style-type: none"> The total infrastructure spend is approx 21% of the national economy: the cost of inefficient infrastructure may be much more. So in principle to generate the funds for R&I investment should not be difficult.
Knowledge circulation	<ul style="list-style-type: none"> Again some kind of 'platform' will be needed, to enable communications between a wider set of stakeholders, whether or not there is a physical organization or institute.

The likely roles of key actors and stakeholders is shown in the summary here:

10.4.4 Table 15b: stakeholder roles: infrastructure cluster

	Government & public agencies	Higher education & related	Private sector industry, finance	Civil Society Organizations
Infrastructure				
Energy	Integrated policy / procurement	Systems level studies for sustainability	Integrated models for sustainable utilities	Enabling integrated energy systems
Water	Integrated policy / procurement	Systems level studies for sustainability	Integrated models for sustainable utilities	Enabling integrated water systems
Waste	Integrated policy / procurement	Integrated supply-demand systems	Business models for integrated resources	Enabling integrated material systems
Transport	Urban planning for new transport models	Integrated supply-demand systems	Business models for sustainable transport	Enabling integrated travel / accessibility

10.5 'Social and cultural resources' cluster

This cluster covers many things – in the Mauritius case it would focus on key national issues, including demographic change, cohesion, empowerment, citizenship, gender. This calls for a social science model which aims at multi-lateral, participative, co-production modes of knowledge gathering, co-production and mutual learning. Some cross-cutting themes include:

- social innovation: sustainability / green economics: island culture & identity: sociology of tourism, etc. liberation ecology and political ecology:
- hybrid cultures, migration, gender & generational issues:
- active citizenship for participative & responsive governance.
- Cultural identity on a multi-cultural island & diaspora.

For the question of a foresight based R&I agenda in social policy research, there are also some topical trends and innovations in methodology, for further discussion and debate:

- A shift from analytic 'subject-object' research modes, towards synthetic, multi-channel, participation-based action research.
- A shift from data-driven social research towards a more holistic systems approach to understanding complex patterns.
- New ways of looking at the policy-research interface, where research can be more embedded in a policy 'learning' organization, and where policy perspectives can be better linked to academic research.

It is also clear that advanced social and cultural studies would aim to support and enable greater understanding of social / cultural issues in the other clusters. For instance, agri-food-health issues are as much about social behaviour as agricultural or medical science. Where innovative solutions are being developed, then again we need to enhance understanding of behaviours, social structures, cultural experience etc.

The likely R&I profile and 'portfolio' includes the following:

- Basic science themes: the whole range of social and economic sciences is potentially involved. There are particular niches and frontiers in each field, which are likely to be more relevant to Mauritius: e.g. social innovation: sustainability / green economics: island culture & identity: sociology of tourism, etc.
- Applied science themes: as above, various branches of study would aim to mobilize the applications of such knowledge, in policy, business and civil society.
- R&TD themes: in the social science context, there is scope for experiments and innovations: for example: local economic exchanges, new forms of land/ property rights, new forms of local/global visitor experience.

10.5.1 Table 16a: alternative futures: social & cultural resources

	'GROWTH AT ALL COSTS'	'WIN-WIN'	'ISLAND'	'SUCCESS'
KEY THEMES & TOPICS	'trend'	'Plan A'	'Plan B'	'no regrets' – agenda for R&I
Social & cultural				
Demographic change	Rise of affluent classes	Balanced population	Income redistribution	Integrated society concepts
Poverty issues	Growth creates divisions	Growth out of poverty	Non-material prosperity	Holistic poverty reduction
Gender & generation	Roles are more polarized	Inclusion through development	Full equality of genders & generations	Socio-cultural transitions
Empowerment etc	Consumer choice designed by MNEs	Active global-oriented citizenship	Active local citizenship	Empowerment agenda

10.5.2 Recommended R&I programs

A topical priority for an Integrated Program would look at **'Gender & Generation'**, for changing identities, aspirations, alternative social models. This is a starting point for a long running program which would combine social data from surveys and census: with 'soft data' from participative action research: with 'new data' from new social technologies and other digital monitoring with new analytic methods. The challenge is then to take this beyond the descriptive, towards a normative development agenda, exploring new social / cultural models in public services, organizations, workplaces, and lifestyle facilities.

An innovative Foresight program would explore **'Empowerment, identity, citizenship'**: using a 'platform' approach oriented to participative input with a range of media) – e.g. stories, clips, visuals, audio / video: and exploring new ways to cross-link and aggregate into new combinations.

This would overlap with **'Poverty, affluence, consumption'**: taking a 'livelihoods & assets' approach as in development literature, using action research methods and participatory mapping: statistical studies on the dynamics & reproduction of poverty, to the policy agenda with a more entrepreneurial approach to upcoming opportunities.

Urbanization and urban-rural change emerged from the consultation, very topical for a nation of a similar size to a small city-region. Clearly there are huge impacts of rapid urbanization, and urgent policy questions for every kind of social science, not least in how best to plan and manage such change.

To enable such programs, there are implications for socio-economic structures: for policies concerning knowledge and innovation system: and then for the 'policy mix': as in the table below.

10.5.3 Table 16b: R&I policy integration: social & cultural resources

SOCIO-ECONOMIC ISSUES	(note – there is much overlap here with the following cluster on ‘Enterprise Resources’).
Economic / enterprise profile	<ul style="list-style-type: none"> Social & cultural resources may play a larger part in the ‘formal’ economy than generally realized. There is also a key role in understanding the ‘informal’ / social / household economy.
Firm structure & profile	<ul style="list-style-type: none"> As above, there is scope for looking at different types of firms and social enterprises / non-profit / cooperative / mutual aid organizations.
Labour structure & profile	<ul style="list-style-type: none"> Skills development, knowledge systems and training for the above are all essential to success.
Public sector & civil society	<ul style="list-style-type: none"> The role of the public sector and civil society is essential to this wider agenda for development beyond the formal economy.
KNOWLEDGE ISSUES	
Internationalization of R&I	<ul style="list-style-type: none"> In general the social sciences are highly internationalized: key R&I players will need funding & resources to travel and network.
Smart Specialization of R&I	<ul style="list-style-type: none"> However, the smart specialization niche of Mauritius should be identified & promoted: as above, a test bed for social-political-economic innovation.
Clusters / networks of R&I.	<ul style="list-style-type: none"> Potential for new ways to share knowledge, debate issues, transfer to students, exchange with R&I users etc.
Innovation & deployment	<ul style="list-style-type: none"> As above the added value niche will be in social innovation and political-economic deployments: a range of activities from blue skies to prototype will be needed.
POLICY MIX ISSUES	
Resource mobilisation	<ul style="list-style-type: none"> funding for social & cultural studies: need to explore new mechanisms to identify added value and reinvest from business and policy users.
Knowledge demand	<ul style="list-style-type: none"> Links with research users to be enhanced: e.g. through exchanges, intermediaries,
Knowledge production	<ul style="list-style-type: none"> Potential for enhanced knowledge infrastructure, e.g. with large datasets, social media, experiential data etc.
Knowledge circulation	<ul style="list-style-type: none"> Possible role for platform initiatives which circulate and exchange and enhance socially-constructed knowledge and intelligence.

The likely roles of key actors and stakeholders is shown in the summary here (to be elaborated in further consultation):

10.5.4 Table 16c: stakeholder roles: social & cultural resources

	Government & public agencies	Higher education & related	Private sector industry, finance	Civil Society Organizations
Social & cultural				
Demographic change	Third age & youth as innovation resources	Lifelong learning networks	Third age & youth as economic resource	Social enterprise networks & resources
Poverty issues	Anti-poverty as social innovation agenda	Widen access & scope of education	Ethical business for anti-poverty agenda	Social enterprise networks & resources
Gender issues	Gender equality as social innovation	Widen access & scope of education	Ethical business for gender equality	Social enterprise networks & resources
Empowerment etc	Active citizenship as social innovation	Education for active citizenship	Social business for active citizenship	Social enterprise networks & resources

10.6 'Enterprise & human resources' cluster

This covers the broad agenda of skills, firms, finance, entrepreneurship, innovation, education, knowledge society and related fields. However in the context of this Foresight, the focus expands to include not only conventional business and economic growth, but looking towards a wider and deeper agenda for innovation. The focused R&I programmes which could provide international added value for Mauritius, would aim look beyond conventional 'products' towards whole supply chains, sustainable investment models, knowledge based entrepreneur models, and social innovation systems. Key themes include -

- sustainable enterprise and CSR-based financial structures:
- integrated cradle-to-grave supply chains and service models
- capacity building and upskilling employees and the supply chain, towards an innovation and knowledge based economy.

For 'enterprise resources' there is a well trodden path which follows the 'innovation systems' approach. There may be future directions now emerging: a focus on intangibles, complexity and ecological perspectives. For human resources, there are new insights such as behavioural psychology and economics, or cognitive sciences, alongside the mainstream themes of skills and training, pay and conditions. Across the board, the new social technologies are driving changes in business models and social business models.

Meanwhile in large parts of the world the apparent failure not only of the economic regime, but the credibility of its models and assumptions, leads to many questions on the nature of the global system and where it might go next. Again, one of the potential USPs of Mauritius could be to develop new models of economic and financial activities which are more resilient, responsive, inclusive and sustainable. This points towards pro-active & creative path towards a 'knowledge society': not only for the financial bottom-line, but more creating a new fabric of economy and society.

This agenda for 'development innovation' also points towards 'knowledge innovation', for a pro-active and creative path towards a 'knowledge society'. Such knowledge is not only concerned with the financial bottom-line, but more involved with creating a new fabric of economy and society, needed for a more integrated and holistic development agenda.

The likely R&I profile and 'portfolio' of such an agenda includes the following:

- Basic science themes: economics, organization / innovation theory, psychology, education theory, cognitive sciences etc, are all relevant on the international scale, and in each there are frontiers with particular relevance.
- Applied science themes: as above there is potential to focus the application of these on the specialization niche of Mauritius: examples include social media studies, behavioural psychology, change management, social network analysis.

- R&TD themes: potential themes here would take the above and apply to social research, prototype development, business / social enterprise innovation.

10.6.1 Table 17a: alternative futures: enterprise resources

	'GROWTH AT ALL COSTS'	'WIN-WIN'	'ISLAND'	'SUCCESS'
KEY THEMES & TOPICS	'trend'	'Plan A'	'Plan B'	'no regrets' – agenda for R&I
Enterprise resources				
Skills & careers	Shaped by MNEs	Holistic skills are valued	non-material skillsets	New skill / learning systems
SMEs & innovation	Profit is the only incentive	Smart networks for SMEs	Social-eco- innovation	SME dynamics
Finance	Low-tax hub & global flows	Integrated smart finance	Social-ecological finance	Integrated financial models
Social enterprises	Picking up the pieces of a privatized state	Integrated to mainstream economy	Combined social-economic-ecological enterprises	Dynamics of social-cultural-ecological enterprise

10.6.2 Recommended R&I programs

The key Integrated Program here could be along the lines of '**Enterprise Value Generation**'. This would look at business and finance systems in the round, alongside alternative economic models. This mirrors the social program in the economic sphere: again combining hard data with soft data with new 'big data' where available. It aims towards a deeper understanding of how business and finance works (or not), how organizations grow and learn (or not), and how the experience of entrepreneurs, workers, customers and others can be improved through new models for enterprise, investment and stakeholder equity. Parallel Foresight-type programs would include:

- **Finance & innovation:** including social & ecological finance: alternative channels for investment, equity, collateral, cooperative capital & risk management for enterprises: this includes business, but also non-profit social /cultural ecological.
- **Skills & careers:** including projections of economic structure & business models: skills and occupational demand: career structures & incentives: comparison with educational pipeline (with a decade lead in time). (this to be in collaboration with HRDC and others).
- **SMEs & innovation:** an innovation platform aimed at pooling & networking the knowledge & skills of SME entrepreneurs: in collaboration with training & skills development agencies.
- **Education & enterprise:** for entrepreneurs & innovators program and platform: working with schools, colleges, universities & training agencies, also with business & enterprise agencies: The purpose is to promote a creative entrepreneur / innovator approach to education methods & curriculum development.

To enable such programs, there are implications for socio-economic structures: for policies concerning knowledge and innovation system: and then for the 'policy mix': as in the table below.

10.6.3 Table 17b: R&I policy integration: enterprise resources

SOCIO-ECONOMIC ISSUES	Note – various overlaps with the previous cluster theme.
Economic / enterprise profile	<ul style="list-style-type: none"> Need to review the national economic development strategy, in terms of national knowledge versus branch-plant dependency
Firm structure & profile	<ul style="list-style-type: none"> New types of firms, networks, consortiums: MNE / local joint ventures and collaborations:
Labour structure & profile	<ul style="list-style-type: none"> In each sector there is a case for upskilling, networking, value generation etc. For example in tourism, many low skill jobs have potential for change to give greater value to workers, customers & enterprises
Public sector & civil society	<ul style="list-style-type: none"> The enterprise resource depends for instance on public education, both formal, professional and informal. There is scope for change and modernization in the structure and process of education.
KNOWLEDGE ISSUES	
Internationalization of R&I	<ul style="list-style-type: none"> The agenda for growth, development, innovation is global:
Smart Specialization of R&I	<ul style="list-style-type: none"> potential niches for smart specialization include new social innovation models: new forms of education: new kinds of knowledge platforms through social media etc.
POLICY MIX ISSUES	
Resource mobilisation	<ul style="list-style-type: none"> the simple solution would be to increase incentives for firms and SMEs to reinvest 1% in R&I which can be directly business related. (then there are arguments about what constitutes R&I)
Knowledge demand	<ul style="list-style-type: none"> this rests on the 'demand side', i.e. firms / SMEs / other enterprises who need and want to use R&I results, and to build in This depends on a cultural shift at the national level: possibly the best way is to demonstrate through example.

The likely roles of key actors and stakeholders is shown in the summary here (to be elaborated in further consultation):

10.6.4 Table 17c: stakeholder roles: enterprise resources

	Government & public agencies	Higher education & related	Private sector industry, finance	Civil Society Organizations
Enterprise resources				
Skills & careers	Incentives for up-skilling	Education / industry & finance links	Incentives for up-skilling	Lifelong skills & mentoring networks
SMEs & innovation	regulation, funding, lead procurement	Education / industry & finance links	Incentives for R&I in SMEs	New models for social business & networks
Finance	Financial access & ethical finance	Business training & mentoring	Financial sector incentives for R&I	New models for social & ecological finance
Social enterprises	Facilitation for social enterprises	Social enterprise training & mentoring	New models for social business & networks	Social enterprise support functions

10.7 'Global links and resources' cluster

This cluster theme covers a wide range – finance, ICT, tourism, trade, security, climate change. In general these are outward facing R&I programmes, which address the inter-connections and synergies between a wide range of challenges and opportunities. This should work with the internationalization of R&I communities and networks: and a 'smart specialization' approach to the unique situation of Mauritius. Key R&I themes include:

- climate change and carbon-related enterprise development:
- financial resilience and transparency in a global system:
- future of air travel and international hubs in a carbon-constrained future
- integrated eco-tourism which can enhance multi-functional ecological-socio-cultural systems.
- Internationalization of R&I itself, and ways forward for the Mauritius R&I community.

This theme raises profound questions on the R&I / STI / R&TD agenda, not only for 'which' research themes, but for 'how' they might best make a contribution. These are some current issues and directions around the world:

- Technical modelling of complex systems, as in economic or climate systems, is now confronting its limits. The economic crisis has defied all the models: the climate change crisis cannot bridge the gap between research and policy.
- One type of response is to look at how to embed research into policy, and vice versa.
- Another type of response is to look for new forms of research which bring in the cultural, psychological, systems dynamics which is often left out by technical research.

For the global issues in Mauritius, there are some interesting possibilities to consider on the frontiers of methodology: i.e. not only 'which' research themes, but for 'how' they might make a contribution.

- Global financial flows might be explored with innovative approaches such as neural networks, complexity economics, agent based modelling:
- Global tourism flows can be explored through behavioural economics & psychology, sustainable consumption studies, social network analysis:
- For climate impacts and responses: there is a serious and urgent agenda to explore the projections, their implications for Mauritius, mitigation and adaptation responses, and how they inter-connect with other global issues.

The likely R&I profile and 'portfolio' for 'Global Resources and Links' includes the following:

- Basic science themes: a wide range of fields is involved:
- Applied science themes: the most relevant applied sciences will be global and globalization studies: energy and climate, food and water, demographics and urbanization: all in the context of systems modelling, foresight and future studies, transition and innovation studies.

- R&TD themes: innovations and prototypes will emerge in each of the fields, e.g: finance and communications: culture and migration: climate and resources.

10.7.1 Table 18a: alternative futures: global links & resources

	'GROWTH AT ALL COSTS'	'WIN-WIN'	'ISLAND'	'SUCCESS'
KEY THEMES & TOPICS	'trend'	'Plan A'	'Plan B'	'no regrets' – agenda for R&I
Global resources				
Communications	Air travel growth 5% p.a.	ICT speed & bandwidth	Shift to localized interactions	Multi-level communications & knowledge management
Finance	Financial flow growth 5%	Diversified & value added financial sectors	Global finance flows shift to local eco-social resources	Diversified global / local financial sector
Tourism	Tourism doubles in 15 years	long stay eco-tourism with social integration	Tourism reduces, long stay	Multi-level integrated visitor hospitality system.
Networks	Diaspora in the service of private MNEs	Diversified social & cultural networks	Shift to virtual networks	Collaborative knowledge via global networks

10.7.2 Recommended R&I programs

A high priority Integrated Program would be **'Climate in the Balance'**: this is the counterpart to the more physical and internally focused 'Climate change island' above: in contrast this aims at an externally focused and inter-disciplinary program for investigation and inter-connection of all global climatic issues relevant to Mauritius. This would develop a national platform of evidence, projections, risks, costs, benefits, investments and business opportunities. It would link global projections and impacts, with national agendas for adaptation, emissions mitigation, carbon trading, credits and offsets, together with indirect effects such as the prospects for air travel in a carbon-constrained world.

- Alongside this would be **'Financial resilience in a global system'**: taking a wider view on the Mauritius role as hub for international banking etc: growth prospects, risks & vulnerabilities, options & opportunities, with particular focus on protection of the national economy and assets, with comparison to other island nation finance problems. This then explores new models for finance for innovation in business and social enterprises.
- **'Tourism & eco-tourism'** explores the behavioural psychology & institutional economics of tourism and tourist-based consumption, in the context of projections & links to national economy, skills & labour force.

- **‘Air travel & global hubs’** looks at the determinants of change in air travel to/from Mauritius: with forward look at projections and structural changes in segments, markets, hub effects, aviation technologies, regulations, and substitution effects:

To enable such programs, there are implications for socio-economic structures: for policies concerning knowledge and innovation system: and then for the ‘policy mix’: as in the table below.

10.7.3 Table 18b: R&I policy integration: global links

SOCIO-ECONOMIC ISSUES	
Economic / enterprise profile	<ul style="list-style-type: none"> • Globalization of business, finance and supply chains: need to look at new kinds of collaboration and linkages between global / national enterprises.
Firm structure & profile	<ul style="list-style-type: none"> • As above
Labour structure & profile	<ul style="list-style-type: none"> • There is a perception of a nation which is divided between educated / mobile middle class, and an unskilled / untravelled other. The previous cluster ‘Enterprise Resources’ would aim to bridge this gap and aim for a global / national balance
Public sector & civil society	<ul style="list-style-type: none"> • The role of government is essential, for example in finance sector, where regulation is needed for quality and reputation: • Finance focused R&I is needed to link the practical needs of ‘KIBS’ (‘knowledge & innovation based services’), with wider knowledge of risks, opportunities, business transformations, social & environmental impacts.
KNOWLEDGE ISSUES	
Internationalization of R&I	<ul style="list-style-type: none"> • One example is climate change: fully global science community, but one which depends on national level R&I on monitoring, impacts, adaptation, innovation for mitigation, etc.
Smart Specialization of R&I	<ul style="list-style-type: none"> • Another example is tourism: with sector growth slowing down, a need to identify niche products & values. • in turn, need for a specialized knowledge base which can support such niches: e.g. tourism psychology, business models, cultural models etc.
Clusters / networks of R&I.	<ul style="list-style-type: none"> • This suggests that such a R&I knowledge base should be networked to much greater effect, with active links between education, policy, business, civil society etc.
POLICY MIX ISSUES	
Resource mobilisation	<ul style="list-style-type: none"> • in principle resources for R&I can be found by identifying the added value and pathways for advance investment. In practice there are problems of time, public goods, asymmetrical knowledge, etc.
Knowledge demand	<ul style="list-style-type: none"> • as a result, government has an essential role as the R&I client, representing the public good. However the R&I output should not stay on the shelf in academic journals, but look actively for pathways to knowledge application.
Knowledge production	<ul style="list-style-type: none"> • on the other side, the production of such knowledge should be in the context of social-political-economic innovation, where users and prototypes are part of the field.
Knowledge circulation	<ul style="list-style-type: none"> • as above, a platform in each thematic area would help to circulate and mobilize.

The likely roles of key actors and stakeholders is shown in the summary here (to be elaborated in further consultation):

10.7.4 Table 18c: stakeholder roles: global resources

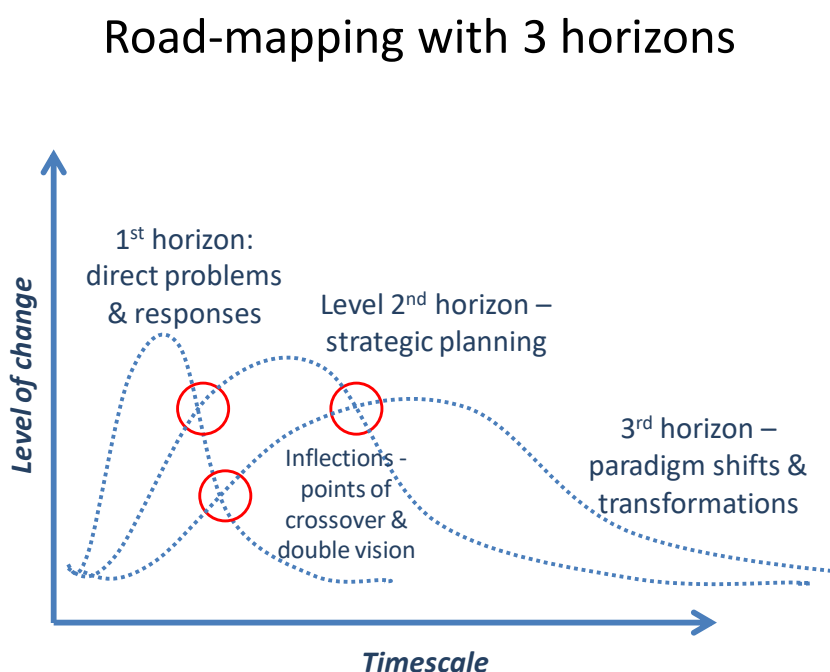
	Government & public agencies	Higher education & related	Private sector industry, finance	Civil Society Organizations
Global resources				
Communications	National wireless coverage	ICT –enabled education	Online business communities	Online social & cultural communities
Finance	Financial sector incentives for R&I	Education / industry & finance links	Access to investment & joint equity	New social & ecological finance
Tourism	Promote responsible eco-tourist activity	Enhance knowledge base for tourism	Incentives for skills & eco-tourism	Social enterprise for eco-tourism
Networks	reverse migration & active diaspora	Incentives for global science networks	joint equity / reverse innovation schemes	promote active diaspora

10.8 Putting it together: an outline roadmap

This roadmap is a synthesis of the consultations and studies so far. It is not intended to be fixed in stone: instead it aims to establish a rolling programme for ongoing review. We recommend that it sets out parallel tracks in the form of ‘3 horizons’: these are to be tested in the final NRFE consultation in 2013.

The chart at Figure 14 shows the general idea of 3 types of change and policy intervention. It also shows ‘inflection’ points of cross-over, where there is more than one agenda, and more than one role for policy intervention.

10.8.1 Figure 14: Roadmapping with 3 horizons



10.8.2 Horizon 1 – near term

This focuses on direct actions in the near term of 1-3 years. General policies should look at getting immediate resources into top priority areas, relieving blockages, and continuing the study and knowledge development programme for Horizons 2 and 3.

Horizon 1 key policy priorities

- Present the case for a target of government investment in R&I. Based on comparable national economies this would be a minimum of 1% of GDP.
- Prioritize short term R&I actions in the cluster themes.
- Explore new R&I models for science participation, funding, dissemination.
- skill development programs, coordinated with SME fiscal incentives.
- Scoping studies on business R&I models, which can address wider policy agendas.

- Next stage of 'cluster themes' development, with focus on supply, demand & networking of R&I assets, for each cluster theme.
- Enhanced tech transfer services & engagement of SMEs & industry associations
- Enhanced IP services & engagement of SMEs & industry associations
- Scoping studies on financial & accounting framework, for social & ecological assets & values.
- Identify public service procurement profiles & processes in the context of wider strategic objectives.
- Identify sources & flows of external finance into business R&I activity:
- Diaspora programme to be extended to a more active multi-level engagement.

10.8.3 Horizon 2 – medium term

This focuses on strategic actions in the medium term of about 5-10 years. General policies can look ahead to strategic aims, for the building of a R&I and higher education community: spread of knowledge-based activities: strategic goals and programmes for each of the thematic clusters. Also this will look at enabling resources for R&I, such as large datasets, upskilling and capacity building in the education sector, and supporting knowledge-based enterprise communities.

Horizon 2 key priorities:

- Medium term objectives -R&I should be a primary focus of lifelong education for all social & business enterprise.
- HR & skills / training systems should be the focus of development in public & private sectors
- Business should orientate R&I activity towards new business models which address wider agendas in policy & society.
- Clusters and R&I networks should be coordinated to address larger social business opportunities.
- Knowledge transfer as part of a broader strategy which includes for new social business models.
- IP-related assets should be managed as part of a wider policy agenda for integrated R&I.
- Finance for R&I should be freely accessible on suitable terms, incl. for social & ecological values and objectives.
- Public sector policy & procurement should prioritize lead markets & critical technologies.
- Balanced diversification of global-local firm structures, equity, finance and human resources, should be the first priority of R&I policy.

10.8.4 Horizon 3 – longer term

This looks towards more structural transitions in the longer term (over 10-20 years): although for every long term agenda, the foundations can be laid, and seeds planted in the shorter term. General policies are aimed more at the transformation of public policy and public services: new kinds of integration of enterprises and communities: and transformational models for R&I with enabling structures. These will continue to explore opportunities in multi-disciplinary R&I: multi-sectoral applications: and multi-level knowledge developments. One of the key actions is to establish a foresight / strategic intelligence unit as a next step.

Horizon 3 priorities:

- Longer term goals & transitions: new models for R&I in society & economy, incl science participation, funding, dissemination.
- continuous skill development across society & economy.
- new social business R&I models, which can address wider policy needs.
- SMEs and firms linked into larger networks of shared intelligence & collaboration
- Knowledge transfer & shared learning is embedded into every sector & organization
- Innovation & creative IP is embedded into every sector & organization
- Fully holistic financial models, including social & ecological assets & values.
- public procurement is the catalyst for enabling wider strategic objectives
- Fully internationalized and smart specialized R&I community.

Each of the 6 thematic clusters would have a more specific application of the 3 horizons roadmap approach. This is all to be explored in the next stages of the proposed continuing foresight programme.

11 RECOMMENDATIONS

These are key recommendations, based on the results of the NRFE study, for a National Research & Innovation Strategy. They are offered in the first case for the Ministry of Tertiary Education, Science, Research and Technology, together with other government departments and other relevant stakeholders.

11.1 National Research and Innovation Strategy

From the consultation and desk study, we recommend that a National Research and Innovation Strategy be established with 5 main aims:

- a) Promote a research and innovation (R&I) culture throughout all parts of society and the economy, based on the unique situation and potential of Mauritius.
- b) Contribute to the national goals of social, economic and ecological development, especially those which involve knowledge-based activity, higher skills base, new kinds of data and evidence, and new models for sustainable development.
- c) Demonstrate economic development pathways for Mauritius beyond the middle-income country stage, with a key role for R&I to enhance productivity and competitiveness.
- d) Prioritize R&I themes which build on world class expertise, and also focus on the unique problems and opportunities of Mauritius.
- e) Develop R&I processes and systems, which are creative, forward looking, holistic, participative, multi-disciplinary, multi-sectoral and transparent.

11.2 Policies and programmes

To achieve these aims, the National Research and Innovation Strategy should establish a policy framework and roadmap. There are some overall features of the policy framework:

- Active collaboration between public, private, civil, and R&I sectors;
- Using the potential of public procurement to lead markets and innovations;
- Knowledge-based innovation approach to public governance and public services.
- Generally a 'Mode 2' approach to shared learning, linking R&I with its social/ economic applications.

To put this into action, the R&I strategy should begin setting up policies and programmes for 10 key policy domains:

1. **Science base and higher education:** identify high priority science areas: promote organizational innovation in universities and related bodies: horizontal resources, databases etc: R&I programmes to study and develop skills for organizational innovation.
2. **Human Resources & training issues:** promote lifelong learning in business: public fiscal incentives for education and skills development:
3. **Business Enterprise R&D / Innovation focus:** fiscal policies to encourage firm-level R&D, for innovation in technology, business models, with social and ecological enterprise models.
4. **SME & firm clusters & networks:** promote innovation networks and forums for businesses, supply chains and social enterprise:
5. **Technology / Knowledge Transfer focus:** develop 'platforms' for transfer and exchange in lead technologies or critical technology sectors and supply chains:
6. **Innovation governance, IP and related issues:** establish clear and accessible routes to IP at all levels: including for alternative modes of social-ecological innovation, e.g. traditional, indigenous or community-based knowledge:
7. **Finance, fiscal, access and equity issues:** set up financial models for strategic R&I for policy agendas on integrated systems:
8. **Policy interventions and public procurement:** identify R&I needs for lead markets and advance procurement programmes, to enhance social and ecological returns.
9. **Globalisation and international links:** mobilize the potential resource of the Mauritian diaspora, with networking facilities and forward-looking migration policies:
10. **Sectoral disparities and distribution issues:** promote lifelong education and diverse forms of R&I participation, by groups such as women, ethnic minorities, migrant workers, youth and elderly groups.

11.3 Priority cluster themes

These are the main features of the R&I agendas and modes of working, based on the current cluster themes. As these are developed, new combinations would emerge.

- **Marine / land-ocean industries:** R&I which follows an industrial ecology integrated systems approach: coupled with social ecology approach for enterprises, employees, residents and visitors.
- **Agriculture / sugar / food / health:** holistic systems analysis of the links between agriculture, landuse, food systems and public health: strategic conversion for social-ecological benefits.
- **Infrastructure resources, (energy / water / transport / waste):** R&I which follows an industrial ecology integrated systems approach: coupled with a social ecology approach for enterprises, employees, residents, visitors and others.
- **Social and cultural issues** (demographic change, cohesion, empowerment, citizenship): social science R&I which aims at multi-lateral, participative, co-production modes of knowledge gathering and mutual learning.
- **Enterprise & human resources:** (skills, firms, finance, entrepreneurs): innovation focused R&I programmes which look beyond conventional themes towards whole supply chains, investment models, entrepreneur models and innovation systems.

- **Global links and resources:** finance, ICT, tourism, trade, security, climate change: outward facing R&I programmes which look at inter-connections and synergies between a wide range of threats and opportunities.

In each of these, the recommended key feature is for an 'Integrated Program' approach to the R&I landscape, together with focused policy-relevant Foresight studies. This will allow specific projects (basic, applied or experimental development), to take shape in a wider context where knowledge is internationally networked, distributed, co-produced and mobilized at all levels of public and private sectors.

11.4 Roles and human resources

The national R&I strategy should aim to involve and mobilize the resources of stakeholders, in ways which are forward looking, participative and inter-connected:

- **Government and public agencies:** integrated strategies which put R&I in the lead role as the catalyst for new business models. These can be facilitated with a combination of procurement, regulation, fiscal incentives and other public facing policies. For instance where each Ministry has its own research and information capacity, these should be linked into common 'platforms' to deal with cross-cutting issues.
- **Higher education** and related organizations: new concepts of inter-disciplinary education and skills development, which focus on integrated systems in industrial ecology and social enterprise, with new paradigms for shared learning and knowledge co-production. For example, the potential resource in student dissertations is far greater than their academic teachers: so a forward looking strategy would aim to mobilize them for mutual benefit.
- **Private sector business and finance:** accelerating R&I to look for new business models, linked to social & ecological agendas, raising the knowledge & skill base of employees. Need to increase R&I and knowledge base at enterprise level. The role of ICT and ICT training may be crucial, as a way of raising the game across whole sectors.
- **Civil society organizations (CSOs):** enabling role as catalysts, facilitators, educators and coordinators of integrated systems models for production, consumption and civil society. Here the role of new social media is likely to be crucial, with new opportunities in real time data on the needs, problems, opportunities and ideas of citizens and society.
- **MRC, and related organizations:** generally a key role as catalysts, facilitators and coordinators of the knowledge and intelligence required for the above. Not least is the need to build capacities and skills of inhouse staff.

The overall principle here is that R&I is one component in a wider picture of innovation across society: this includes skills development, organizational change, economic capitalization, technology deployment, social enterprise and public services.

11.5 Financial resources

Adequate levels of funding for R&I are essential: also so is the strategic planning and targeting of the funding which exists. The current estimate (2012) of total R&I investment in Mauritius is 0.36% of

GDP, which compares to the OECD recommendation of a minimum 1% of GDP. Meanwhile, innovation-focused small countries / islands such as Finland, Malta or Singapore regularly invest 3-4% of GDP. However in practice there may be constraints on both government and business direct expenditure: so the recommendation here is to investigate alternative sources of finance. Options might include:

- Mobilization of a proportion of the current business CSR “2%” scheme for R&I funding. This would need national level planning and management, in order to meet the current concerns on accountability and effectiveness of the use of these funds. Such planning would include for incentives and value-added return to the relevant business sector.
- A parallel model in principle seems viable in the public sector: for instance in health or education, where the majority of costs are in staff, organizational innovation and up-skilling is very likely to increase efficiency and effectiveness.
- Public procurement and infrastructure procurement, should include for ‘advance innovation programs’, to provide long term incentives and reduced risks in lead technologies, and also in organization change. Again some form of strategic framework will be needed to coordinate and focus these resources to best effect.

Overall, the recommended National Research and Innovation Strategy would provide the essential coordination and direction of R&I needs and capacities.

11.6 R&I infrastructure resources

There are certain items of R&I ‘infrastructure’ which would generate large added value at (relatively) small cost. These are recommended here for further investigation.

11.6.1 A continuing foresight capacity

The first is to establish a ‘foresight and strategic intelligence unit’, for the continuous development of the ‘3 horizon roadmap’ for each of the cluster themes, and applied to the knowledge society. One example is the APEC Centre for Technology Foresight in Bangkok, which prepares APEC economies for rapid change and major societal challenges (www.apecforesight.org). For Mauritius, the recommended activities would include:

- Research: a series of foresight based study reports: these would form the backbone and reference point for each of the cluster themes above.
- Consultancy: targeted studies for clients and government departments, drawing on the futures oriented evidence base of the foresight papers reports.
- Training & capacity building: programs for engagement of business, policy, education and civil society, with the aim of promoting a forward R&I culture and practice.
- Communications: establish a platform (with both ICT and human resources) relevant to each cluster theme, for communications, knowledge exchange, events and initiatives.

11.6.2 Horizontal infrastructures

There are also 'horizontal' R&I infrastructure items, which would support and enable the cluster R&I programs:

- Scientific library: the University and/or MRC should have access to international standard academic library facilities. This might be negotiated with academic publishers through overseas partners or networks.
- Integrated database and data management program: potential for inter-operability of national geo-spatial, economic, infrastructure and social datasets. This could also link to new social media data feeds.
- Integrated educational & training resource program: coordinates the curriculum & methods & learning resources at each stage & each field, from primary school to higher education: then also inter-connected with business, public services & governance.

11.7 Existing initiatives

There is already a huge range of activity (given the size of Mauritius), and it is important that any longer range strategy based on the Foresight approach can build on and help to mobilized this. Firstly there are several research centres or collaborations now emerging:

- The CBBR (Centre of Excellence for Biomedical and Biomaterials Research) is now established as an internationally leading research centre. Ongoing R&I activity here should be able to lead or make major contributions to the clusters on 'Ocean & Island Resources', and 'Agriculture-Food-Health'. In terms of the R&I framework above, the CBBR has both a USP, direct policy-relevance and scientific excellence: so it deserves the highest level of support. The CBBR also includes two of the National Research Chairs, in 'Biomaterials and Drug Delivery', and in Biochemistry.
- The National Centre for Diabetes Research is a new collaboration with the University of Oxford, UK, and should be able to make major contributions to the 'Agri-Food-Health' cluster programme.
- A third National Research Chair in Solid Waste Management, is also an important source of expertise, to be mobilized for the 'Infrastructure Resources' cluster.

11.7.1 Other initiatives

The National Research Groups were set up in 2010-12, covering Energy, Human Resources, 'Food Quality on Human Health': Water Resources: and Road Traffic Management. These cover many of the issues in the NRFE cluster themes. The main focus of these National Research Groups is on a 5-year horizon, focused on immediate and pressing policy issues, and looking more at the applied research and consultancy end of the spectrum. Various members have also contributed to the NRFE consultations and the 6 cluster themes have aimed to build on these with a longer term futures perspective in each case.

The MID ('Maurice Isle Durable') consultation programme has also produced very topical and challenging findings, some of which are on the interface between R&I, policy, business and civil society. Overall, it seems that the sustainable development of Mauritius faces very similar

challenges and R&I themes, to that of much larger countries or continents: for instance the world's largest single R&I programme in the EU is addressing very similar issues, with over 100 times the resources. This suggests three points for the NRFE:

- Mauritian R&I should be internationally networked, distributed, co-produced and mobilized at all levels of society and economy:
- Mauritian R&I should identify its USP, as a unique test bed and demonstration of integrated sustainable development:
- With these in mind, strategic direction and priority setting for all types and levels of R&I, will be essential.

The current government-backed 'Ocean Economy' programme is one example of this approach. The wide range of expertise and R&I which is needed will not all be found in Mauritius: so to grasp this huge opportunity will depend on the capacities for networking, co-production and mobilization, as above.

The MRC itself is also responsible for many cross-cutting initiatives, which would also be essential components in the NRFE cluster themes. The IPR and Technology Transfer Programme: Collaborative Mauritius: Research-Industry Linkage: Research and Science Outreach and others, are each potentially part of the Foresight-based policy agenda as recommended above.

11.8 Final recommendations & next steps

This report, following the final round of consultation, is now submitted to the Mauritius Research Council.

The overall recommendations are to work towards a National Research and Innovation Strategy, with 6 main next steps:

- a) Identify priority actions to be carried out by the government, by MRC or by others, in the roadmap format: near term, medium and longer term.
- b) Identify strategic goals for each of the thematic clusters in the roadmap format: near term, medium and longer term.
- c) Establish a rolling work program & knowledge platform to mobilize and coordinate activity in each cluster theme.
- d) Identify opportunities for new funding mechanisms as **input** for R&I: these may be national level or at the cluster / sector level.
- e) Identify opportunities for uptake of **output** of R&I: not only dissemination of knowledge, but a culture of active learning, skills and innovation at all levels of all organizations.
- f) Establish a continuing 'foresight and strategic intelligence unit', for ongoing development of the '3 horizon roadmap' for each of the cluster themes, and for the over-arching goals of the knowledge society.

11.9 Postscript

The transition to an innovation and knowledge-based country is a wide ranging process of creative collaboration. This needs more than a list of government policies and funding streams (although these are essential). It depends on the vision and commitment of many organizations and individuals across the economy and society, for looking ahead, rethinking current business and policy models, and forward investment of human and other resources.

In this process, the Manchester team as far as possible aimed at pro-active dialogues and a capacity building approach (rather than 'parachuting in'). Likewise the outcome aimed to be not only a list of projects and policies, but more to explore a collective vision for a knowledge-based sustainable development of the national economy and society. It seemed the time was right for this, in view of the trajectory of growth, along with the perception that such growth could endanger social or ecological assets.

If this study, with all the commitment and contributions from stakeholders, helps to establish a continuing process of strategic thinking and creative collaboration, then the results will be a great investment for all concerned.

12 NOTES

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12.2 Project team & advisors

- Joe Ravetz (project manager and lead author) is a leading thinker on futures and innovation studies and strategic policy intelligence, with particular applications to cities / regions, and environment / climate / resource issues. He has advised the UK government, research councils and regional bodies: European Commission and EU agencies: United Nations Industrial Development Organization and others.
- Dr Ozcan Saritas is a Research Fellow at the Manchester Institute of Innovation Research (MIOIR, formerly PREST) and is the editor of Foresight: the journal of future studies, strategic thinking and policy.
- Dr Paul Cunningham: specialist in national science & innovation policy
- Deborah Cox has experience of leading and managing successful transnational research projects.
- Dr Jennifer Cassingena Harper; specialist in Foresight & innovation policy for small nations and island states.
- Prof. Ian Miles: Co-Director of MIOIR, expert on services innovation, and co-developer of Foresight methods.
- Prof. Luke Georghiou, Co-Director of MIOIR, expert on innovation policy & evaluation, and co-developer of Foresight methods

12.3 Membership of NRFE Steering Group

The Steering Group includes representatives from the following:

- Agricultural Research and Extension Unit
- Enterprise Mauritius
- Food and Agricultural Research Council
- Human Resources and Development Council
- Mauritius Chamber of Commerce and Industry
- Mauritius Institute of Education
- Ministry of Tertiary Education, Science, Research and Technology
- Mauritius Oceanographic Institute
- Mauritius Research Council
- Mauritius Sugar Industry Research Institute
- Tertiary Education Commission
- University of Mauritius
- University of Technology, Mauritius

12.3.1 In depth interviews

These interviews included representatives of:

- CBBR
- Human Resources Development Council
- Maurice Isle Durable (MID)
- University of Mauritius
- Enterprise Mauritius
- Joint Economic Development Council

12.4 Internal reports and resources:

12.4.1 Consultancy materials

These are the main materials produced during the study by Manchester staff, including written reports and spreadsheets. They are summarized in the Technical Annex, and full versions are available on the NRFE webpages.

- Proposal for inception workshop
- Inception report
- Mid-term report
- Work programmes Phase 2
- Work programmes Phase 3

- Scenarios interim report
- Cluster working group templates
- Online survey report (spreadsheet & slides).

12.4.2 Inhouse materials

These are the main reports produced for the NRFE program by MRC staff, including written reports and some spreadsheets. They are available on the NRFE webpages.

- NRFE 01/11: Introduction to the National Research Groups
- NRFE 02/11: Mauritius Vision 2020: a summary
- NRFE 02/11: Competitiveness Foresight: What Orientation for Mauritius?
- NRFE 02/11: MRC Thematic Working groups- A summary
- NRFE 03/11: National trend analysis: energy
- NRFE 03/11: Compilation of executive summaries of MID working groups
- NRFE 04/11: Parastatal Organisations and Ministries involved in Research in Mauritius
- NRFE 05/11: Projections for Resident Population of Mauritius from 2009/10 to 2034/9
- NRFE 06/11: researchable issues from the MID working groups: (report & spreadsheet)
- NRFE 07/11: Global Scan (report & spreadsheet)
- NRFE 08/11: National Trend Analysis -Climate change
- NRFE 10/11: National trend analysis – local environment
- NRFE 11/11: National trend analysis – greenhouse gas emissions
- NRFE 12/11: National innovation landscape for Mauritius
- NRFE 13/11: National technology landscape for Mauritius
- NRFE 14/11: National trends from Thematic Working Groups (spreadsheet)
- NRFE 14/12: S.T.I. in Mauritius – Landscape and review
- NRFE 15/12: Tertiary education and knowledge sectors in Mauritius
- NRFE 16/12: IP considerations in Mauritius
- NRFE 17/12: National Research Chairs
- NRFE 18/12: National Research Groups – a status quo
- NRFE 19/12: MID – a status quo
- NRFE 20/12: National Trend Analysis -Climate change (updated)