An investigation into the challenges of transdisciplinary R&D: Values, culture and the case of the BIOSSAM project

by
Alan Colin Brent

Thesis presented in partial fulfilment of the requirements for the degree Master of Philosophy in Sustainable Development Planning and Management at Stellenbosch University

Supervisor: Prof Mark Swilling
Faculty of Economic and Management Sciences
School of Public Leadership

March 2012

Declaration

By submitting this thesis/dissertation electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the sole author thereof (save to the extent explicitly otherwise stated), that reproduction and publication thereof by Stellenbosch University will not infringe any third party rights and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

Alan Colin Brent
February 2012

Integrated Abstract – of two journal article submissions

The emerging classification of Sustainability-oriented Innovation Systems places an emphasis on the social elements of change, as well as the technological. However, sustainability-oriented problems are too vast for one person or discipline to comprehend; thus people tend to want to collaborate, meaning they form teams. As a further extension to address sustainability-oriented problems, there is an increasing emphasis on transdisciplinary research and development (R&D) efforts, whereby co-production transgresses boundaries, and science becomes visible before it becomes certain. To reach the objectives of transdisciplinary R&D efforts will require two key concepts: the gathering of information from experts, namely *knowledge transfer*; and making connections between them, namely *knowledge integration*. Nevertheless, challenges have been noted in terms of academic tribes that impede teamwork, and, importantly, the lack of combined thought and action in R&D.

This research, which is compiled as two journal articles, explored the collaboration, between disciplines, that has been described as the means of meeting the requirements of transdiscplinary R&D to identify, structure, analyse and deal with specific problems in such a way that it can: grasp the complexity of problems; take into account the diversity of life-world and scientific perceptions of problems; link abstract and case-specific knowledge; and develop knowledge and practices that promote what is perceived to be the common good. However, the latter brings into question how values and culture influence collaboration and thus transdisciplinary R&D efforts. The first article set out to investigate, from a literature analysis, how the culture and values of individuals in a transdisciplinary R&D team, as well as those of the organisation, determine the potential success or failure of the R&D effort. A conceptual framework is derived based on the theories of complexity, as it relates to knowledge management, learning within organisations, cognitive and behavioural approaches to culture and values, and communication. The framework also builds on previous research that has been conducted with respect to the management of transdisciplinary R&D. The second article then utilises the introduced conceptual framework for an in-depth investigation of a case study in the bioenergy field. The R&D project, which spanned over three years in South Africa, required a transdisciplinary team of engineers and scientists of various fields to collaborate with stakeholders outside the R&D team. The case emphasises that the lack of disciplines to recognize, understand and incorporate values and culture into R&D practices will lead to project failure; pre-empting and managing expectations of social change (often) far outweigh the necessity for technological change. A number of recommendations are thus made to improve R&D practices.

Keywords: Transdisciplinarity, sustainability, innovation, technology colony, green economy, Africa.

Geïntegreerde Opsomming – van twee joernaal artikels vir indiening

Die opkomende klassifikasie van Volhoubaarheid-georiënteerde Innovasie Sisteme plaas 'n klem op die sosiale elemente van verandering, sowel as die tegnologiese. Volhoubaarheid-georiënteerde probleme is egter te groot vir een persoon of dissipline om te verstaan, dus neig individue om saam te wil werk, wat beteken dat hulle spanne vorm. As 'n verdere uitbreiding om volhoubaarheid-georiënteerde probleme aan te spreek, is daar 'n toenemende klem op transdissiplinêre navorsing en ontwikkeling (N&O) pogings, waardeur mede-produksie grense oortree, en die wetenskap sigbaar word voor dit sekerheid bereik. Om die doelwitte van transdissiplinêre N&O pogings te bereik sal twee sleutelkonsepte vereis: die insameling van inligting van deskundiges, naamlik die oordrag van kennis, en die maak van skakels tussen hulle, naamlik kennis integrasie. Desondanks is die uitdagings wel bekend in terme van akademiese stamme wat spanwerk belemmer, en, baie belangrik, die gebrek aan gekombineerde denke en optrede in N&O.

Hierdie navorsing, wat saamgestel is as twee joernaal artikels, ondersoek die samewerking, tussen dissiplines, wat al beklemtoon is vir die vereistes van transdissiplinêre N&O om spesifieke probleme te identifiseer, struktuur, ontleed en hanteer in 'n manier wat: die kompleksiteit van probleme op 'n verstaanbare wyse beskryf; rekening hou met die diversiteit van die lewe-wêreld en wetenskaplike persepsies van probleme; abstrakte en geval-spesifieke kennis skakel; en die ontwikkeling van kennis en praktyke bevorder wat beskou word as die algemene goed. Maar die laasgenoemde bring in twyfel hoe die waardes en kultuur samewerkings, en dus transdissiplinêre N&O pogings, beïnvloed. Die eerste artikel, met behulp van 'n literatuur-analise, ondersoek hoe die kultuur en waardes van individue in 'n transdissiplinêre N&O span, sowel as dié van die organisasie, die potensiële sukses of mislukking van die N&O poging bepaal. 'n Konseptuele raamwerk is afgelei wat gebaseer is op die teorieë van kompleksiteit, soos dit verband hou met die bestuur van kennis, leer binne organisasies, kognitiewe en gedrag benaderings tot kultuur en waardes, en kommunikasie. Die raamwerk bou op vorige navorsing wat gedoen is met betrekking tot die bestuur van transdissiplinêre N&O. Die tweede artikel gebruik dan die konseptuele raamwerk vir 'n in-diepte ondersoek van 'n gevallestudie in die gebied van bio-energie. Die N&O-projek, wat gestrek het oor 'n tydperk van drie jaar in Suid-Afrika, het van 'n transdissiplinêre span van ingenieurs en wetenskaplikes, van verskeie gebiede, verwag om saam te werk met belanghebbendes buite die N&O-span. Die gevallestudie beklemtoon die gebrek van dissiplines om waardes en kultuur te erken, verstaan en inkorporeer in N&O-praktyke wat sal lei tot die mislukking van sulke projekte; vooruitskatting en die bestuur van die verwagtinge van sosiale verandering is (dikwels) veel swaarder as die noodsaaklikheid van tegnologiese verandering. 'n Aantal aanbevelings word derhalwe gemaak om N&O praktyk te verbeter.

Kernwoorde: Transdissiplinariteit, volhoubaarheid, innovasie, tegnologie kolonie, groen ekonomie, Afrika.

Acknowledgements

The researcher would like to acknowledge the (other) researchers that had undertaken this transdisciplinary research effort, and had shared their experiences, good and bad. In particular, the following individuals are acknowledged for the ‘post-mortem’ analysis of the bioenergy case study:

- Dr William Stafford – (later) leader of the BIOSSAM project;
- Dr Lorren Hayward – driver of the sustainability visioning process;
- Ms Benita de Wet – implementation of the sustainability visioning process;
- Ms Josephine Musango – system dynamics modelling; and
- Mr Maxwell Mapako – technology transfer to communities.

Finally, the researcher wishes to thank stakeholders of the Agulhas Plains case in the BIOSSAM project. Without their efforts the transdisciplinary focus of the project would not have been possible.

Table of Contents

List of Figures

List of Tables

List of acronyms and abbreviations

BIOSSAM	Bioenergy Systems Sustainability Assessment and Management
CSIR	Council for Scientific and Industrial Research
IAPs	Invasive Alien Plants
MCDA	Multi-Criteria Decision Analysis
MLP	Multi-Level Perspective
NSI	National System of Innovation
PPP	Policies, Programmes and Projects
R&D	Research and Development
SoIS	Sustainability-oriented Innovation Systems
TFP	Total Factor Productivity

1 Introduction

As per the Prospectus of the postgraduate programme in Sustainable Development Planning and Management, it was elected to compile this research document in the format of two academic articles for submission to journals – see section 1.5.

It is now well understood that the dominant systemic features of the current global economic system are unsustainable (Swilling, 2010; Söderbaum, 2009). Numerous indicators show economic activities to be direct causes of global instabilities, including, amongst others, climate change, resource depletion, and eco-system and habitat destruction (UNEP, 2010). The increasing need for economic system transitions toward more sustainable trajectories is evident and a pressing concern for policy-makers worldwide (Elzen et al., 2004). Many governments now pursue the potential opportunities offered by the global 'green economy' (UNEP, 2011). Developing countries, in particular, have recognised that a transition towards a green economy is inextricably intertwined with meeting the Millennium Development Goals (UNEP, 2010). To initiate such an economy in South Africa, Peter and Swilling (2011) highlight one key intervention being investment in and incentivising sustainability-oriented innovations in technology and enterprise[1]: "*to kick-start a green economy based on innovation, a system of innovation that works well and preferably better than one of the main competitors worldwide would be an important success factor*". From a green economy perspective, with its particular focus then on innovation, the following should be considered (McCarthy, 2005):

- The contribution of Total Factor Productivity (TFP) to growth in South Africa is lower than that for the selected faster-growing economies; and
- The gap in TFP between South Africa and the 'world technology frontier' is large and has grown.

Eyrand (2009) suggests that these characteristics of South Africa may be linked to an underinvestment in research and development (R&D) as measured through: relatively lower investments in R&D, and relatively lower number of R&D researchers in the country. Arora and Bhundia (2003) also observed that R&D did not play a significant role in TFP growth in the post-apartheid era of the South African history, which was emphasised by the South African Innovation Survey (Oerlemans et al., 2003) in that the R&D effort by firms in South Africa was shown to be generally low when compared to other countries with similar economies. The situation is further exasperated by the persistence of the challenges of a 'technology colony' (de Wet, 1999) in terms of weak technology transfer flows between local basic and applied R&D and the requirements of the local market (see Figure 1). From a sustainability perspective it means that current R&D efforts are

[1] Peter and Swilling (2011) state that: "*where technology is concerned, new technology uptake and pure technological innovation should be pursued by the state and private sector institutions. Where enterprise is concerned, innovative business models and processes that operate at SMME scale to the large scale can transition from niche to regime levels of operation. Niche-level innovation refers to (1) technological innovation: technology solutions for developing world contexts, and (2) enterprise innovation: business process and model innovations to catalyse transition green innovations and products to regime level*".

(often) not focused on, or well-organised for, real societal needs to address the problems of sustainable development.

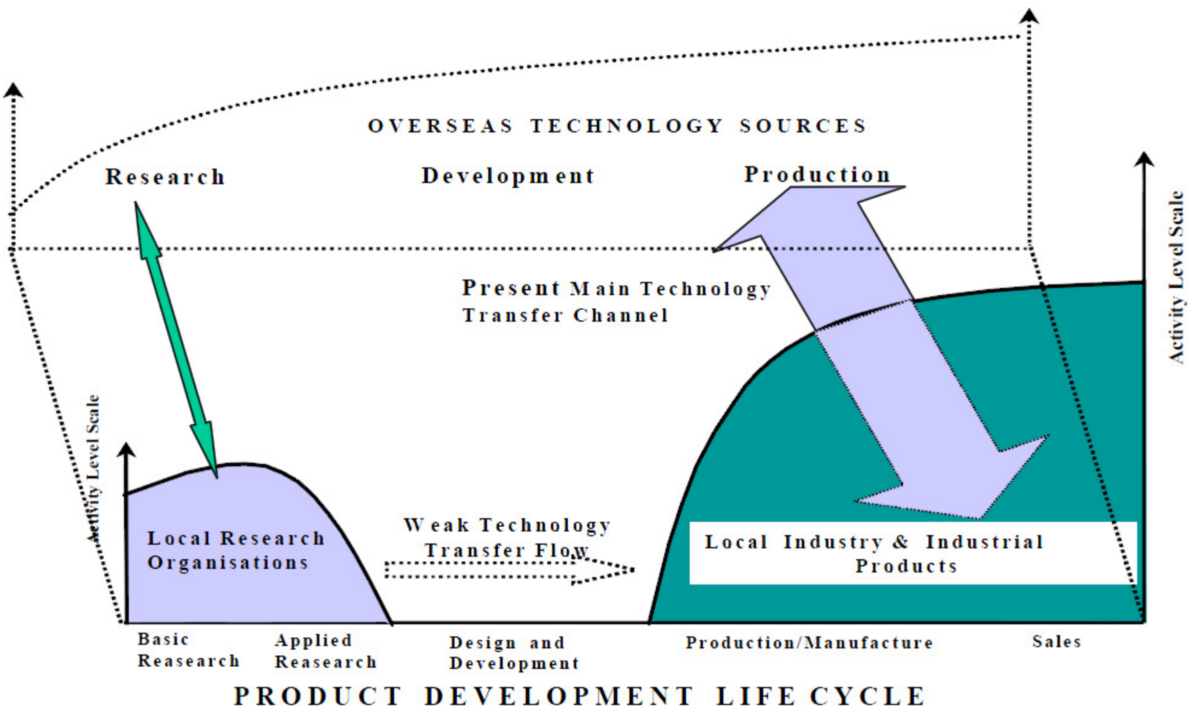

Figure 1. Technology transfer channels in (African) technology colonies
(Source: de Wet, 1999)

1.1 R&D and Sustainability-oriented Innovation Systems

Innovation is viewed as a key driver of economic progress. Conversely economic systems themselves, to a large extent, determine the trajectory of innovation. Furthermore, the conceptual understanding of innovation, and hence its application, is diversified by theoretical heterogeneity. This is due to a plethora of theoretical understandings stemming from different epistemic origins and varying user contexts (Peneder, 2010).

The dominant view of innovation over the past two decades relates to technological progress, competitiveness and economic growth (Coenen and Lopez, 2010; Acs, 2000). This strong tradition stems from an era where resource constraints, ecological and social pressures were not as apparent as they are today. Environmental pressures and social inequalities are precisely the reason that narrow understandings of innovation and innovation systems are being challenged to include alternative and wider and more suitable conceptions (Lundvall et al., 2009). The agglomeration of several and aligned incremental or radical innovations is thus required that results in system innovation and, at a macro level, a national system of innovation (NSI), which is increasingly supported as a capable avenue for achieving sustainable economic growth (Stamm et al., 2009), or 'decoupling' (see Figure 2). Where transitioning towards sustainable development is concerned, the innovation literature (Geels, 2002; Smith et al., 2010) places much emphasis on the multi-level perspective (MLP) as a conceptual framework for understanding the dynamics of this transition[2].

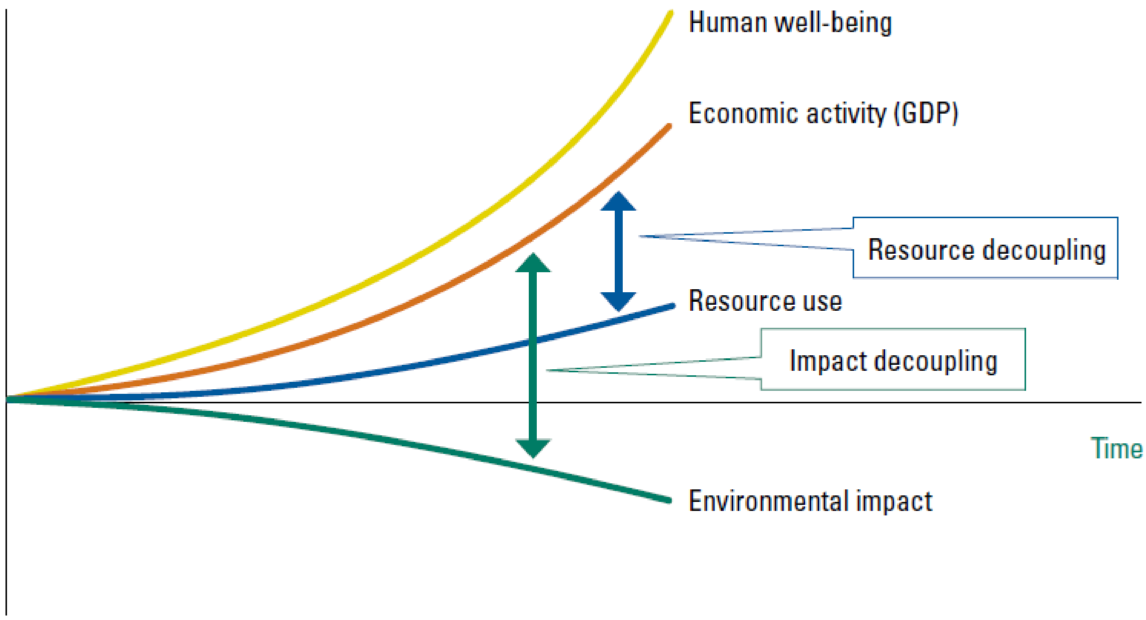

Figure 2. The two aspects of 'decoupling'
(Source: UNEP, 2011)

The MLP framework accommodates three levels, namely the socio-technical landscape (or exogenous context) that brings about pressure upon the socio-technical regime (consisting of policy, regulation, technology, industry, science and culture) and socio-technical niche innovations (or small networks of actors that support the introduction of novel ideas, concepts, products, and processes) (Peter and Swilling, 2011). This notion fits into an emerging classification of Sustainability-oriented Innovation Systems (SoIS) that places an emphasis on the social elements of change, as well as the technological (Elzen et al., 2004; Stamm et al., 2009); thereby providing for a more vibrant culture of innovation. Such a SoIS, in turn, then requires a different, concerted approach to R&D to address sustainability-oriented problems that are identified in the NSI with the transition to a green economy.

1.2 Research rationale

Sustainability-oriented problems are too vast for one person or discipline to comprehend; thus people tend to want to collaborate, meaning they form teams (Nortje, 2011). As a further extension to address sustainability-oriented problems, there is an increasing emphasis on transdisciplinary R&D projects, whereby co-production transgresses boundaries (see Figure 3), and science becomes visible before it becomes certain (Collins and Evans, 2002). To reach the objectives of

[2] The MLP has been criticized for its select focus on (physical) technology and the exclusive focus on the emergence of system innovation within niche environments. Although the MLP provides a valuable conceptual framework for the integration of a variety of theoretical perspectives on innovation and evolutionary economics, it can be improved upon, although this is not the focus of this study.

transdisciplinary R&D, projects will require two key concepts (Carlson, 2007): the gathering of information from experts, namely *knowledge transfer*; and making connections between them, namely *knowledge integration*. The latter is the creative extension of knowledge transfer and occurs when there is a convergence of different knowledge - from different sources - and within this convergence solutions are found that transcends the boundaries of specific disciplines. Nevertheless, when considering the necessity of larger transdiscplinary R&D projects, challenges have been noted in terms of academic tribes that impede teamwork (Sillitoe, 2004), and, importantly, the lack of combined thought and action in R&D management practices (Quinlan and Scogings, 2004).

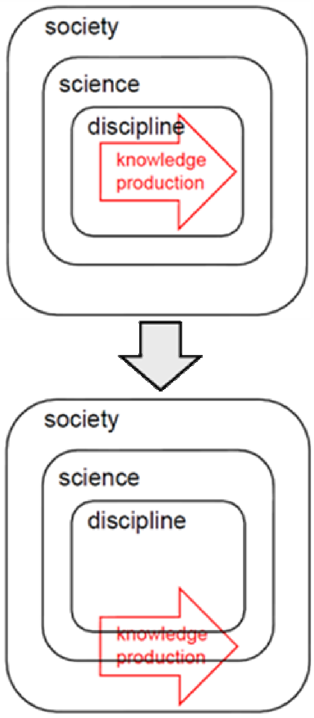

Figure 3. Transdisciplinary R&D projects transgress boundaries

1.3 Research problem and objectives

The study intended to explore the collaboration, between disciplines, that has been described as the means of meeting the requirements of transdiscplinary R&D to identify, structure, analyse and deal with specific problems in such a way that it can (Pohl and Hirsch Hadorn, 2008):

- Grasp the complexity of problems;
- Take into account the diversity of life-world and scientific perceptions of problems;
- Link abstract and case-specific knowledge; and
- Develop knowledge and practices that promote what is perceived to be the common good.

The latter raises the research question:
How do values and culture influence collaboration and thus impede transdisciplinary R&D efforts?

Thus, the study set out to investigate how the values of individuals in a transdisciplinary R&D team are influenced by culture and how the values (and culture) differences determine the potential success or failure of the R&D project. The associate propositions are summarised in Figure 4.

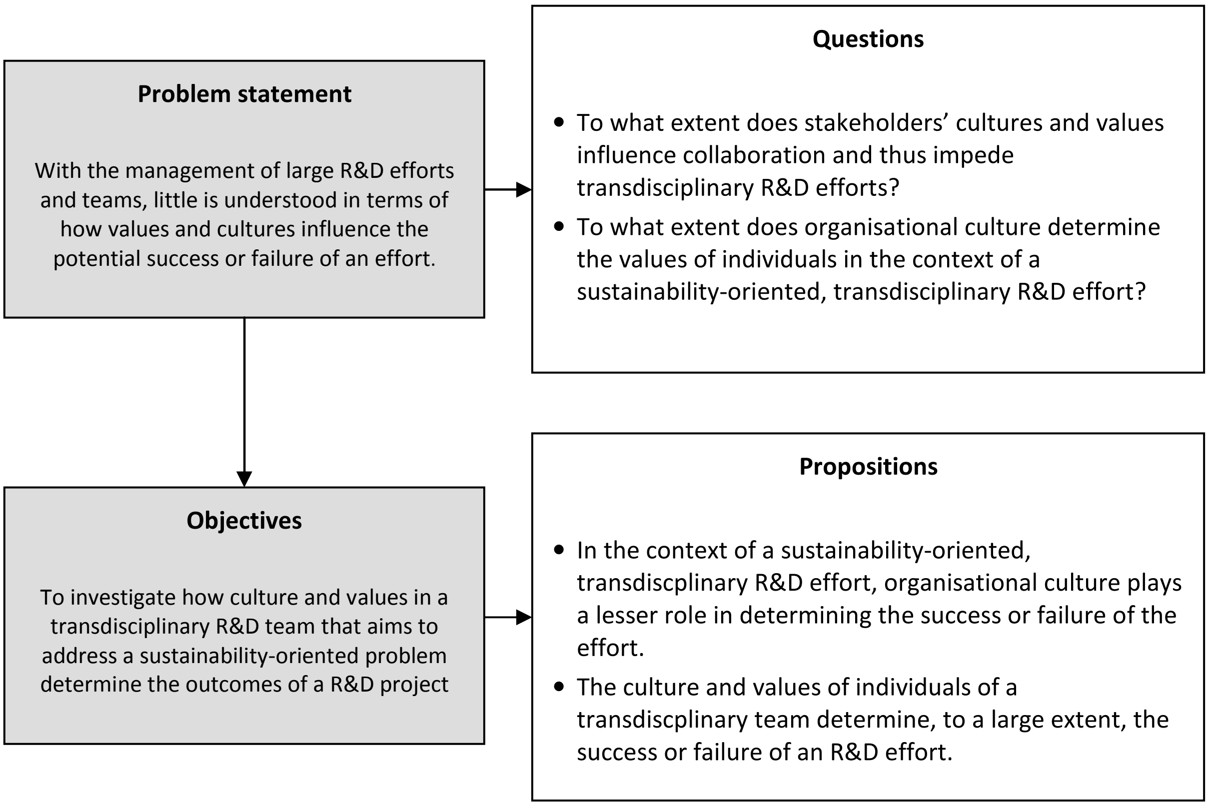

Figure 4. Research problem statement and associated objectives

1.4 Importance of the research problem

In 2007 the Department of Science and Technology (DST, 2008) adopted a Ten-Year Innovation Plan (2008-2018). The purpose of the Ten-Year Innovation Plan is to help drive South Africa's transformation towards a knowledge-based economy, in which the production and dissemination of knowledge leads to economic benefits and enriches all fields of human endeavour. The Ten-Year Plan is underpinned by five grand challenges, one of which is called "*Science and technology for global change with an emphasis on climate change*" (DST, 2008).

Amongst other characteristics of the current global change R&D implementation landscape (see Figure 5), the Ten-Year Plan emphasises the necessity to address sustainability issues, and that concerted, transdiscplinary R&D efforts will be required to address these issues. How these R&D efforts will be coordinated and, specifically, how large, cross-institutional projects will be managed effectively, is of key importance to the overall success of the Global Change, Society and Sustainability Research Programme (GCSSRP), which forms part of the Ten-Year Plan. The study then aims to contribute to the success of the GCSSRP by informing the R&D management practices of projects that will be rolled out as part of the programme.

- Following the adoption of the National R&D strategy in 2002, South Africa has invested in the development and implementation of strategies that takes advantage of the geographical and scientific advantages offered by South Africa. South Africa is a major investor in Global Change research taking into account investments in the key science platforms of astronomy, Antarctica, marine sciences and palaeontology.
- In South Africa there exists significant political will at regional, national and provincial levels to address sustainability issues and especially the threats and opportunities posed by climate change. This includes investment in negotiations at many international forums and with strong cross linkages to trade and other economic negotiations and considerations. South Africa's and even SADC negotiating positions will benefit greatly from an improved and more coherent science base to inform policy. National to local scale development planning will also benefit if effective channels of communication can be opened to fast track scientific knowledge to policy makers and implementers.
- Lack of detailed information on capacity, investment, influence, outputs, and impacts in both the areas of Science for Global Change as well as Technology Development to support effective responses to the impacts of negative Global Change.
- Initial high-level assessments as well as anecdotal evidence suggest that there is a significant base of science-based programmes (or fragments thereof) that fall under the Global Change umbrella.
- In addition to DST investments, significant resources are directed towards science and technology for global change by other players in the National System of Innovation and considerable opportunities exist for tapping into additional sources of investment.
- There exists no focused "Global Change" national institution to co-ordinate research direction and priority in this multi- and trans-disciplinary field of science. The challenges of global change demand innovative thinking, tools and action that is not discipline-bound. As a consequence, aspects of global change science are carried out piecemeal by a wide range of research groups.
- There are a number of important large-scale research projects that involves co-operation between South Africa and other nations (both on a bilateral as well as multilateral basis). In addition, there is considerable interest in enhancing research co-operation with South Africa on areas that have continental and global utility.
- South Africa has existing technological capabilities in a range of areas that can be classified under the umbrella of adaptation technologies.
- Notwithstanding the impressive collection of projects, South Africa does not have a unified, common, and ambitious vision on how South Africa can contribute towards improved scientific understanding of global change as well as how it can contribute to technological development; Research programmes remain fragmented and small-scale with limited incentives for collaboration (although this is changing).
- Feedback from both the scientific and policy and decision-making communities confirmed the existence of a considerable 'knowledge chasm' in the area of global change.
- Due to the lack of a long-term ambitious vision, the approach to building the required human, institutional, and infrastructural platforms is ad-hoc and no effective mechanism currently exist that can exploit possible synergies.
- There are considerable human capital challenges which constitute the primary implementation constraint for enhancing South African effort in global change related science and technology. This national lack of capacity impacts on the ability to both implement the research programme (i.e. finding researchers) and to implement the research outputs (in the state departments). Notwithstanding important efforts to build capacity, particularly amongst blacks and women, these efforts remain ad-hoc with the existence of considerable barriers for scale-up.
- South Africa is well-connected to continental efforts as well as international efforts.
- Significant efforts have taken place over the last few years to facilitate integration and consolidation of global change research efforts in South Africa. However, there is still a lack of significant large-scale flagship South African projects that can galvanise high levels of public and political interest and support.
- Sporadic and sometimes large flows of incoming and pending funding for mainly implementation-oriented projects (i.e. technology development) to address sustainability, some of which is already saturating the capacity of the region's science capacity.

Figure 5. Characteristics of the current global change implementation landscape
(Source: DST, 2008)

1.5 Research approach and strategy

The research approach and strategy, which is based on two articles for journal submission, is summarised in Figure 6. The study commenced with a literature analysis on values and culture in the context of transdisciplinary R&D projects. The initial literature was obtained by first utilising existing scholarly databases such as ScienceDirect and SCOPUS, with key words on 'values', 'culture', and 'R&D management'; and then by applying the snowballing technique[3], but with a 'literature window' of ten years, namely after 2000. The obtained literature was then scrutinised from a transdisciplinary R&D project perspective. The intent of the literature analysis was to develop a conceptual framework of the applicable theory, which could be applied to analyse a specific case.

A triangulation methodology (Sandura and Williams, 2000) was then utilised to engage with a specific case study, namely that of the Bioenergy Systems Sustainability Assessment and Management (BIOSSAM) project (Stafford and Brent, 2010; 2011). The project, which the researcher initiated and led, was undertaken over a three-year period and required a transdisciplinary approach. A combination of personal observations, reflections and informal discussions with the R&D team members, anonymous written feedback from the R&D team members, and available documentation on the R&D project, was used. In terms of the written feedback, the application of the content analysis technique (Stemler, 2001), to a limited extent, was deemed suitable to identify patterns of how values and culture manifested during the execution of the transdiscplinary R&D project, in relation to the conceptual framework that was derived from the literature analysis.

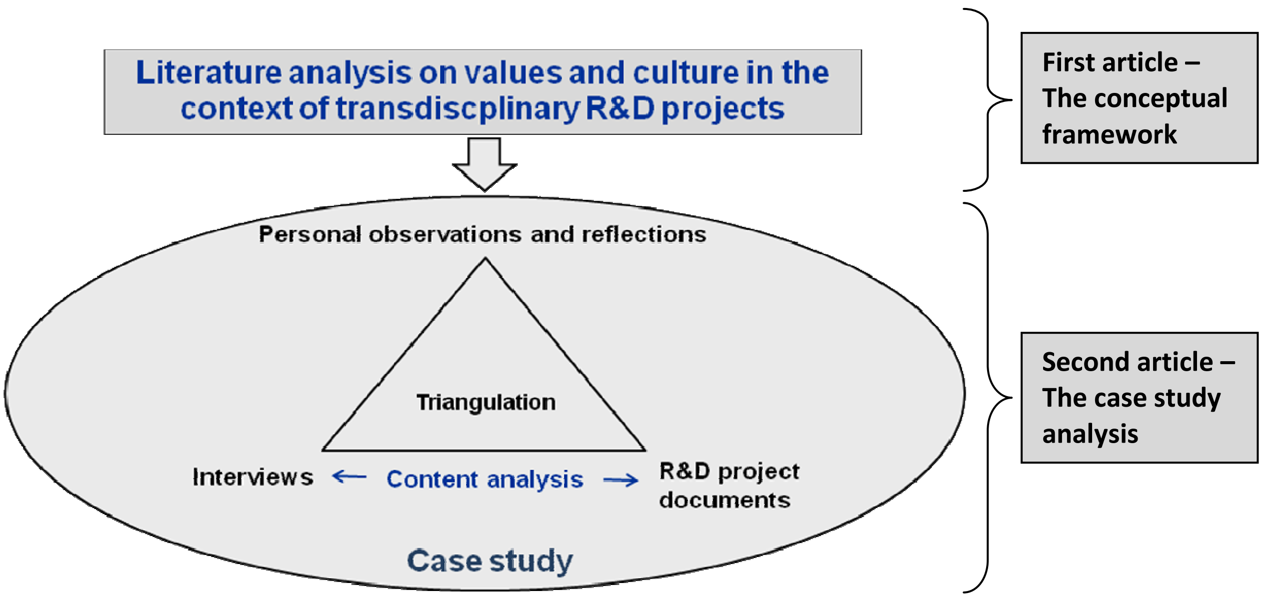

Figure 6. An overview of the research approach and strategy

[3] http://www.enotes.com/oxsoc-encyclopedia/snowballing-technique

2 First Article – Development of the conceptual framework

This article was presented at R&D Management 2011 conference – see Appendix A – and will subsequently be submitted to the journal R&D Management with the title: Managing transdiscplinary R&D projects – A conceptual framework of the influence of values and culture.

2.1 Introduction

The development of research and development (R&D) practices has been described by Aasen et al. (2010); they highlight that, since the 1990's, R&D has shifted its focus based on an increasing recognition that the practices need to be more oriented towards strategic goals (of society) and the production of relevant knowledge (Hessels and van Lente, 2008). The concept of 'Mode 2' knowledge production was then introduced (see Table 1) to denote "*knowledge produced in the context of application, by so-called transdisciplinary collaborations*" (Hessels & van Lente, 2008: 740). In 'Mode 2', the distinction between basic and applied R&D is no longer relevant, and the overall objective is to respond to perceived needs for new applications, involving the necessity of taking into account the different requirements, values and demands of collaborating partners. Specifically, R&D teams are increasingly guided by societal concerns, rather than being driven by techno-scientific possibilities with vague promises (see Figure 7).

Table 1. The distinction between 'Mode 1' and 'Mode 2' knowledge production

Mode 1	Mode 2
Academic context	Context of application
Disciplinary	*Transdisciplinary*
Homogeneity	Heterogeneity
Autonomy	Reflexivity / social accountability
Traditional quality control (peer review)	Novel quality control

(Source: Aasen et al., 2010)

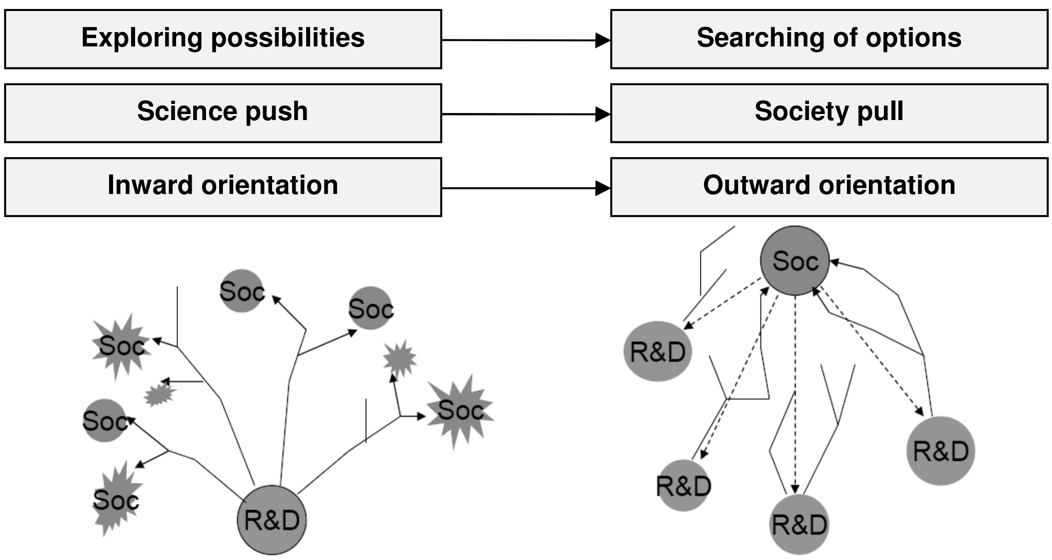

Figure 7. The R&D shift from a techno-scientific orientation to that of societal concerns
(Source: Voß, 2009)

The shift in R&D focus has meant that knowledge production is now more complex: "*knowledge is shaped by broad specters of intellectual, social, and also commercial needs*" (Aasen et al., 2010). R&D is not delegated to the traditional marketing and lobbying of technocrats only, but the societal embedding becomes part of R&D (Voß, 2009); the social dimension of innovation thus introduces an additional complexity to R&D management practices.

Table 2. The three forms of knowledge that characterise transdisciplinary R&D

Forms of knowledge	Research questions
Systems knowledge	Questions about genesis and possible further development of a problem and about interpretations of the problem in the life-world.
Target knowledge	Questions related to determining and explaining the need for change, desired goals and better practices.
Transformation knowledge	Questions about technical, social, legal, cultural and other possible means of acting that aim to transform existing practices and introduce desired ones.

(Source: Pohl and Hirsch Hardon, 2007)

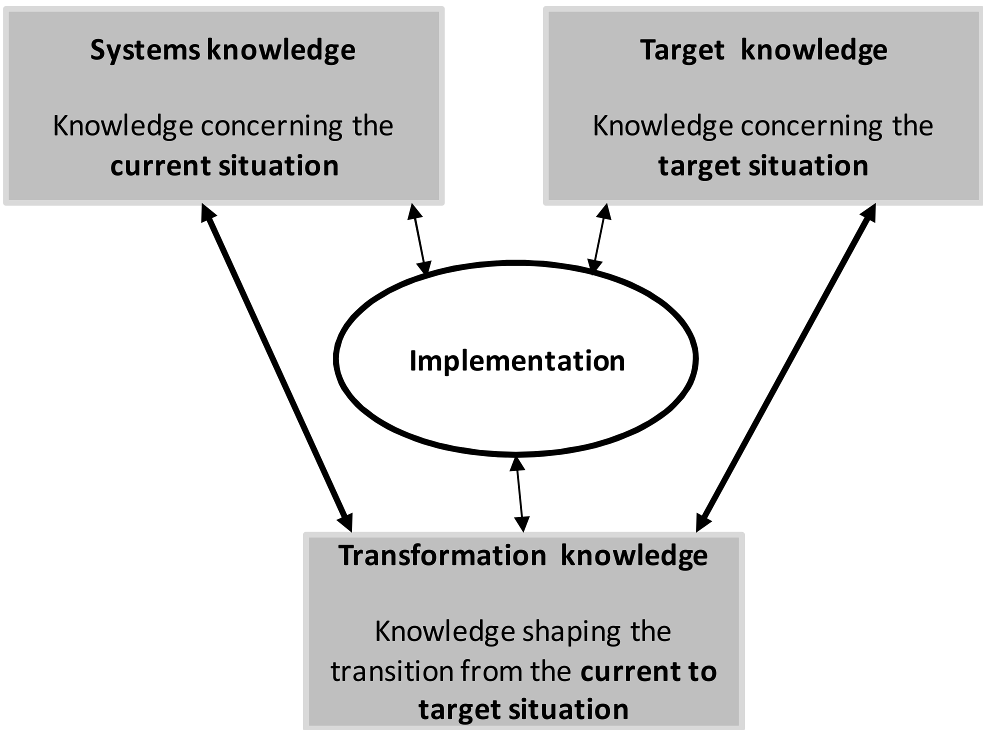

Figure 8. Types of knowledge in a transdisciplinary research and their relation
(Adapted from: Messerli and Messerli, 2008)

Apgar et al. (2009) also argue that: "*dealing with complex societal problems requires knowledge across all aspects of society; research disciplines, communities, civil society and governments*". They emphasise that sustainability science already recognises the need for research that includes multiple knowledge spheres (Clark and Dickson, 2003; Kates et al., 2001); three forms of knowledge characterise transdisciplinary research, as depicted in Table 2 and Figure 8. Further, the inclusion of non-research knowledge spheres necessarily involves the participation of stakeholders. For participation to be effective, the boundaries between the different groups involved must be transgressed, not simply worked across. Transdisciplinary R&D approaches do this by recognising complexity and producing knowledge for decision-making and action on a specific problem (Lawrence and Despres, 2004).

2.2 Complexity theory and its relation to R&D management practices

Complexity theory is an emerging field of study in science and technology and has grown out of systems theory and chaos theory (Dann and Barclay, 2006). Fundamentally, a system is complex when it is non-linear and dynamic; incorporating both positive and negative feedback loops without simple cause and effect relationships, and is beyond analysis by the standard methods of systems analysis (Kiel, 1999). Complex systems are ones in which patterns can be observed and studied, but interactions between individual elements of the systems cannot be reduced to the study of individual elements. In other words, it is recognised that components of a system come together to produce overarching patterns as the system learns, evolves or self-organises, and adapts (Dann and Barclay, 2006).

Thus, there are many aspects of complexity, some of which, from a social sciences perspective, are illustrated in Figure 9. The complexity of a transdisciplinary R&D effort mainly consists of the number of stakeholders, each with their own values and beliefs, notions and perceptions, interests, and capabilities (as highlighted in Figure 9); their relationships and dependencies; and the organisational substructures of the R&D effort. In the transdisciplinary R&D effort, as with any complex system: "*it is not the greater number of its elements that is essential for the emergence of collective (synergetic) order phenomena, but their nonlinear interactions*" (Mainzer, 1996: 273). Voß (2009) also highlights the complexity in the R&D process in terms of:

- R&D processes should refer to real world problems, which involves the challenge of translating non-scientific questions into issues that can be addressed scientifically, and taking knowledge from outside the realm of science into account; and
- Researchers participate in 'social experiments', and thus face the challenge of taking into account the attitudes and interests of persons and groups within society whereby non-scientific knowledge and normative aspects are integrated into the research process.

These complexity-characteristics of transdisciplinary R&D efforts require changes in how they are managed. Specifically, new approaches and methods must be legitimatised in terms of deriving required research practices from concrete (transdisciplinary) challenges, and developing quality criteria and carry out self-evaluation. Also, management practices need to build on established approaches and methods by identifying and supporting niches within the research system, and developing social and institutional capacities (and capabilities). Then a balance must be found between embedding and protecting the various approaches and methods, namely a trade-off is required between contextualisation and productivity. All these required changes must allow for continuous experimenting and learning; transdisciplinary R&D efforts need to adhere to the principles of learning organisations.

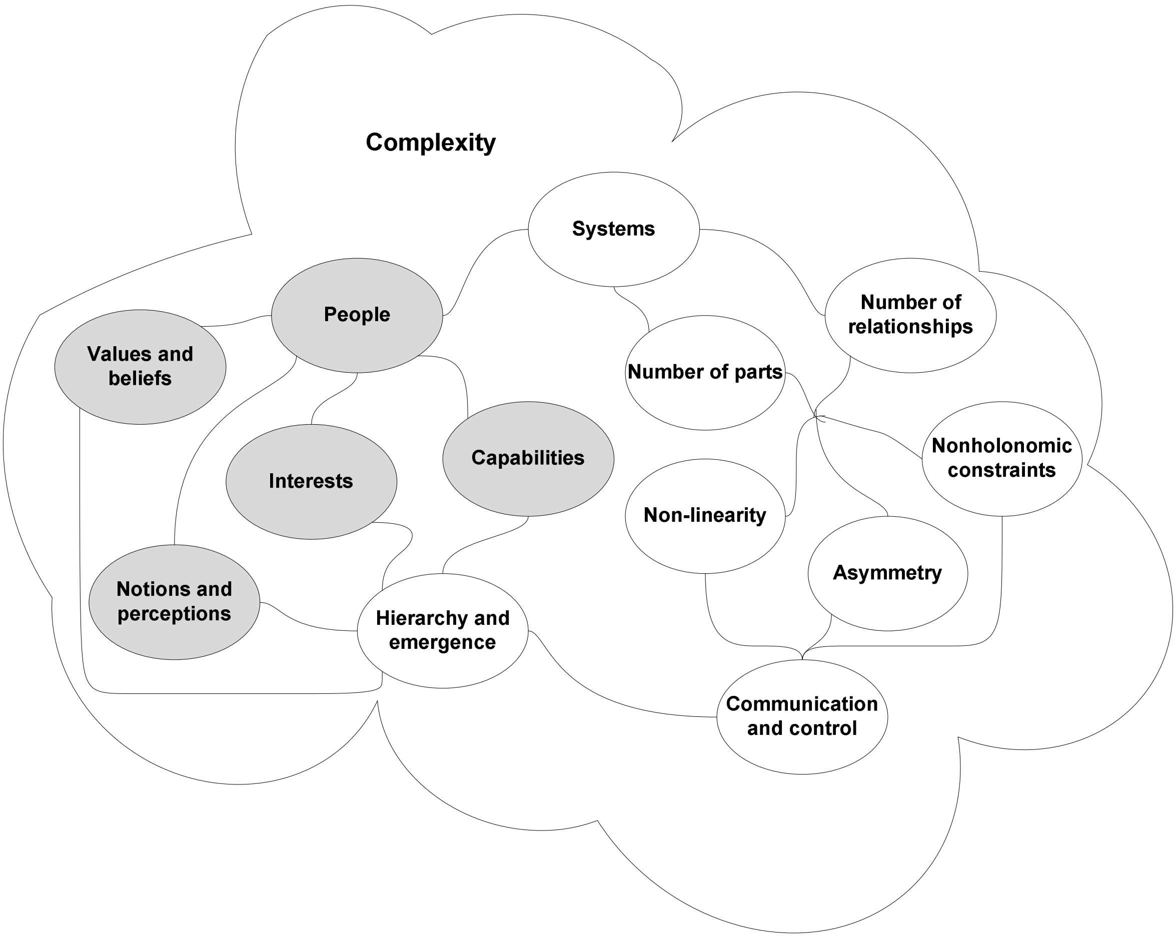

Figure 9. Meanings of complexity
(Source: Mainzer, 1996: 273)

2.3 The principles of organisational learning

Management complexity theory strives towards re-describing the organisational world (Rosenhead, 1998); it argues that the traditional management theory and practice is characteristic of over-rationalist thinking. Although the organisation may be conceptualised as an engineered or a natural system, the discoveries by the theorists of complexity and chaos show that even such systems do not, necessarily, operate in a predictable way; this revelation of the role of creative disorder in the universe needs to be taken to heart by managers (Rosenhead, 1998). The consequences are that much management orthodoxy must be reconsidered. Stacey (1996) comprehensively describes some examples: analysis loses its primacy; contingency (cause and effect) loses its meaning; long-term planning becomes impossible; visions become illusions; consensus and strong cultures become dangerous; and statistical relationships become dubious.

The general lessons associated with management complexity theory are concerned with how learning can be fostered in organisations, how they should view instability, and the (negative) consequences of a common internal culture (Rosenhead, 1998), also termed behavioural patterns (Goldratt and Cox, 1992: 330). The need for developing learning capabilities within an organisation has been argued in literature (Marquardt and Reynolds, 1994; Schwandt and Marquardt, 2000). For example, it has been suggested that: "*learning will become the only viable alternative to corporate extinction*" (Schwandt and Marquardt, 2000: 16).

Senge (1990) proposed that learning organisations use five disciplines to create effective learning: systems thinking, mental models, personal mastery, shared vision, and team learning/dialogue (Kezar, 2005). Further, Garvin (2004) ascertains that learning organisations are skilled at five main activities: systematic problem solving, experimentation with new approaches, learning from their own experience and past history, learning from the experiences and best practices of others, and transferring knowledge quickly and efficiently throughout the organisation. These five activities are viewed as the building blocks towards a successful learning organisation. Two issues emerge from the literature (Williams, 2008) as important to support these building blocks, namely:

- Organisational structure. Lipshitz et al. (2002) look to roles and procedures that enable organisational members to collect and analyse data, and Reger and von Wichert-Nick (1997) argue that organizational learning needs hierarchy-free communication and flow of information.
- National culture and internal organisational culture. Lipshitz et al. (2002) found that the cultural values that promote learning are: transparency, integrity, issue orientation, inquiry, and accountability. Similarly, Reger and von Wichert-Nick (1997) emphasise that learning requires a culture of supporting teamwork, which supports experimentation, and is open to risks.

Cultural values are of key importance in terms of how stakeholders of a transdisciplinary R&D effort may influence the adaptive learning, and subsequent emergence, of the R&D effort (see Figure 9).

2.4 Examining cultural values

Various meanings have been ascribed to the concept of culture. Some of these are summarised in Table 3.

Table 3. Some meanings of the term 'culture'

Paradigm	Comment
Culture as the tillage of the soil	The importance of this definition is that it withholds us from a superficial spiritualisation of culture by emphasising manual labour and the material context
Culture as the transformation of nature into the human environment	In this sense culture is nature in the presence of human beings, whether they are working or playing
Culture as the form of life or life-style of a community	A community viewed as a group of people sharing certain characteristics and interests
Culture as the form of life of an ethnic community	The term ethnicity refers to a group of people sharing a common ancestry
Culture as a form of life of a national community	A uniformity of culture is achieved by the imposition of either a dominant ethnic culture or a common culture brought about by the processes of industrialisation and modernisation
Culture as a form of life of society as a whole that succeeds in accommodating a variety of ethnic communities	In this context one speaks of a democratic culture that is based on a constitution that protects the rights of individuals and the rights of ethnic communities
Culture as a dynamic system of knowledge, values, actions, artefacts, and articulations of a community in particular historical contexts	Culture in this sense refers to all meaningful expressions and symbolic formations by a community

(Source: Degenaar, 1993)

The latter meaning (of Table 3) resembles, closely, that of transdisciplinary R&D efforts. But, regardless of the specific meanings, Degenaar (1993) highlights that it is the tensions between these meanings of culture, and associate values or beliefs, that are of importance to understand the emergence of communities.

To study these tensions, or conflicts, culture can be conceptualised as consisting of two dimensions, namely: a cognitive and a behavioural (Das and Kumar, 2010). In terms of the latter, the work of Hofstede (1980) has increasingly been used in the international and comparative management literatures; he classifies cultures into five (measurable) parameters (see Table 4). However, the behavioural approach to culture analysis has been criticised and debated (Hofstede, 2002). Specifically, interpretive conflicts arise from conflicting interpretive systems. Interpretive systems, in turn, are rooted in the cognitive component of cultures. To fully understand the origins and the consequences of interpretive conflicts it is, therefore, "*useful to focus on a definition of culture that has a strong cognitive slant*" (Das and Kumar, 2010).

Table 4. The five cultural dimensions of Hofstede

Dimension	Description
Power Distance Index (PDI)	That is the extent to which the less powerful members of organizations and institutions (like the family) accept and expect that power is distributed unequally. This represents inequality (more versus less), but defined from below, not from above. It suggests that a society's level of inequality is endorsed by the followers as much as by the leaders. Power and inequality, of course, are extremely fundamental facts of any society and anybody with some international experience will be aware that 'all societies are unequal, but some are more unequal than others'.
Individualism (IDV)	On the one side versus its opposite, collectivism, that is the degree to which individuals are integrated into groups. On the individualist side we find societies in which the ties between individuals are loose: everyone is expected to look after him/herself and his/her immediate family. On the collectivist side, we find societies in which people from birth onwards are integrated into strong, cohesive in-groups, often extended families (with uncles, aunts and grandparents) which continue protecting them in exchange for unquestioning loyalty. The word 'collectivism' in this sense has no political meaning: it refers to the group, not to the state. Again, the issue addressed by this dimension is an extremely fundamental one, regarding all societies in the world.
Masculinity (MAS)	Versus its opposite, femininity, refers to the distribution of roles between the genders which is another fundamental issue for any society to which a range of solutions are found. The IBM studies revealed that (a) women's values differ less among societies than men's values; (b) men's values from one country to another contain a dimension from very assertive and competitive and maximally different from women's values on the one side, to modest and caring and similar to women's values on the other. The assertive pole has been called 'masculine' and the modest, caring pole 'feminine'. The women in feminine countries have the same modest, caring values as the men; in the masculine countries they are somewhat assertive and competitive, but not as much as the men, so that these countries show a gap between men's values and women's values.
Uncertainty Avoidance Index (UAI)	Deals with a society's tolerance for uncertainty and ambiguity; it ultimately refers to man's search for Truth. It indicates to what extent a culture programs its members to feel either uncomfortable or comfortable in unstructured situations. Unstructured situations are novel, unknown, surprising, different from usual. Uncertainty avoiding cultures try to minimize the possibility of such situations by strict laws and rules, safety and security measures, and on the philosophical and religious level by a belief in absolute Truth; 'there can only be one Truth and we have it'. People in uncertainty avoiding countries are also more emotional, and motivated by inner nervous energy. The opposite type, uncertainty accepting cultures, are more tolerant of opinions different from what they are used to; they try to have as few rules as possible, and on the philosophical and religious level they are relativist and allow many currents to flow side by side. People within these cultures are more phlegmatic and contemplative, and not expected by their environment to express emotions.
Long-Term Orientation (LTO)	Versus short-term orientation: this fifth dimension was found in a study among students in 23 countries around the world, using a questionnaire designed by Chinese scholars It can be said to deal with Virtue regardless of Truth. Values associated with Long Term Orientation are thrift and perseverance; values associated with Short Term Orientation are respect for tradition, fulfilling social obligations, and protecting one's 'face'. Both the positively and the negatively rated values of this dimension are found in the teachings of Confucius, the most influential Chinese philosopher who lived around 500 B.C.; however, the dimension also applies to countries without a Confucian heritage.

(Source: http://www.geert-hofstede.com/)

A value orientation framework has, for example, been developed (Kluckhohn and Strodtbeck, 1961) that is based on the premise that while all societies are confronted with similar sets of problems, their approach to managing these problems is culturally variable. The different approaches are reflective of different preferences, with the different preferences being described as "*variations in value orientations*" (Das and Kumar, 2010):

- Relationship of humans to nature: Is the desirable goal to achieve mastery over nature, live in harmony with it, or be subjugated to it?
- Time orientation: Is it desirable to have a past, present, or future orientation?
- Assumption about human nature: Are individuals primarily evil, good or are they a little bit of both?
- Activity orientation: Is it desirable to have a doing as opposed to a being orientation?
- Relationships among people: Is it desirable to be responsible for others or should one primarily look after oneself?

An implicit assumption of this framework is that the variability across cultures is dominated by different orientations and not the absence of any one particular orientation. The framework assumes that while all of the variations may be present in all cultures the relative salience of such variations differs across cultures. Where different cultures, and values systems, need to collaborate towards a common goal, such as that of a transdisciplinary R&D effort, good communication is essential.

2.5 The essence of communication

In a transdisciplinary R&D effort Roux et al. (2010) emphasise that, only once a proper understanding (not necessarily agreement) of the various stakeholders' contexts and perspectives, basic trust, and a common language are achieved, are the stakeholders ready to:

(a) Transform the knowledge that is produced at a disciplinary level to have meaning at a pragmatic or normative level; and

(b) Co-produce the new knowledge that transcends disciplines and contributes to broader societal goals.

Aenis (2010) discusses the essentials of a communication model for transdisciplinary consortium research. Such research often manifests itself in the form of networked projects that are implemented and reported upon within the large group consortium or smaller research teams. Communication then has two aspects: project implementation as the factual aspect, and team communication on a meta level. Regarding management and taking into consideration the principal differences between large group and small group communication, three fundamental categories of communication can be distinguished: process, team, and organisational communication (see Figure 10). van Haaften (2003) emphasises that the management of transdisciplinary R&D efforts needs to acknowledge cultural biases and facilitate communication if the common goals are to be achieved. Also, from an organisation structure perspective (see section 2.3), Reger and von Wichert-Nick (1997) have argued that organisational learning needs hierarchy-free communication and flow of information, and Hollaender (2003) argues that careful planning and active management of communication and co-ordination are vital to the success of transdisciplinary R&D efforts.

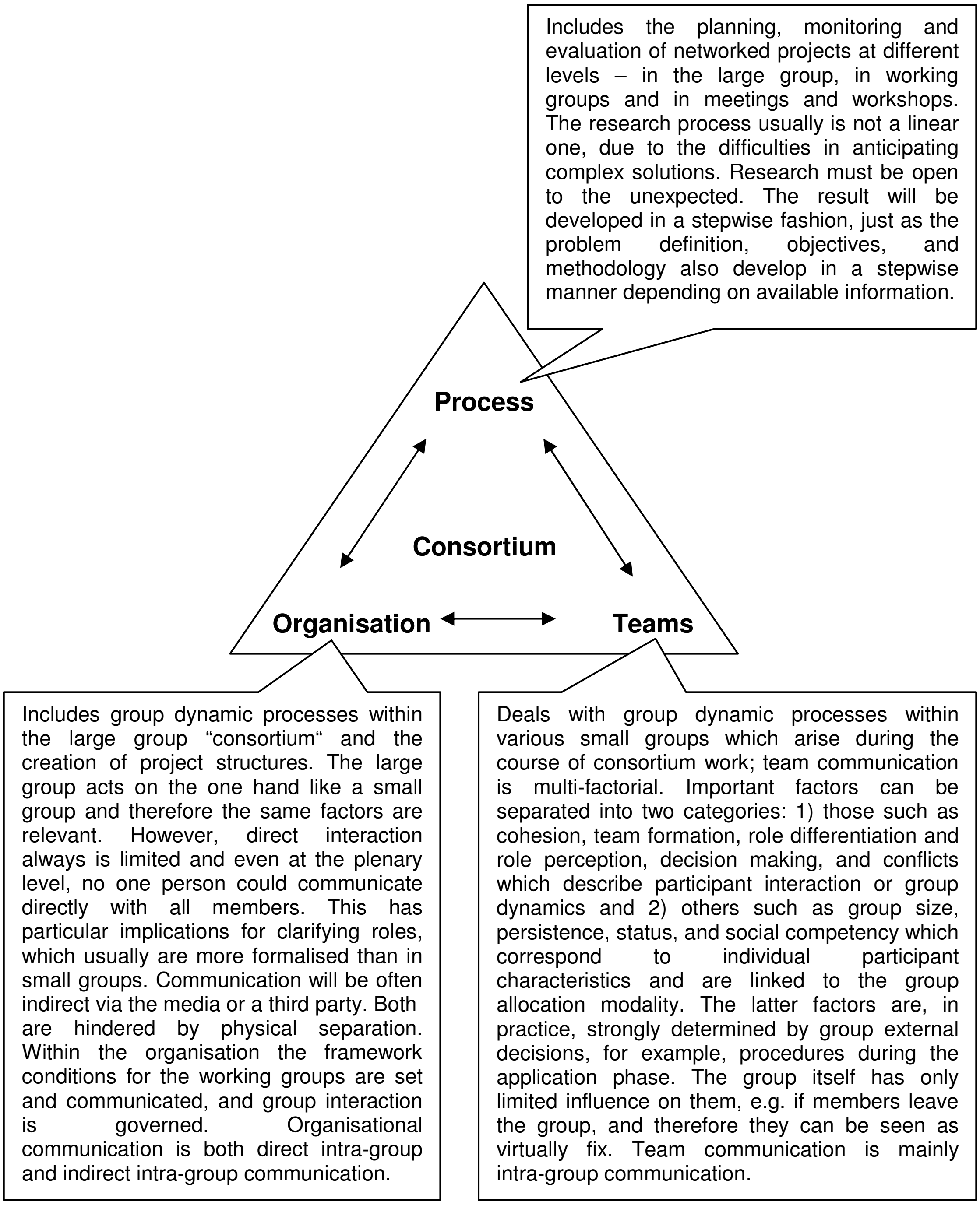

Figure 10. The communication system “consortium”
(Source: Aenis, 2010)

2.6 Conceptual framework to analyse values and culture in transdisciplinary R&D efforts

From the above literature analysis, a conceptual framework is derived to analyse the effect of values and culture in transdisciplinary R&D efforts (see Figure 11). The framework also builds on previous research that has been conducted with respect to the management of transdisciplinary research (Hollaender, 2003), and specifically the recommendations that were made by the participants of a questionnaire that had been involved in transdisicplinary R&D teams; these outcomes inform the requirements for organisational structure. Values and culture are distinguished between those that are characteristics of the stakeholders themselves, namely the R&D team members and the societal participants of the transdisciplinary effort, and those of the organisation (of the R&D effort) itself. Finally, the management of transdisciplinary R&D efforts needs to acknowledge values and culture biases and facilitate a good flow of communication within the organisation structure and the stakeholders, if the common goals of the effort are to be achieved.

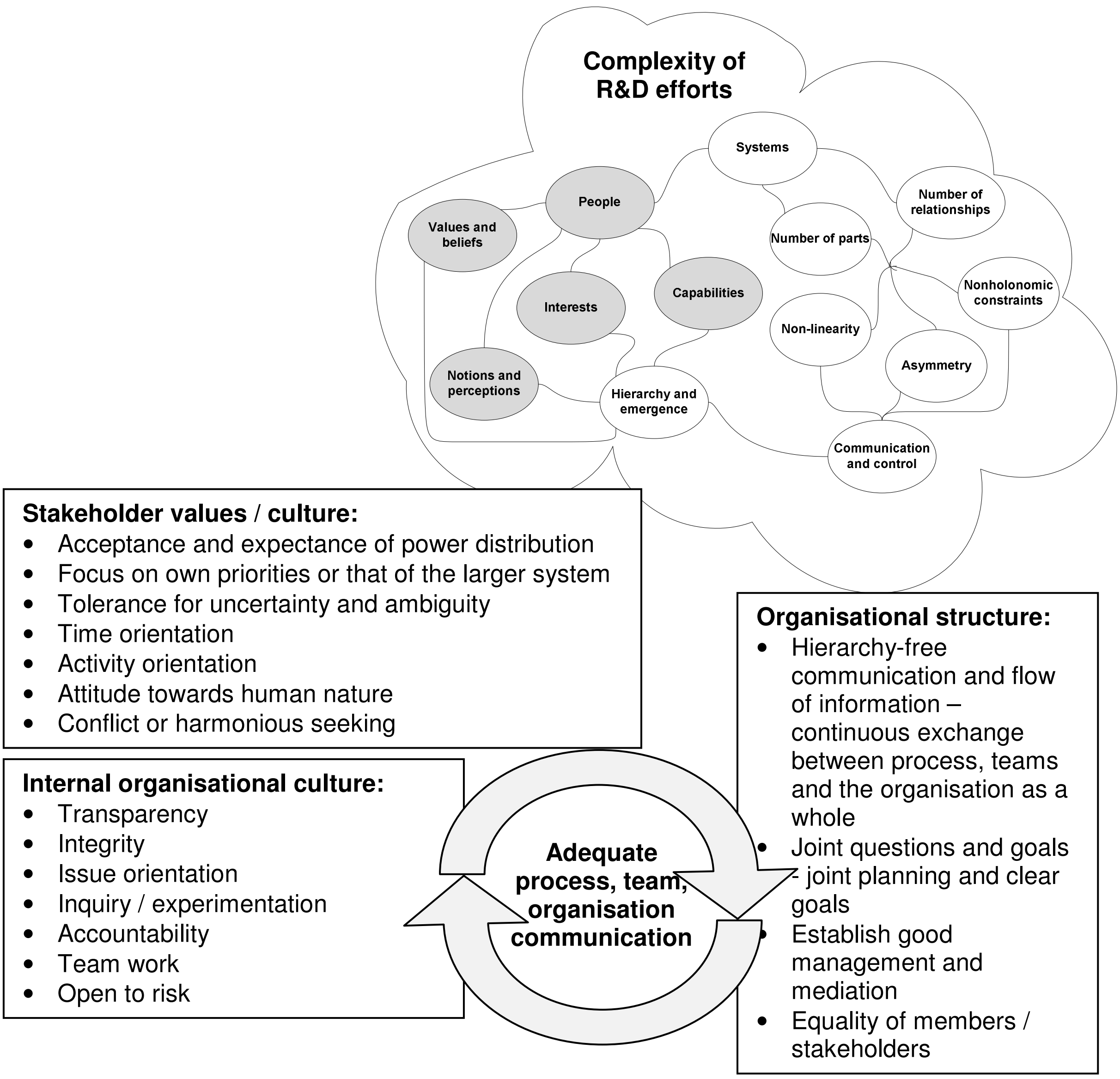

Figure 11. Conceptual framework to analysis the effect of values and culture in transdisciplinary R&D efforts

2.7 Synopsis of the literature analysis

Several studies have attempted to provide the definition of transdisciplinary. Mittelstraß (1992:250) defines transdisciplinary as "*knowledge or research that frees itself of its specialised or disciplinary boundaries, that defines and solves its problems independently of disciplines, relating these problems to extra-scientific developments*". According to Scholz et al. (2006) transdisciplinary research:

- Deals with relevant, complex societal problems;
- Compliments traditional disciplinary and interdisciplinary scientific activities by integrating actors from outside academia;
- Organises processes of mutual learning among science and society; and
- Does not constitute research for society, but research with society (mutual learning).

Pohl and Hirsch Hardon (2008) further distinguish four dimensions of transdisciplinary research as:

- Transcending and integrating disciplinary paradigms;
- Participatory research;
- Relating to life-world problems; and
- Searching for a unity in knowledge.

To this end, Hirsch Hardon et al. (2008) describe transdisciplinarity as a reaction against the dissociation of scientific knowledge, and the recent need for reshaping the conception of science and the distinctions of science and the life-world. According to McGregor and Volckmann (2011) the current practice in the application of a transdisciplinary approach can then be classified into two fundamental views:

- It is an exclusive concentration on the joint solving of problems that concern the science-technology-society triad. This notion rejects the notion of a transdisciplinary methodology (Nicolescu, 2010); and
- It is a methodology in its own right, in addition to empirical, interpretive and critical methodologies (Regeer and Bunders, 2009).

Regardless, transdisciplinary R&D has been described as a process of collaboration between scientists and non-scientist on a specific real-world problem. A large number of such problems are strongly linked to sustainable development (Blattel-Mink and Kastenholz, 2005). Accordingly, any planning and learning process for sustainable development requires a transdisciplinary approach (Meppem and Gill, 1998), which, in turn, addresses the challenge of integration of those 'inside' (academics) and 'outside' (non-academics) of the R&D efforts; the researchers thus become active parts of the R&D field.

Mobjörk (2009) identifies two kinds of transdisciplinarity in terms of the extent of collaboration between scientist and non-scientists. These are consultative and participatory transdisciplinarity. In the case of consultative, the non-scientist actors are not actively incorporated into the knowledge production process. On the other hand, participatory transdisciplinarity fully incorporates the non-scientist actors in the knowledge generation process.

Given the subsequent different levels of reality and perceptions, it is clear that the objective of transdisciplinary R&D is to deal with complex ill-defined (or 'wicked') real-world problems (Pohl and Hirsch Hardon, 2008). The complexity lies in the need for more than a single expert solution, and achieving a shared or common purpose that deals with individual uniqueness, differences in priorities, and different motivations. In other word, solving sustainable development problems is augmented with dealing with confrontational values (and culture) across stakeholders (of the problem) and R&D team members.

Part A has thus developed a conceptual framework (summarised in Figure 11) that highlights, for the R&D practitioner, the complexity in the R&D process (Voß, 2009):

1. R&D processes should refer to real-world problems, which involves the challenge of translating non-scientific questions into issues that can be addressed scientifically, and taking knowledge from outside the realm of science into account; and
2. Researchers participate in 'social experiments', and thus face the challenge of taking into account the attitudes, beliefs, notions and perceptions, interests, and capabilities of persons and groups within society whereby non-scientific knowledge and normative aspects are integrated into the R&D process.

In terms of the latter, a dynamic environment for continuous experimenting and learning must be allowed whereby transdisciplinary R&D efforts then adhere to the principles of learning organizations. Two issues emerge from the literature (Williams, 2008) as important to support the building blocks of learning organizations, namely:

1. Organizational structure. Lipshitz et al. (2002) look to roles and procedures that enable organizational members to collect and analyze data, and Reger and von Wichert-Nick (1997) argue that organizational learning needs hierarchy-free communication and flow of information.
2. National culture and internal organizational culture. Lipshitz et al. (2002) found that the cultural values that promote learning are: transparency, integrity, issue orientation, inquiry, and accountability. Similarly, Reger and von Wichert-Nick (1997) emphasize that learning requires a culture of supporting teamwork, which supports experimentation, and is open to risks.

Cultural values are of key importance in terms of how stakeholders of a transdisciplinary R&D effort may influence the adaptive learning, and subsequent emergence, of the R&D effort. Cultural values, in turn, have been described in terms of: acceptance and expectance of power distribution; focus on own priorities or that of the larger system; tolerance for uncertainty and ambiguity; time orientation; activity orientation; attitude towards human nature; and conflict or harmonious seeking (Hofstede 2002; Das and Kumar 2010). An implicit assumption of the theoretical notions of cultural values is that the variability across cultures is dominated by different orientations and not the absence of any one particular orientation. The conceptual framework thus assumes that while all of the variations may be present in all cultures the relative salience of such variations differs across cultures.

Where different cultures, and values systems, need to collaborate towards a common goal good communication is essential. In a transdisciplinary R&D effort, in particular, Roux et al. (2010) emphasise that, only once a proper understanding (not necessarily agreement) of the various stakeholders' contexts and perspectives, basic trust, and a common language are achieved, are the stakeholders ready to transform the knowledge that is produced at a disciplinary level to have meaning at a pragmatic or normative level; and co-produce the new knowledge that transcends disciplines and contributes to broader societal goals.

van Haaften (2003) emphasizes that the management of transdisciplinary R&D efforts needs to acknowledge cultural biases and facilitate communication if the common goals are to be achieved. Also, from an organization structure perspective, as stated above, learning needs hierarchy-free communication and flow of information (Reger and von Wichert-Nick 1997). Hollaender (2003) also argues that careful planning and active management of communication and co-ordination are vital to the success of transdisciplinary R&D projects. To this end, the conceptual framework builds on the recommendations that were made by participants of transdisicplinary R&D teams; these outcomes inform the requirements for organizational structure in Figure 11.

The conceptual framework provides the means to engage with a transdisciplinary R&D case study to investigate, and understand, the implication of values and culture on the outcomes of the R&D effort.

3 Second Article – The case study analysis

This article will be submitted to the Journal for Transdisciplinary Research in Southern Africa – see Appendix B – with the title: Transdisciplinary approaches to R&D – A case study to understand the importance of values and culture.

3.1 Introduction

Part B explores, through a case study in the bioenergy sector, the collaboration, between disciplines and stakeholders, that has been described as the means of meeting the requirements of transdiscplinary R&D. Part B utilises the conceptual framework that was derived in Part A to analyse the effect of values and culture on these collaborations in transdisciplinary R&D efforts.

3.1.1 Engaging with the case study

Yin (2009: 10) states that "*how*" and "*why*" questions in research are likely to favour the use of case studies. In addition, the case study method is preferred in examining contemporary events and when the relevant behaviours cannot be manipulated (Yin, 2009: 11). For this investigation, the case study methodology was also selected to prove if what was derived from literature is relevant to real life. According to Hofstee (2006: 123) a case study is useful to test a proposition that the researcher has about the case itself, and, possibly, to find principles that can be extrapolated to similar cases. Well designed case studies can then play a role in testing certain propositions (Levy, 2008). Flyvbjerg (2006) also believes that the case study method is useful for both generating and testing propositions, such as those depicted in Figure 4 for this investigation. George and Bennett (2005) propose the following six theory building research objectives for case studies, namely:

- Theoretical / configurative idiographic case studies. These studies do not directly contribute to theory but provide good descriptions for use in subsequent theory building research. Many of the current case studies in renewable energy technologies in Africa are of this nature.
- Disciplined configurative case studies. These studies use existing theory to explain a case by testing theory.
- Heuristic case studies. These studies are used to identify new variables, hypotheses, causal mechanisms and causal paths.
- Theory testing case studies. These studies are used to test the validity and scope conditions of single or competing theories.
- Plausibility probes. These studies are used to test untested theories and hypotheses to determine whether more in depth testing is warranted.
- Building block studies. These are single case studies or multiple case studies with no variance which can be used as parts of larger contingent generalisations and typological studies.

The case study research used in this study was heuristic in nature. For such (and any) case studies, it is important to identify the unit of analysis, which Yin (2009: 29) describes as defining what the "*case*" is. For this research effort, the case is a bioenergy intervention on the Agulhas Plains in the Western Cape Province of South Africa, which formed part of the BIOSSAM project (see section 3.2). BIOSSAM is the only case that was selected for this investigation; thus a single case study approach was followed. Nevertheless, Ragin (1992) believes that "*it is misguided to see the single case study as* *being inferior to multiple case studies, because even single case studies are multiple in most research efforts because ideas and evidence may be linked in many different ways*".

As indicated in section 1.5, a triangulation methodology (Sandura and Williams, 2000) was utilised to engage with the identified case study. A combination was used of personal observations and reflections; content analyses (Wilson, 2004; Notz, 2005) of the various observations of researchers and the project management of the BIOSSAM R&D effort, from semi-structured interviews (Sandura and Williams, 2000); and available documentation on the R&D project, primarily reports, e-mail communiqué, and minutes of meetings – these are confidential to the R&D project.

3.2 The BIOSSAM R&D project

Bioenergy, as an alternative energy option, can potentially contribute to a wider range of economic, social, and environmental objectives, and facilitate sustainable development. The assessment, management and monitoring of the various bioenergy development options are complex in nature and deliver varying benefits; depending on the appropriateness of the implementation, management structure, as well as the degree of uptake and adoption. Therefore, both public and private sector policy-makers, decision-makers, and technology developers (at the local, regional and national levels) require robust methods to assess and manage proposed bioenergy interventions. The response of the South African government was a transdisciplinary R&D effort to develop and establish the Bioenergy Systems Sustainability Assessment and Management (BIOSSAM) portal (Stafford and Brent, 2010). The basis for the portal is an analytical approach that incorporates planning for sustainability and the use of decision-support tools and modelling to assess and manage the entire bioenergy value chain. It provides a complete assessment of the costs and benefits of various bioenergy options and uses a participatory process, which involves multi-stakeholder engagement coupled with expert and public opinion, and transparency in the decision-making process. This facilitates technology transfer and promotes stakeholder buy-in; thereby increasing the long-term success of the bioenergy intervention. The increased understanding of the bioenergy systems, gained through the BIOSSAM approach, can also help to formulate supporting institutional arrangements and policies that that can enable bioenergy developments to improve livelihoods while facilitating a new green economy and aiding a low carbon development path. The details of the BIOSSAM approach, and associated methods, are described elsewhere (Stafford and Brent, 2011), and is illustrated in Figure 12.

The BIOSSAM R&D effort was undertaken over a three-year period from the second quarter of 2008 to the first quarter of 2011; the researcher conceptualised the project who, until mid-2009, also acted in the capacity of project leader, and thereafter as advisor to the project manager. The R&D team comprised of over ten individuals, through the different phases of the effort, from various disciplines, including engineering, environmental, economic, social, and business sciences. A specific case study was used as basis to develop the range of BIOSSAM methods, which focused on the utilization of invasive alien plants (IAPs) on the Agulhas Plains of the Western Cape Province of South Africa (Figure 13) to produce bioenergy for different applications (Stafford and Brent, 2011). The entity that was used to engage the various stakeholders was the Agulhas Biodiversity Initiative, which, in turn, comprises of business owners; commercial farmers; rural communities, including subsistence farmers; and eco-tourism entrepreneurs; amongst others.

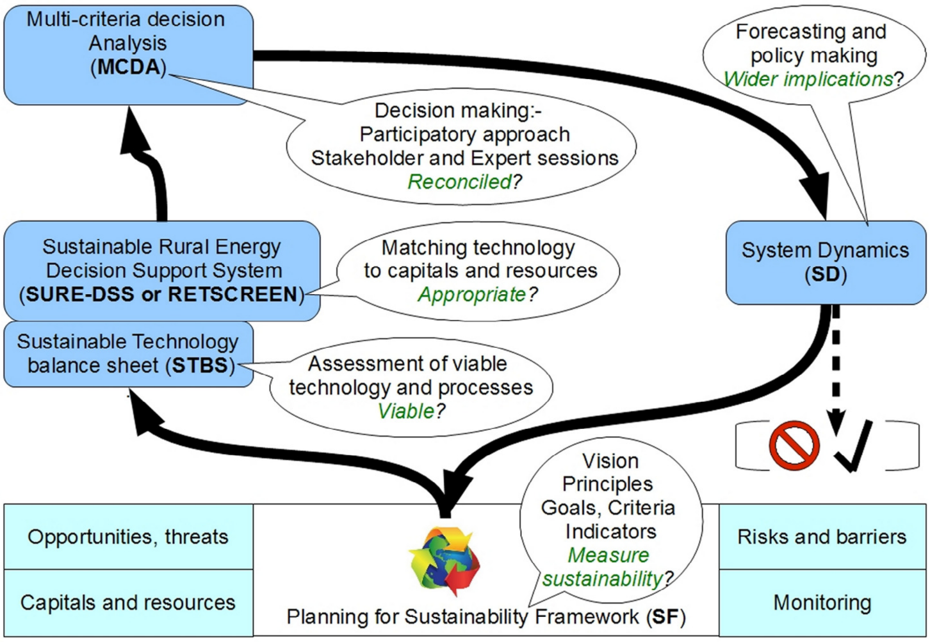

Figure 12. The analytical framework of BIOSSAM showing the cycle of active learning and R&D for the assessment, management and monitoring of bioenergy interventions
(Source: Stafford and Brent, 2011)

Figure 13. The location of the Agulhas Plains at the southern tip of Africa

3.2.1 BIOSSAM and the case of IAPs on the Agulhas Plains of South Africa

Invasive alien plants (IAPs) are one of the greatest threats to plant and animal biodiversity. Of the estimated 9000 plants introduced into South Africa, 198 are currently classified as being invasive. It is estimated that these plants cover about 10% of the country and the problem is growing at an exponential rate (Stafford and Brent, 2011).

IAPs result in a net loss of value amounting to some 100 million US$ per year to the Cape Floristic Region (CFR) in the Western Cape Province of the country. This includes significant costs due to the impact of IAPs on water resources (utilizing 7 to 13% of the available surface water) and the loss of income for the wild flower and tourism industry. The cost of clearing IAPs represents a considerable burden and farmers are unlikely to clear IAPs due to financial reasons unless there are gains from clearing their lands (such as aesthetic values) or appropriate incentives are put in place (such as payment for ecosystem services). The flora of the CFR is highly threatened and designated as a biodiversity conservation 'hotspot'. The Cape Action for People and the Environment (C.A.P.E.) Program unites government and civil society in a strategy to conserve biodiversity, while creating benefits for all the people of the CFR. The Agulhas Biodiversity Initiative (ABI) is a pilot landscape initiative that builds on a partnership between South African National Parks and Fauna and Flora International; the partnership was initiated in 2004.

The BIOSSAM intervention explored the opportunity to reduce the cost and burdens of clearing IAPs by producing bioenergy; referred to as IAP2Energy. Multi-stakeholder engagement and a process of planning for sustainability (see Figure 12), developed the vision, principles, criteria and indicators that can be used to guide the assessment and management of IAP2Energy-related projects.

3.2.2 The planning for sustainability framework

The planning for sustainability framework was developed, based on emerging international and current praxis in sustainability assessment (Bell and Morse, 2008; Pope and Grace, 2006; Pope et al., 2004; Gibson et al., 2005) and drawing on experience and learning in Strategic Environmental Assessment (for example in Dalal-Clayton and Sadler, 2005). The framework is described by Haywood et al. (2009) and shown in Figure 14.

In summary, the framework comprises two phases, namely the preparation for the sustainability assessment, followed by the sustainability assessment itself, and further appraisal work on proposed policies, programmes or projects. The preparatory phase (Task I) provides the foundation and context for all evaluations and appraisals of proposed Policies, Programmes and Projects (PPPs), to ensure alignment with a sustainability focus. During the preparatory phase stakeholders are engaged in a process of defining a common sustainability vision, which they also help to translate into sustainability principles (or broad goals) and sustainability criteria (or objectives); the latter will show whether the principles and vision are being satisfied.

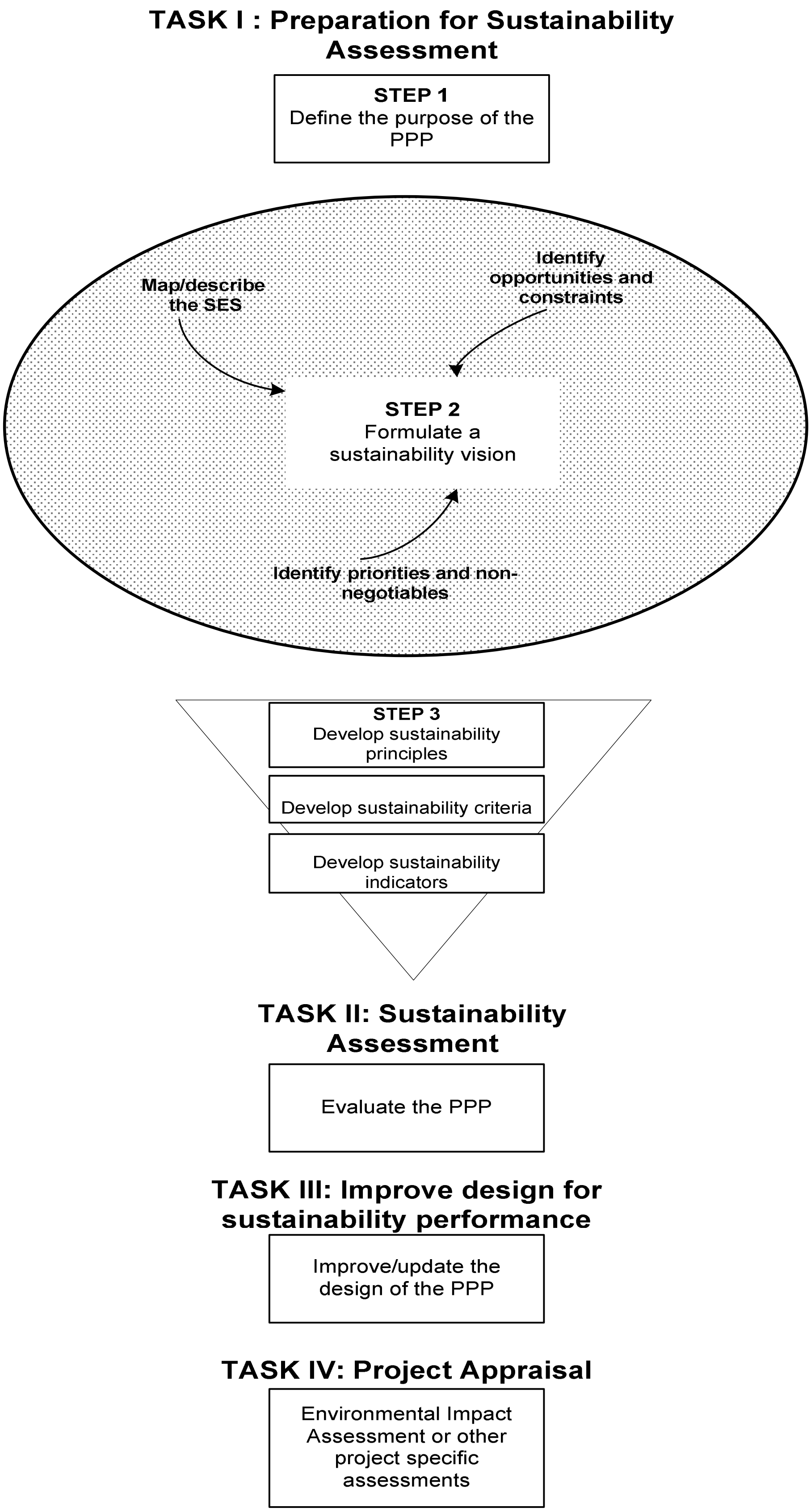

Figure 14. The planning for sustainability framework

(Source: Haywood et al., 2009)

Formulating the sustainability vision draws on the knowledge and insight of stakeholders including local residents, and the knowledge and insights of "specialists" (science and other forms of formal knowledge), in a facilitated process. Through the framework, the combined knowledge and insights is then used to map out or describe the receiving environment within which a bioenergy intervention is proposed. This information is used in open stakeholder engagement and amongst R&D project team members to identify the opportunities and constraints offered by the receiving environment for a proposed bioenergy PPP. The stakeholders and R&D project team members also identify and deliberate on the necessity for trade-offs and offsets to be made between social, natural and economic capitals.

The three inputs are used as the foundation for formulating a sustainability vision that constitutes a common ground amongst all stakeholders and captures what people feel is a desirable future for their area. The sustainability vision provides the frame of reference for all further planning work regarding a particular bioenergy intervention in the area in question.

The vision is translated into sustainability principles that ensure that all elements of the environment (biophysical, social and economic) are expressly provided for in working towards an overall sustainability goal. In turn, the sustainability principles need to be translated into practical sustainability criteria (objectives) and sustainability indicators that are identified for each of the criteria. The sustainability indicators will be used to measure whether the criteria have been met by a proposed bioenergy PPP.

This concludes the preparatory phase and detailed appraisal can now be conducted on the proposed bioenergy PPP. Various forms of sustainability assessment can be applied but the sustainability criteria agreed by the stakeholders must be consistently applied regardless of the technique chosen. The purpose of the sustainability assessment task (Task II) is to identify areas for possible improvement of the proposal for a bioenergy PPP, namely improved design, or other changes in the concept. Alternatively, the sustainability assessment can be used to select best options or scenarios according to performance against the sustainability criteria. In the case of policies or programmes, the programmes may then be implemented and monitored for their sustainability performance using the sustainability indicators. In the case of proposed projects, once the changes and improvements have been made to the project or facility design, or a preferred scenario or option is selected, in both cases to ensure alignment to the sustainability vision, principles and criteria; the bioenergy project can be subjected to conventional detailed appraisal.

3.2.3 IAP transdisciplinary stakeholder engagement

The process of planning for sustainability is permeated by public participation throughout the process, but most importantly and specifically during the preparation phase (Task I). It is during this phase, that the boundaries and foundations of the planning of the bioenergy interventions are established and for sustainability to be achieved, the decisions made here must be situated with the community who will be affected by the interventions. The decisions made by local people in this process, are based on a range of forms and sources of knowledge of their local environment and the social fabric in the local context, and how these two components interact in reality. They are also able to bring issues such as cultural nuances and historical perspectives into the planning process.

At the start of the case study, the stakeholder interaction was limited to the ABI Energy Working Group, specifically to define, with this smaller group, what the intent of the IAP2Energy project was. For the later engagements – visioning, defining principles and criteria, by applying a multi-criteria decision analysis (MCDA) technique – a very broad range of stakeholders was identified and invited to participate. The stakeholder engagement was thus conducted in:

- Small group meetings – with the ABI Energy Working Group; and
- Three larger interactive stakeholder workshops – one workshop each for the visioning, the formulation of the sustainability principles and criteria, and the MCDA process.

Feedback on the process and outcomes were also be provided to the stakeholders following the workshops.

At the request of the ABI Energy Working Group the first two stakeholder workshops focused on ensuring the involvement of landowners and local residents, although a broad range of stakeholders were invited to participate. A much wider range of stakeholders was invited to participate in the MCDA workshop. Very few participants attended all three workshops and this raises questions regarding continuity and the capacity for meaningful participation.

Important concerns were raised by some groups of stakeholders, such as the farmers, regarding the time that was required to participate in the initiative. This is not an uncommon challenge in public engagement. However, according to best practice and within the time and budgetary constraints of the project, the principle applied in this case study was to provide the opportunity for as wide a range of stakeholders to participate as much as possible. The choice regarding actual participation was then left up to the stakeholders themselves to make. The first meeting with the ABI Energy Working Group was attended by eight participants (all local people), the visioning workshop by sixteen people – only one of whom was not from the local area but had a direct interest in the area, the workshop to formulate principles and criteria by five stakeholders – mostly Working Group members and therefore locals, and the MCDA workshop by eighteen stakeholders – less than half of whom were local residents. The other stakeholders attending the latter workshop represented organisations with an interest in bioenergy planning in the Agulhas Plains area.

3.2.4 Outcomes of the stakeholder engagement

For the case of IAPs on the Agulhas Plains the vision was established as:
"*Landowners, business, government, civil society and communities in the Agulhas Plains area are working together to enable the sustainable production and use of green energy derived from invasive alien plants to conserve biodiversity, restore the land and promote resilient and continuous livelihoods for the equitable benefit of all*" (Stafford and Brent, 2011).

The vision embodies the thinking of the stakeholders in terms of placing any bioenergy development into a broader strategic, and spatial and economic development context. The thinking also reflects the knowledge and participation of many of the stakeholders in broader sustainable energy and development initiatives on the Agulhas Plains. For example, there have been discussions about developing a green economy for the area and this was taken into account in the visioning. The vision is thus consistent with the broader purpose of the project, namely being used as a catalyst for an incremental shift towards broad based sustainability on the Agulhas Plains.

The sustainability vision was translated into sustainability principles and criteria in a facilitated interactive workshop. All of the participants in this workshop had also participated in the visioning process. Stakeholders were introduced to the concept and motivation for developing sustainability principles, criteria and indicators; and the need for stakeholders to be closely involved in their definition. Participants were presented with a list of draft principles and criteria that had been prepared by the project team prior to the workshop to assist in orientation and to provide a foundation upon which deliberation could be based to formulate refined principles and criteria. The group produced a set of refined principles and criteria, which the project team then further refined and developed to ensure that the intent in the vision had been comprehensively addressed.

The final set of sustainability principles and criteria are listed in Appendix C. Although some progress was made in defining sustainability indicators for each of the sustainability criteria, the convergence in time of the activities of the preparation phase of planning for sustainability, and conducting the MCDA, caused some conflict of interest. The sustainability criteria formulated by the stakeholders, as described above, were not used in the MCDA process, but different criteria were generated by the MCDA team to be able to fit these into a computer-based tool. This created a conceptual hiatus for the planning for sustainability process. Strenuous attempts were made to try to merge the processes of defining and selecting common indicators for the MCDA and the sustainability assessment tasks. However, in the end the MCDA went ahead with its own set of criteria and indicators consistent with the capabilities of the computer-based tool and the focus on the selection of technology-based scenarios (described below):

- Technology Criteria: Energy efficiency; Maturity; Modularity; Mobility.
- Economic Criteria: Economic efficiency; Local investment and financing
- Societal Criteria: Local (regional) benefits; Job creation; Developing skills for life
- Environmental Criteria: Maximise IAP clearing; Minimise impact on natural resources

All of these issues must ensure the certainty of benefits to local people of the Agulhas Plains. A key aspect is the delicate balance between ensuring that the process is economically feasible without being driven by market demands that would create the dependency on IAPs and provide incentives for the farming of IAPs. IAPs are considered a non-renewable resource since the eradication of IAPs is the ultimate objective that complies with government legislation so that the farming of IAPs will not be permitted. In this IAP2Energy pre-feasibility assessment, the project lifetime was 20 years in order to synchronize the IAP2Energy technology lifetime with the proposed period of IAP biomass eradication (resource depletion). Four areas on the Agulhas Plains were identified (to minimize transportation costs), and the available IAP biomass stocks within these areas were estimated to have a total energy content of 25 TJ, which could generate 12 MW of electricity and thereby provide sufficient energy for at least 20 000 people over a 20 year period; about half the people resident on the Agulhas Plains. This indicates a considerable bioenergy potential and there are established commercial technologies available that can generate valuable bioenergy products from these IAPs.

The technology options were explored and developed into feasible scenarios (see Figure 14). The scenarios were scored and ranked using weighting values that were determined by the stakeholders, using the MCDA technique, and performance data for the defined IAP2Energy scenarios, using a life-cycle approach where the entire value chains (production to end use) were analyzed. The most appropriate IAP2Energy scenarios (in order of preference) were:

1. Compressed logs;
2. Pyrolysis for charcoal;
3. Gasification for electricity; and
4. Combustion for electricity.

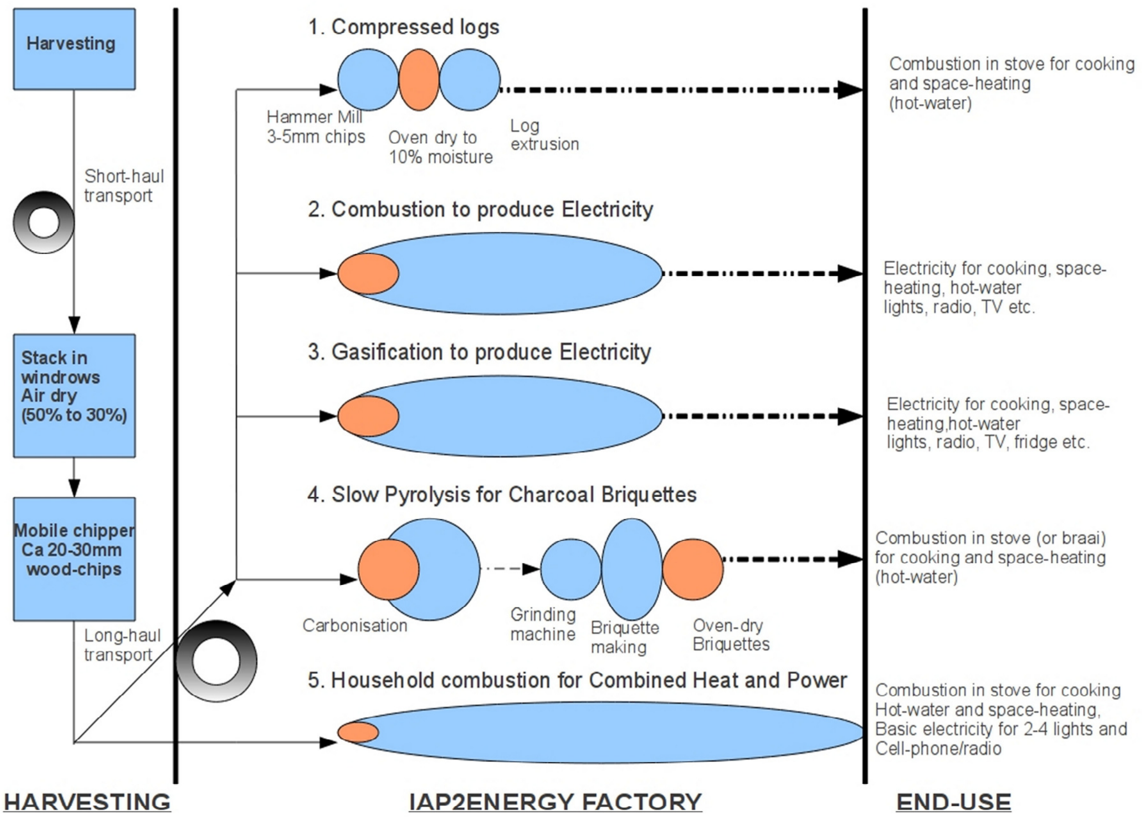

Figure 14. The IAP2Energy scenarios (1-5) showing the bio-energy value chain from IAP biomass harvesting to the end-use of the bio-energy product

(Source: Stafford and Brent, 2011)

This choice was largely determined by the preference for localisation and resource efficiency in terms of minimizing impacts on natural ecosystems. The smaller, modular technology approaches are localised, namely using wood-chips directly in efficient combined heat and power stoves, and have the added benefits of developing local skills and capacity in their manufacture, sales and maintenance. Changes in the practices of usage can greatly improve the overall efficiency; for example, more efficient stoves and energy efficient appliances. All stakeholders therefore recognised that the implementation strategy should more carefully consider end-user energy efficiency, preferences and needs.

3.3 Perspectives on the influence of culture and values on the BIOSSAM R&D effort

The R&D team was engaged, after completion of the IAP case study, to obtain some insights in terms of how cultural values, and organizational structure, including communication, affected the transdisciplinary R&D effort. The content analyses of the narratives that were received in written format (in Appendix D); with the personal observations, reflections and discussions with the team members; and a review of project-related documentation; are consolidated in Table 5 – according to parameters of the conceptual framework (of Figure 11).

Table 5. Consolidation of the reflections, observations and perceptions of the BIOSSAM transdisciplinary R&D effort pertaining to the IAP2Energy case study on the Agulhas Plains of South Africa

Parameter	Positive effect on the R&D effort?	Outcomes based personal reflections, reflections of the R&D team members, and analyses of the project communiqué
Stakeholder values / culture:		
Acceptance and expectance of power distribution	~	Expectations, and acceptance, of power distribution had to change through the process, which caused friction. For example, although the participating stakeholders and the R&D team members engaged on an equal footing, which was experienced as overly positive, the situation did arise where the team leader had to make judgments on taking the research forward, which was met with resistance, particularly if such decisions were perceived to infringe on disciplinary discourse.
Focus on own priorities or that of the larger system	×	The dominant culture was that of fulfilling one's own needs, which meant that the holistic vision and goals of the larger system was difficult to achieve. Individual team members felt that it was extremely difficult to influence the overall R&D process to encourage some cohesion and common purpose, despite the logical necessity for doing so. Eventually they felt compelled to focus on their own priorities (and deliverables) in isolation of the broader project goals.

Parameter	Positive effect on the R&D effort?	Outcomes based personal reflections, reflections of the R&D team members, and analyses of the project communiqué
Tolerance for uncertainty and ambiguity	×	From the onset, the project did actually display itself as handling an 'ill-defined' problem where clarity on many issues was identified in the course of the project lifespan. BIOSSAM portrayed itself as an open-ended learning project where the ideas and thinking was not confined in a box but rather organized in a way that it allowed thinking outside the box Although there was acceptance of uncertainty and ambiguity upfront, vague outcomes were not dealt with well, especially the stakeholders (from the Agulhas Plains) that were seeking definite answers from the process and team members with strong discipline orientation. Timeframes and limitations on funding meant that uncertainty could not always be indulged or explored. This may have hampered innovative thinking. The uncertainty grew towards the latter stages of the project (rather than the opposite which should have been the case); the consequence was a complete breakdown of tolerance among some of the team members.
Time orientation	√	The orientation of the BIOSSAM project was long-term from the outset. This is due to the understanding that the actual impacts of the project would be felt after the formal project had ended, which was three years All parties could thus accept that the identified 'solutions' would be medium- to long-term in nature.
Activity orientation: 'doing' or 'being' orientation	×	In the project as a whole there was very much a 'doing' orientation – not enough time and attention to reflection of the ultimate purpose of the tasks, namely the 'being' orientation. Differences of perceptions between doing and being orientations were also experienced, with no clear characteristic associated with a stakeholder type or a R&D team member type of participant. The consequence was many frustrations in the larger group.
Attitude towards human nature	~	Initially, there was a general acceptance of human nature and its influence on the R&D process. However, towards the end, there was a growing tendency, as perceived by some team members, in terms of individuals retreating into the terrain of their own disciplines and being defensive about their domain / boundaries; thus, reflecting human nature in terms of retreating into familiar / safe territory.
Conflict or harmonious seeking	~	Although there were strong opinions, especially between the (disciplinary) R&D team members, there was a general sense that a harmony was to be found. Nevertheless, perhaps attributable to a lack of common purpose and defensiveness about disciplinary territoriality, some members felt that there was a sense that some team members held the 'ultimate truth', which prevailed as a negative aspect throughout the project.
Internal organizational values / culture:		
Transparency	×	Some perceptions were that it was difficult, at times, to track what was happening through the R&D process, with the formation of smaller teams to deal with specific aspects of the R&D effort. Thus, very little communication occurred with no collaborative working within the team. Another issue that impacted on the transparency of the project was the geographical split of the project team members that proved challenging, although, at first, it was perceived to be of strategic advantage.

Parameter	Positive effect on the R&D effort?	Outcomes based personal reflections, reflections of the R&D team members, and analyses of the project communiqué
Integrity	√	In general it was felt that the organization had integrity although, at times, project work with large teams could lose this characteristic. This was not experienced to be an issue with this R&D effort in that the team member perceived the management thereof to be executed with integrity. Thus, there was an underlying commitment to finding common ground and purpose.
Issue orientation	√	All participants were able to concentrate on the issue at hand; there was clear communication about the expectations and intentions of the BIOSSAM and opinions on the work that need to be done. there was also communication on the budget when it did not correspond to the deliverables and a discussion among the team on what action plans need to be done to correct the situation; ant the progress and status report of the project also kept the team informed and aware of what is on track and what needs intervention.
Inquiry / experimentation	√	All participants were eager to engage in an exploratory-type mode. However, overall, the perception was that the emotional commitment is developing slowly – there is still a fear of stepping fully into the transdiciplinary way of working and thinking. Thus, there was a tendency to accommodate the changes resulting from the new ideas, but at the same time keeping the overall goal of the project in mind.
Accountability	×	All participants accepted accountability of their respective contributions to the R&D effort. Nevertheless, some observations were that the "*stakeholders who were engaged in the IAP2Energy case study testing process were drawn into a badly designed and truncated process that raised expectations and then they were just left hanging*". So the project team obtained what they needed (to some extent) but the stakeholders merely had information extracted from them and received nothing in return.
Team work	×	It was agreed that the organization attempts to instil team work that is multi-disciplinary in nature, but, still, scientist's (and engineers) battle with team work unless the team members all have similar world views and points of engagement.
Open to risk	×	The organization is extremely risk-adverse, and this manifested in, especially, the R&D team members' behaviours.
Organizational structure:		
Hierarchy-free communication	×	The operational structure of the organization, particularly in terms of financial resource allocations, meant that communication, in many instances, was not hierarchy-free. This, in turn, was not conducive to working together in a spirit of cooperation and joint accountability, which led to delays in the R&D effort.
Joint planning, including questions and goals	×	The R&D questions and goals were reasonably formulated in the larger group, but the planning was, at first, left to the team leader, and then occurred ad hoc in the smaller teams. This *modus operandi* was not conducive to working together in a spirit of cooperation and joint accountability, which made the R&D management process extremely challenging.

Parameter	Positive effect on the R&D effort?	Outcomes based personal reflections, reflections of the R&D team members, and analyses of the project communiqué
Good management mediation	~	The management tools and practices of R&D efforts are well established in the organization, but there were differences in opinion as to their effectiveness. Unwillingness to learn or be exposed to different ways of thinking and knowledge (risk aversion) and a lack of humility / flexibility, and defensiveness on the part of the key team members including the technical project manager, caused serious conflict and damaged working relationships.
Equality of members / stakeholders	~	The organization structure was 'flat-based' oriented. However, some members of the team perceived themselves to know more than the others, namely, to hold the 'ultimate truth', and so especially during the case study there was much conflict, contestation and judgment rather than collaboration on an equal footing in an environment of mutual respect.

3.4 Conclusions from the case study analysis

The R&D effort was very exploratory-oriented and therefore evolved, as a project, over the three years. However, on reflection, the R&D team members felt strongly that the project was not explicitly conceptualized from the outset as a transdisciplinary R&D effort and communicated as such. The consequence was that the transdisciplinarity of the R&D effort was not internalised by all the team members, and the organization. Values and culture subsequently influenced the R&D effort, overall, in a negative way. In terms of the values and culture of the stakeholders and team members, the most important parameters that must be considered to improve the outcomes of transdisciplinary R&D efforts are:

1. Focusing on the priorities of the overall R&D effort, rather than sub-components thereof, to encourage some cohesion and common purpose;
2. Instilling a tolerance for uncertainty and ambiguity and thereby stimulate more innovative thinking; and
3. Striking a balance between 'doing' and 'being' orientations, to ensure that the R&D effort strives towards the common purpose.

As to the values and culture of the organization, the most important parameters that must be adhered to are: transparency, accountability, team work, and, especially, openness to taking risks. Because these issues were not addressed adequately, in the BIOSSAM case, the team members, of the different work packages, easily retreated to disciplinary domains, or comfort zones, rather than consciously engaging with the transdisciplinary nature of the work of the project as a whole. To this end it would be useful to have a scene-setting workshop at the beginning of the project, with at least annual refreshers, where transdisciplinarity and integrative thinking and focus are emphasized as the points of departure. This would include engaging with the different worldviews and perspectives of each of the team members, and the stakeholders. Being aware of these upfront, rather than to discover them through conflict and contestation in the project work, would significantly improve the productivity and outcomes of transdisciplinary R&D efforts.

4 Conclusions of the overall study

Increasingly it is recognised that a concerted effort is now needed for global transitions to sustainability – towards a humane and diverse world (Adams and Jeanrenaud, 2008). The challenge is considerable and endless innovation, technological and otherwise, will be needed in terms of low-energy industrialism and low-impact living, away from the more usual polluting, resource-heavy and energy-intensive production and consumption. With respect to technological advancements, Allenby and Sarewitz (2011), however, emphasise that a 'level III' understanding of technology is required, where: "*complexity becomes pervasive – integrated in ways that can never be fully understood, with an array of human, built and natural subsystems creating adaptive systems, which increasingly characterise Earth*".

In response the concept of transdisciplinarity has emerged as radically distinct from multi- and interdisciplinarity because of its goal – the understanding of the present world – which cannot be accomplished in the framework of disciplinary research. Transdisciplinarity is often confused with inter- and multidisciplinarity, largely due to the fact that all three overflow disciplinary boundaries. Nevertheless, the goals of the three approaches are different. The three pillars of transdisciplinarity, namely: multiple levels of reality, the logic of the included middle, and complexity (Nicolescu, 1999); determine the methodology of transdisciplinary research.

Transdisciplinarity entails both a new vision and a lived experience – of transformation-oriented – towards knowledge of the self, the unity of knowledge, and the creation of a new understanding of social-ecological systems. With respect to research and development (R&D) into technological innovation, a profound interaction of conventional multi- and interdisciplinary R&D teams with stakeholders that define the context of technology uptake – in distinct social-ecological systems – is required. The consequence is the potential conflict that arises from different culture and values across transdisiplinary R&D teams. As an example, the learning preferences of disciplines (and individuals within disciplines) are likely to 'pull' an R&D effort in different directions. As shown in Figure 15, transdiscplinary team members will in all likelihood include individuals with orientations towards practical application and experimentation, associated with those that, for example, will drive the uptake of developed technologies, as well as individuals with orientations towards reflective observations that typically characterise the researchers themselves. This study subsequently set out to investigate how culture and values in a transdisciplinary R&D team that aims to address a sustainability-oriented problem determine the outcomes of a R&D project. Specifically, the proposition was put forward that, in the context of a sustainability-oriented, transdiscplinary R&D effort, organisational culture plays a lesser role in determining the success or failure of the effort, but that the culture and values of individuals of the transdiscplinary R&D team determine, to a large extent, the success or failure of the R&D effort.

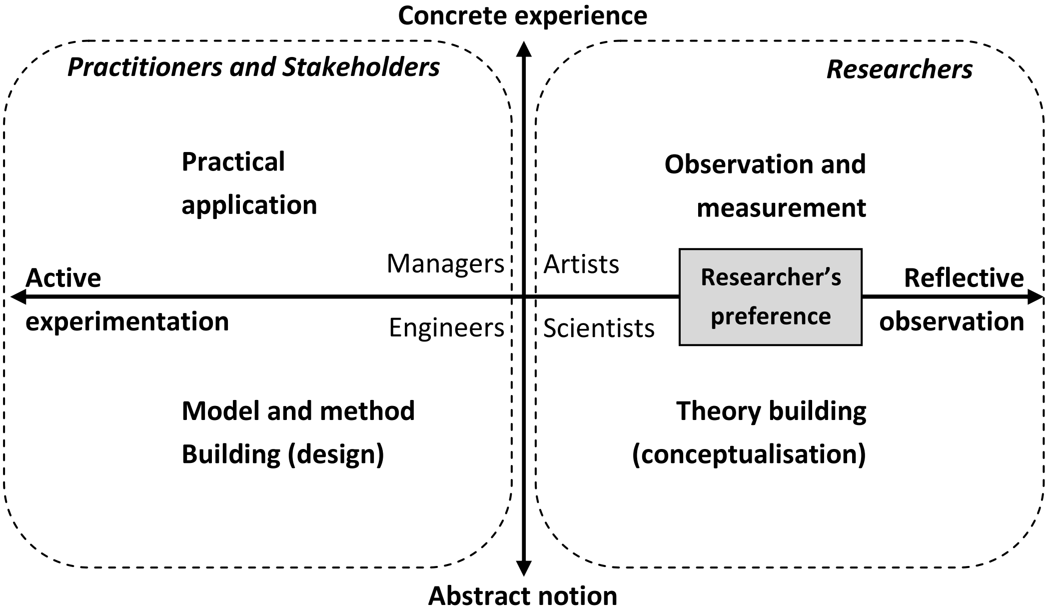

Figure 15. The preferences of disciplines, researchers and practitioners, including those typically of stakeholders that are engaged with in transdiscplinary R&D efforts
(Adapted from Kolb, 1984)

The study commenced with a literature analysis on values and culture in the context of transdisciplinary R&D projects. The literature analysis developed a conceptual framework of the applicable theory. In the framework values and culture are distinguished between those that are characteristics of the stakeholders themselves, namely the R&D team members and the societal participants of the transdisciplinary effort, and those of the organisation (of the R&D effort) itself. The former, namely 'stakeholder values and culture', is described by the notions of: acceptance and expectance of power distribution; focus on own priorities or that of the larger system; tolerance for uncertainty and ambiguity; time orientation; activity orientation; attitude towards human nature; and conflict or harmonious seeking. The latter, namely 'internal organisational culture', is characterised by: transparency, integrity, issue orientation, inquiry or experimentation, accountability, team work, and openness to risk.

The conceptual framework also highlights key aspects of organisational structure that are determinants of R&D success, namely: hierarchy-free communication and flow of information – continuous exchange between process, teams and the organisation as a whole; joint questions and goals - joint planning and clear goals; equality of members and stakeholders; and the establishment of good management and mediation. In terms of the management of transdisciplinary R&D efforts, values and culture biases must be acknowledged and facilitated by a good flow of communication within the organisation structure and the stakeholders, if the common goals of the effort are to be achieved.

The conceptual framework provided the means to engage with a transdisciplinary R&D effort to investigate, and understand, the implication of values and culture on the outcomes of the R&D effort. An R&D project that the researcher had initiated whilst being employed in the Council for Scientific and Industrial Research (CSIR) was chosen for this purposes; the Bioenergy Systems Sustainability Assessment and Management (BIOSSAM) project. The BIOSSAM project was funded by a parliamentary grant over a three-year period and derived a number of methods and tools to improve the sustainability of the bioenergy sector. Some of these methods and tools were developed through a specific case study of utilising invasive alien plants in the Agulhas Plains area to the benefit the local communities – termed IAP2Energy.

The researcher engaged with the BIOSSAM R&D team, after the completion of the IAP2Energy case study, to obtain some insights in terms of how cultural values, and organizational structure, including communication, affected the transdisciplinary R&D effort. The content analyses of the narratives that were received in written format; with personal observations, reflections and discussions with the team members; and a review of project-related documentation; were consolidated according to parameters of the conceptual framework.

The BIOSSAM case showed that, indeed, culture and values of individuals, rather than those of the organisation, are pivotal for R&D project success (see Figure 16). For a transdisciplinary R&D project to be successful, there must be acceptance across the board that power dynamics will change throughout the R&D effort. Furthermore, stakeholders and R&D team members must be willing to relinquish their own priorities for the good of the larger R&D effort, and be tolerant to uncertainty, ambiguity, and risk. The nature of some disciplines is to be observant, whilst others are to get something done (as illustrated in Figure 15); this difference in values and culture needs to be managed carefully. A specific occurrence was the formation of smaller teams, especially disciplinary- and problem-oriented, which made the management of these teams towards the larger goal challenging. To this end, management with integrity plays a key role to ensure openness and truthfulness of all participants in the R&D effort. From an organizational structure perspective, communication channels remain a challenge, and especially, the joint planning and formulation of R&D questions and goals, which are vital for the success of transdisciplinary R&D efforts. Other R&D management practices, methods and tools appear to be secondary.

The case thus emphasizes that the lack of disciplines to recognize, understand and incorporate values and culture into R&D practices will lead to project failure; for technology-oriented R&D pre-empting and managing expectations of social change (often) far outweigh the necessity for technological change. A key cultural aspect that emerged from the R&D effort was the crucial importance of attitudes. If the correct attitudes towards transdisciplinary are not instilled upfront, and maintained throughout the R&D effort with sound communication practices, then the effort will surely fail. This also places the responsibility for project success on participating members, as stated by Swindoll (2006):

"The longer I live, the more I realize the impact of attitude on life.
Attitude, to me, is more important than facts. It is more important than the past, than education, than money, than circumstances, than failures, than successes, than what other people think or say or do. It is more important than appearance, giftedness or skill. It will make or break a company... a church... a home.
The remarkable thing is we have a choice every day regarding the attitude we will embrace for that day. We cannot change our past... we cannot change the fact that people will act in a certain way. We cannot change the inevitable. The only thing we can do is play on the one string we have, and that is our attitude... I am convinced that life is 10% what happens to me and 90% how I react to it. And so it is with you... we are in charge of our attitudes".

- Working in a transdisciplinary manner towards a common goal requires concerted effort and commitment on the part of every team member. If this is not facilitated and encouraged there is a tendency for team members to gravitate back into their disciplinary arenas and to work in isolation, which has consequences for the coherence and congruity of final outcomes. This was due to different groupings that worked towards different goals, rather than a common goal.
- Problems arise if there is a lack of recognition and explicit expression by all members of the team, of the different origins and purposes, of the different tools available for planning and assessment; for example, in this case of bioenergy development. Some tools are reductionistic, others more integrative, some based on a weak sustainability goal, others on achieving strong sustainability, and so on. A tendency to see all "sustainability planning tools" under the same umbrella is bound to cause conflicts of interest.
- A dissonance between expressed intent to plan and assess for sustainability, but a strong tendency to retreat into linear reductionistic and familiar techniques and approaches suggests a need for strong conceptual guidance of this kind of research. Expressed differently: all team members need to "be on the same page".

Figure 16. Key lessons learnt from the BIOSSAM case

4.1 Reflection on the undertaken investigation

Metcalfe (2005) emphasises that for research to be judged as scientific, the work must be empirical - based on objective observation; public – open to scrutiny and criticism; repeatable – the same steps will yield the same results; and generalisable – must be valid in other similar situations.

4.1.1 Empirical

The researcher was intricately involved throughout the BIOSSAM project. He had conceptualised the scope of work, and had subsequently leveraged the funding, to undertake the R&D effort over the three year project. For about 40% of the project's timeline he had also acted in the capacity of project leader; thereafter he played in an advisory role to the newly appointed project leader. Therefore, an argument could be made against the objectivity of the empirical evidence derived from the personal observations and informal discussions component of the research strategy. However, by utilising the triangulation approach, by also relying on the narratives and observations of others involved with the R&D effort, as well as project documentation – that cannot be divulged here, it is believed that sufficient empirical evidence had been derived to answer the research question: cultures and values significantly influence collaboration and thus impede transdisciplinary R&D efforts – if they are not acknowledged and managed accordingly.

4.1.2 Public

Apart from this thesis document, which will be available publically, the content of the research has been put into the public domain for scrutiny and criticism. The first part, namely the literature analysis and development of the conceptual framework, was published in the proceedings of the R&D Management 2011 conference. The researcher was given the opportunity to deliver an oral paper, with at least one other author, in the same track, assigned to read and scrutinise the paper. The subsequent discussions after the oral presentation provided for valuable guidance for the post-mortem analysis of the BIOSSAM case. The second part, on the BIOSSAM case, has been accepted as a chapter for the forthcoming textbook: Handbook of Sustainable Engineering. It is then believed that others can sufficiently criticise and (hopefully) build on this work.

4.1.3 Repeatable

The observations greatly depend on individual perspectives. It may then be argued that given a different R&D team on the same project may lead to different observations. However, it is argued that, in a transdisciplinary R&D effort, if individualism is not recognised, as occurred with BIOSSAM, and individuals are not given the means to take responsibility of their own culture and values, including attitudes, for the greater good of the R&D effort, then the same project outcomes would be observed. A similar undertaking in the CSIR, as documented by Nortje (2011), shows similar outcomes in terms of the behaviours of R&D teams; albeit that culture and values were not explicitly investigated.

4.1.4 Generalisable

This investigation relied on a single case study approach, which, for some empirical undertakings, has been criticised from a generalisability perspective. Although similar outcomes have been document on at least one similar case (Nortje, 2011), it would be impossible to generalise these findings to all transdisciplinary R&D efforts, even to those that are all technology-oriented. However, it is possible to generalise to the case itself in that it is not the subject matter, or focus, of the BIOSSAM project that determined the outcomes. Indeed, it is argued that the general outcome for management practices, that the challenges of transdisciplinary R&D efforts need to be acknowledged upfront and managed accordingly, with full participation of all team members and stakeholders, will determine the success (or not) of any transdisciplinary R&D effort.

References

Aasen TMB, Amundsen O, Mølnvik M, Tangen G, 2010. Innovation in transdisciplinary and heterogeneous collaborations: Exploring new ways of organizing environment-friendly energy research. COMBI2010 Conference Proceedings, Vantaa, Finland.

Acs Z, 2000. Regional innovation, knowledge, and global change. Pinter, London.

Adams WM, Jeanrenaud SJ, 2008. Transition to sustainability: Towards a humane and diverse world. International Union for Conservation of Nature and Natural Resource (IUCN), Gland, Switzerland, available from: http://cmsdata.iucn.org/downloads/transition_to_sustainability__en__pdf_1.pdf

Aenis T, 2010. A communication model for transdisciplinary consortium research. 9th European IFSA Symposium, Vienna, Austria, 500-509.

Allenby BR, Sarewitz D, 2011. We've made a world we cannot control. New Scientist, 14 May, 28-29.

Apgar JM, Argumedo A, Allen W, 2009. Building transdisciplinarity for managing complexity: Lessons from indigenous practice. International Journal of Interdisciplinary Social Sciences, 4 (5), 255-270.

Arora VB, Bhundia A, 2003. Potential output and Total Factor Productivity growth in post-apartheid South Africa. IMF Working Paper, WP/03/178, Washington DC, available from: http://www.imf.org/external/pubs/ft/wp/2003/wp03178.pdf

Bell S, Morse S, 2008. Sustainability indicators measuring the immeasurable? Earthscan, London.

Blättel-Mink B, Kastenholz H, 2005. Transdisciplinarity in sustainability research: Diffusion conditions of an institutional innovation. The International Journal of Sustainable Development and World Ecology, 12 (1) , 1-12.

Carlson L, 2007. Crossing the line. Alternatives Journal, 33 (5), available from: http://www.alternativesjournal.ca/articles/crossing-the-line

Clark WC, Dickson NM, 2003. Sustainability science: The emerging research paradigm. Proceedings of the National Academy of Science of the USA, 100 (14), 8059-8061.

Coenen L, Lopez JD, 2010. Comparing systems approaches to innovation and technological change for sustainable and competitive economies: An explorative study into conceptual commonalities, differences and complementarities. Journal of Cleaner Production, 18 (12), 1149-1160.

Collins HM, Evans R, 2002. The third wave of science studies: Studies of expertise and experience. Social Studies of Science, 32 (2), 235-296.

Dalal-Clayton B, Sadler B, 2005. Strategic Environmental Assessment – A sourcebook and reference guide to international experience. Earthscan, London.
Dann Z, Barclay I, 2006. Complexity theory and knowledge management applications. The Electronic Journal of Knowledge Management, 4 (1), 11-20, available from: http://www.ejkm.com

Das TK, Kumar R, 2010. Interpartner sensemaking in strategic alliances: Managing cultural differences and internal tensions. Management Decision, 48 (1), 17-36.

Degenaar JJ, 1993. Art and culture in a changing South Africa. South African Journal of Philosophy, 12 (3), 51-56.

Department of Science and Technology (DST), 2008. The global change grand challenge implementation framework – Executive summary. Global Change, Society & Sustainability Research Programme (GCSSRP), Pretoria, South Africa, available from: http://globalchange.grandchallengeonline.org/

de Wet G, 1999. Emerging from the technology colony: A view from the south. Proceedings of the Portland International Conference on Management of Engineering and Technology (PICMET), 1, 418.

Elzen B, Geels FW, Green K, 2004. System innovation and the transition to sustainability: Theory, evidence and policy. Edward Elgar Publishing, Massachusetts.

Eyraud L, 2009. Why isn't South Africa Growing Faster? A comparative approach. IMF Working Paper, WP/09/25, Washington DC, available from: http://www.imf.org/external/pubs/ft/wp/2009/wp0925.pdf

Flyvbjerg B, 2006. Five misunderstandings about case-study research. Qualitative Inquiry, 12 (2), 219-245.

Garvin DA, 2004. Building a learning organisation. In: Burgelmann RA, Christensen CM, Wheelwright SC (eds). Strategic management of technology and innovation, Fourth Edition, McGraw-Hill, Irwin, 1162-1174.

Geels FW, 2002. Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case-study. Research Policy, 31, 1257-1274.

George AL, Bennett A, 2005. Case studies and theory development in the social sciences. MIT Press, Cambridge, Massachusetts.

Gibson RB, Hassan S, Holtz S, Tansey J, Whitelaw G, 2005. Sustainability assessment: Criteria, processes and applications. Earthscan, London.

Goldratt EM, Cox J, 1992. The goal, Second revised edition, Creda Press, Cape Town.

Haywood LK, de Wet B, von Maltitz GP, Brent AC, 2009. Development of a sustainability assessment framework for planning for sustainability for biofuel production at the policy, programme or project level. In: Mammoli AA, Brebbia CA (eds). Energy and Sustainability II. WIT Press, Southampton, 355-366.

Hessels LK, van Lente H, 2008. Re-thinking new knowledge production: A literature review and a research agenda. Research Policy, 37, 740-760.

Hirsch Hadorn G, Hoffmann-Rien H, Biber-Klemm S, Grossenbacher-Mansuy W, Joye D, Pohl C, Wiesmann U, Zemp E, 2008. Handbook of transdisciplinary research. Springer.

Hofstede G, 1980. Culture's consequences, international differences in work-related values, Newbury Park, Sage, California, available from: http://www.geert-hofstede.com/geert_hofstede_resources.shtml

Hofstede G, 2002. Dimensions do not exist: A reply to Brendan McSweeney. Human Relations, 55 (11), 1355-1361.

Hofstee E, 2006. Constructing a good dissertation. EPE, South Africa.

Hollaender K, 2003. Success factors in inter- and transdisciplinary research: Selected results from the program Urban Ecology. In: Tress B, Tress G, van der Valk A, Fry G (eds). Interdisciplinary and transdisciplinary landscape studies: Potential and limitations. DELTA Series 2, 91-99, Wageningen.

Kates RW, Clark WC, Corell R, Hall JM, Jaeger CC, Lowe I, McCarthy JJ, Schellnhuber HJ, Bolin B, Dickson NM, Faucheux S, Gallopin GC, Grübler A, Huntley B,
Jäger J, Jodha NS, Kasperson RE, Mabogunje A, Matson P, Mooney H, Moore III B, O'Riordan T, Svedin U, 2001. Sustainability science. Science, 292 (5517), 641-642.

Kezar A, 2005. What campuses need to know about organizational learning and the learning organization. In: Kezar A (ed). Organizational learning in higher education, Jossey-Bass, San Francisco, 131, 7-22.

Kiel LD, 1999. Knowledge management, organizational intelligence and learning, and complexity. School of Social Sciences, The University of Texas at Dallas, available from: http://www.utdallas.edu/dept/socsci/Fourth.htm

Kluckhohn FR, Strodtbeck FL, 1961. Variations in value orientation. Row Peterson, New York.

Kolb DA, 1984. Experiential learning: Experience as a source of learning and development. Prentice-Hall, Englewood Cliffs, NJ.

Lawrence RJ, Despres C, 2004. Futures of Transdisciplinarity. Futures, 36, 397-405.

Levy JS, 2008. Case studies: types, designs, and logics of inference. Conflict Management and Peace Science, 25, 1-18.

Lipshitz R, Popper M, Friedman V, 2002. A multifacet model of organizational learning. Journal of Applied Behaviour Science, 38, 78–98.

Lundvall B-Å, Joseph KJ, Chaminade C, Vang J, 2009. Handbook of innovation systems and developing countries: Building domestic capabilities in a global setting. Edwar Elgar, Massachusetts.

Mainzer K, 1996. Thinking in complexity: The complex dynamics of matter, mind and mankind. Springer-Verlag, New York.

Marquardt MJ, Reynolds A, 1994. Global learning organization: Gaining competitive advantage through continuous learning. Irwin Professional Publishing, New York.

McCarthy C, 2005. Productivity performance in developing countries – country case studies – South Africa. United Nations Industrial Development Organization (UNIDO), Vienna, available from: http://www.unido.org/fileadmin/user_media/Publications/Pub_free/Productivity_performance_in_DCs_South_Africa.pdf

McGregor SLT, Volckmann R, 2011. Transversity. Integral Publishers, Tucson, AZ.

Meppem T, Gill R, 1998. Planning for sustainability as a learning concept. Ecological Economics, 26, 121-137.

Metcalfe M, 2005. Generalisation: Learning across epistemologies. 6 (1), 17; available from: http://www.qualitative-research.net/index.php/fqs/article/viewArticle/525/1136#g7

Mittelstraß J, 1992. Auf dem weg zur transdisziplinarität. GAIA, 1 (5), 250.

Mobjörk M, 2009. Crossing boundaries – the framing of transdisciplinarity. Centre for Housing and Urban Research Series, Report number 64, available from: http://www.oru.se/PageFiles/30510/Malin%20Mobj%C3%B6rk%20-%20Crossing%20boundaries.pdf

Nicolescu B, 2010. Methodology of transdisciplinarity. Transdisciplinary Journal of Engineering and Science, 1, 19-38.

Nicolescu B, 1999. The transdisciplinary evolution of learning. UNESCO, available from: http://www.unesco.org/education/educprog/lwf/dl/nicolescu_f.pdf

Nortje K, 2011. Understanding the research and thinking process of a multi-disciplinary group planning for sustainability. Working Paper, Natural Resources and the Environment, CSIR, Pretoria.

Notz P, 2005. Secondary qualitative analysis of interviews - A method used for gaining insight into the work/life balance of middle managers in Germany. Forum Qualitative Sozialforschung / Forum: Qualitative Social Research, 6 (1), Art. 34, available from: http://nbn-resolving.de/urn:nbn:de:0114-fqs0501347

Oerlemans LAG, Pretorius MW, Buys AJ, Rooks G, 2003. South African Innovation Survey 2001: Industrial innovation in South Africa 1998-2000. University of Pretoria, available from: http://web.up.ac.za/UserFiles/sais2001-1.pdf

Peneder M, 2010. Technological regimes and the variety of innovation behaviour: Creating integrated taxonomies of firms and sectors. Research Policy, 39 (3), 323-334.

Peter C, Swilling M, 2011. Greening the South African growth path: Transitioning to sustainability. Development Bank of Southern Africa, Midrand.

Pohl C, Hirsch Hadorn G, 2008. Methodological challenges of transdisciplinary research. Natures Sciences Sociétés, 16, 111-121.

Pope J, Grace W, 2006. Sustainability assessment in context: Issues of process, policy and governance. Journal of Environmental Assessment Policy and Management, 8 (3), 373-398.

Pope J, Annandale D, Morrison-Saunders A, 2004. Conceptualising sustainability assessment. Environmental Impact Assessment Review, 24, 595-616.

Quinlan T, Scogings P, 2004. Why bio-physical and social scientists can speak the same language when addressing sustainable development. Environmental Science and Policy, 7, 537-546.

Ragin CC, 1992. “Casing” and the process of social inquiry. In: Ragin CC, Becker HS (eds). What is a case? Exploring the foundations of social inquiry. Cambridge University Press, Cambridge, United Kingdom, 217-226.

Regeer BJ, Bunders JFG, 2009. Knowledge co-creation: Interaction between science and society. A transdisciplinary approach to complex societal issues. Advisory Council for Research on Spatial Planning, Nature and the Environment (RMNO), 10e, available from: http://eeac.hscglab.nl/files/NL-RMNO_knowledgecoop_Jun09.pdf

Reger G, von Wichert-Nick C, 1997. A learning organization for R&D management. International Journal of Technology Management, 13, 796–817.

Rosenhead J, 1998. Complexity theory and management practice. Working Paper Series, LSEOR 98.25, London School of Economics and Political Science, available from: http://human-nature.com/science-as-culture/rosenhead.html

Roux DJ, Stirzaker RJ, Breen CM, Lefroy EC, Cresswell HP, 2010. Framework for participative reflection on the accomplishment of transdisciplinary research programs. Environmental Science & Policy, 13, 733-741.

Sandura TA, Williams EA, 2000. Research methodology in management: Current practices, trends and implications for future research. Academy of Management Journal, 43 (6), 1248-1264.

Schmidt JC, 2008. Towards a philosophy of interdisciplinary: An attempt to provide a classification and clarification. Poiesis & Praxis, 5, 53-69.

Scholz RW, Lang D, Walter AI, Wiek A, Stauffacher M, 2006. Transdisciplinary case studies as a means of sustainability learning: Historical framework and theory. International Journal of Sustainability in Higher Education, 7 (3), 226-251.

Schwandt DR, Marquardt MJ, 2000. Organizational learning: From world-class theories to global best practice. St Lucie Press, New York.

Senge P, 1990. The fifth discipline. Doubleday, New York.

Sillitoe P, 2004. Interdisciplinary experiences: Working with indigenous knowledge in development. Interdisciplinary Science Reviews, 29 (1), 6-23.

Smith A, Voß J-P, Grin J, 2010. Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges. Research Policy, 39 (4), 435-448.

Söderbaum P, 2009. A financial crisis on top of the ecological crisis: Ending the monopoly of neoclassical economics. Real-World Economics Review, 49, 8-19.

Stacey, RD, 1996. Complexity and creativity in organizations. Berrett-Koehle. San Francisco.

Stafford WHL, Brent AC, 2011. Bioenergy Systems Sustainability Assessment and Management. Renewable Energy Law & Policy, 3, 205-222.

Stafford WHL, Brent AC, 2010. An introduction to BIOSSAM – the South African Bioenergy Systems Sustainability Assessment and Management portal. Journal of Energy in Southern Africa, 21 (4), 32.

Stamm A, Dantas E, Fischer D, Ganguly S, Rennkamp B, 2009. Sustainability oriented innovation systems: Towards decoupling economic growth from environmental pressures? German Development Institute (DIE), Bonn.

Stemler S, 2001. An overview of content analysis. Practical Assessment, Research & Evaluation, 7 (17), available from http://PAREonline.net/getvn.asp?v=7&n=17

Swilling M, 2010. Sustainability, poverty and municipal services: The case of Cape Town, South Africa. Sustainable Development, 18 (4), 194-201.

Swindoll CR, 2006. Great attitudes! 10 choices for success in life. Thomas Nelson Publishers, New York.

United Nations Environment Programme (UNEP), 2011. Towards a Green Economy: Pathways to sustainable development and poverty eradication. Green Economy Initiative, Geneva, available from: http:// www.unep.org/greeneconomy

United Nations Environment Programme (UNEP), 2010. A brief for policymakers on the Green Economy and Millennium Development Goals. Prepared for the UN Summit on MDGs, Green Economy Initiative, Geneva, available from: http:// www.unep.org/greeneconomy

United Nations Environmental Programme (UNEP), 2009. Decoupling and sustainable resource management: Towards a conceptual framework. UNEP International Panel for Sustainable Resource Management, Paris, available from: http://www.unep.fr/scp/rpanel/publications/

van Haaften EH, 2003. Disciplinary perception and interdisciplinary communication in management of natural resources. In: Tress B, Tress G, van der Valk A, Fry G (eds). Interdisciplinary and transdisciplinary landscape studies: Potential and limitations. DELTA Series 2, 107-113, Wageningen.

Voß J-P, 2009. Barriers to research and innovation for solving social challenges: Lessons from social-ecological research in Germany. CSTP Expert Workshop, OECD, Paris, available from: http://www.oecd.org/dataoecd/28/2/43278129.pdf

Williams T, 2008. How do organizations learn lessons from projects – and do they? IEEE Transactions on Engineering Management, 55 (2), 248-266.

Wilson TD, 2004. Talking about the problem: A content analysis of pre-search interviews. Information Research, 10 (1), paper 206, available from: http://InformationR.net/ir/10-1/paper206.html

Yin R, 2009. Case study research. SAGE Publications, United States of America.

Appendix A: R&D Management 2011 proceedings

The R&D Management Conference 2011

R&D, Sustainability & Innovation

- the need for new ideas , initiatives and alliances

Norrköping, Sweden—June 28-30, 2011

Book of Abstracts

ISBN 978-0-9559367-3-9

Linköping University

KTH VETENSKAP OCH KONST

R&D MANAGEMENT

Norrköping, Sweden 28-30 June 2011

Table of Contents

Norrköping, Sweden 28-30 June 2011

II

Appendix B: Editorial guidelines of the Journal for Transdisciplinary Research in Southern Africa

TD The Journal for Transdisciplinary Research in Southern Africa

Editorial policy

1. TD is an international transdisciplinary journal for research in all fields of scientific endeavour. It is published and edited in the Vaal Triangle Faculty of North-West University in South Africa.

2. Contributions may be in the natural sciences or the humanities. Articles in which transdisciplinary collaboration between natural and the social or human sciences are explored, are most welcome.

3. The term transdisciplinarity is meant to imply the integrated use of conventional scientific theory and methodology in an effort to explore quantum frontiers of new knowledge in all spheres of scientific endeavour.

4. Regionally editorial content can be based on empirical research in Southern Africa.

5. Authors can make individual contributions or submit work, done in teams.

6. TD is a peer reviewed journal. Contributions of authors will be subject to review by two or more reviewers in disciplines used in the research and writing of an article.

7. Language of the journal: Articles may be in any of the 11 official languages of South Africa. It could also be in any of the major international languages, e.g. French, Italian, Japanes, Dutch, German, Portugese and Spanish.

8. A maximum of 30 per cent of the editorial content of each edition of the journal may be in a non-English language.

9. Abstracts: Contributions must be accompanied by an abstract of not more than 250 words in the language in which the article is written. Should the text not be in English, an abstract in English (250 words), as well as an executive summary of the article content (about 1 500 word) should accompany the article.

10. Titles of articles: The titles of articles should preferably not exceed 20 words.

11. Names of authors: The names of authors and their institutional affiliation must accompany all contributions. Authors also have to enclose their telephone and fax numbers, email addresses and postal addresses.

12. Reference system: The reference system of authors will be respected by the editorial management, providing it is current

in the academic writing in the particular disciplines used to research and write the article. References must also be clear, lucid and comprehensible for a general academic audience of readers. The Harvard and APA reference styles are acceptable. The conventional footnote system of references may also be used.

13. Illustrations: Editorial material, with illustrations, photographs, tables and graphs is welcome. The illustrations should however be of a high-density quality. Should the files be large, they have to be posted in seperate emails and appropriately numbered in sequence.
14. Articles should be posted to the editorial secretary electronically at GSKJWNT@puknet.puk.ac.za. Notification of receipt of material will take place within 48 hours.
15. Text format: Text must be in 12pt text, with double spacing. Text should preferably be in Microsoft Word.
16. The lenght of articles should preferably not exceed 8 000 to 10 000 word or 15 to 20 journal pages.
17. Articles that have been published previously in other journals, may not be republished in the journal.

Appendix C: Final list of Sustainability Principles and Criteria generated by stakeholders and refined by the project team

Principle 1: The removal of IAPs must contribute significantly to restoration of ecosystem services.

Criteria:

- Alien invasive plants are cleared according to a code of best practice that avoids any further environmental damage, and through coordinated and integrated (work) planning.
- Alien invasive plants are cleared to maximise the effectiveness of eradication, namely avoid re-growth, which is supported by regular inspections and corrective action.
- There is no (re)planting of any invasive alien species in the plains area.
- Biodiversity and water availability are restored and improved .

Principle 2: The biomass to energy cycle of production and use must have net benefit for the natural environment.

Criteria:

- Only clean and appropriate technologies for conversion of biomass to energy are chosen, so that greenhouse gas emissions and other pollutants are minimized.
- Use of resources such as energy and water is minimized in the conversion process, namely low input production.
- Production processes are designed for maximum efficiency.

Principle 3: The removal, handling and processing of IAPs will be managed within appropriate policy and legislative frameworks and every effort will be made to work with the relevant authorities to optimise legal and policy frameworks.

Criteria:

- There is continuous collaborative and integrative interaction with the planning authorities, to ensure that preparation for and implementation of projects within the IAP2Energy initiative take cognizance of the provisions of the relevant IDP(s) and that revisions of the IDP(s) are influenced by the initiative.
- The provisions of policy and legislation governing the management and effects of IAPs and other relevant policy and legislation are complied with.

Principle 4: The people of the Agulhas Plains area are the beneficiaries of human, social and socio-economic development and improvements in wellbeing resulting from all IAP removal programmes and activities.

Criteria:

- Employment and (economic) equity are created for people living on the Agulhas Plains.
- Relevant skills are developed and transferred to local people.

- The people of the Agulhas Plains area who are associated with the IAP2Energy project have a strong sense of working together, with nature and the land.
- The energy products or services generated from IAPs are produced primarily for the use and benefit of local people, in preference to exporting to areas outside the Agulhas Plains.

Principle 5: Co-learning is the foundation of the IAP2Energy project and actions taken towards developing a green economy for the Agulhas Plains area are continuously supported by awareness creation amongst all people who live in the area.

Criteria:

- A central bureau is in place and accessible to all, and which is a coordinating office for the IAP2Energy Coordinating Body (ABI Energy), a project office for the IAP2Energy Project, and an information hub for the project; as well as a space for interaction between all parties about the project.
- Access is provided to the people of the Agulhas Plains, to education and information regarding the opportunities created by a green economy. Information and materials are created to cut across barriers and around a common vision of how to use resources effectively.

Principle 6: The IAP2Energy projects must be self sustaining and economically competitive with other energy sources i.e. the energy products and services must be economically competitive with equivalent energy products and services elsewhere.

Criteria:

- People involved in the IAP2Energy initiative are working together in non-conventional, creative and informal organizational structures – cooperatives, traditional leadership structures.
- A mixture (diversity) of funding sources is being tapped into to support the IAP2Energy initiative.
- The economic performance (value) of the initiative and the individual implementation projects within it, are evaluated using new economic models including; for example, resource economics or new and unconventional financial models that are focused on sustainability, rather than the conventional cost-income financial model.

Principle 7: The IAP2Energy project must expand opportunities for resilient and sustainable livelihoods in the Plains area by being a catalyst for the development of a green economy.

Criterion:

- Further sustainable renewable energy projects are initiated on the Agulhas Plains to take into account the inevitable depletion of the IAP stock in the future.

Appendix D: Written feedback from R&D team members

Researcher 1:

Guiding aspect	Positive experience √ | ~ | ×	Comments
R&D team member's own values, and how the BIOSSAM project was experienced:		
Acceptance and expectance of power distribution	~	There was much uncertainty with regards to leadership in this project. One was never sure who was the person ultimately in charge of the project and thereby who had the power. Was the technical person or the administrative person, and why was there always uncertainty between the two?
Focus on own priorities or that of the larger system	x	I focused only on my area/work package as the larger system of the project was not coming together and no matter how hard to tried to understand the bigger picture and how the work packages fit together the more frustrating it got.
Tolerance for uncertainty and ambiguity	X	It was last year while we were trying to get things started with regards to the case studies that I lost all tolerance as there was just to much uncertainty as to how BIOSSAM was supposed to now fit/merge with IAP. Both has separate deliverable which the project team leaders decided could be achieved by doing one case study together. This did not work as it caused much conflict with us due to the reductionistic approach they were undertaking to address sustainability.
Time orientation: short-, medium- or long term		?
Activity orientation: 'doing' or 'being' orientation		?
Attitude towards human nature	X	The main attitude that I experience by the leadership is "it is my way or the highway". This was extremely unproductive and caused much unhappiness and confusion within the team. Things were being focused on us so that boxes could be ticked as complete.
Conflict or harmonious seeking	X	Mostly conflict. This was mainly due to the so called merging of the BIOSSAM project with IAP. Work package 1 did not agree with what was now being focused on us to do just because it was a tool that was needed to be used.
Other values of importance to you?	X	Another value would be that of sustainability. This word has a different meaning and value to everyone depending on their point of origin and as a result it was this value that caused the most conflict within the project team. Everyone wanted their value around sustainability to be the main focus of the project. The project team were not open minded and willing to incorporate everyone's views and values into the project design and

Guiding aspect	Positive experience √ | ~ | ×	Comments
		outcome.
Perception of internal organisational culture, and how the BIOSSAM project was experienced:		
Transparency	~	Due to limited communication between the leadership to the project team there was little transparency. Another issue that impacted on the transparency of the project was the geographical split of the project team. A split in the project team compounded by kilometres has a serious affect on the project outcome. Because we were in Pretoria we were not able to interact sufficiently with the team in Stellenbosch and as a result the Stellenbosch team made decisions that we did not always agree with. We had no option but to proceed with them
Integrity	X	Well due to conflicting world views and strong ones at that there is a question about integrity. I think organisation has integrity but it sometimes gets lost on project work with large teams. The integrity of the BIOSSAM project is questionable
Issue orientation	~	Not necessarily in the BIOSSAM project
Inquiry / experimentation	√	Experimentation in the BIOSSAM situation was mainly by case study.
Accountability		Because the experimentation part of the BIOSSAM was via case studies that requires stakeholder engagement for input, I believe that we as a project team had huge accountability to them. However, I felt that once we got what we wanted we just left them with a half finished job on their behalf. We are more worried about accountability to the RAP than to stakeholders that ultimately we are supposed to be helping
Team work	~	Team work, what team work? The organisation tries to instil team work that is multi disciplinary but scientists battle with team work unless the team all have similar world views and points of engagement. Team work on the BIOSSAM project was extremely difficult as everyone was focused a case study that did not necessarily work for their work package and as a result caused conflict and limited team work.
Open to risk	x	Very open to risk especially as a result of case studies and conflict in project team
Other organisational culture traits?		
Perception of organisational structure, and how the BIOSSAM project was experienced:		
Hierarchy-free communication	X	No. I think my points above have covered this
Joint planning, including	X	Joint planning would really have benefited the BIOSSAM

Guiding aspect	Positive experience √ | ~ | ×	Comments
questions and goals		project.
Good management mediation	X	Split management and change in management did not do much good for the BIOSSAM project
Equality of members / stakeholders	~	No really comment here
Other organisational structure characteristics?		

Other comments/reflections on the BIOSSAM project as a transdisciplinary R&D effort:
Trying to merge to separate project with separate goals and objectives does not work unless there is good amicable management between the two projects and all the team members are on board.

Researcher 2:

Guiding aspect	Positive experience √ | ~ | ×	Comments
R&D team member's own values, and how the BIOSSAM project was experienced:		
Acceptance and expectance of power distribution	~	A number of changes in the project management / directorship role through the course of the project caused corresponding changes in the way the project and process were managed. Some management approaches / styles were easier to work within than others and the level of disruption caused towards the end of the project were substantive – specifically having administrative and technical project management roles fulfilled by two different people. So expectations sometimes were in conflict. It was easier to accept the power distribution in the early stages of the project – the power distribution was made clear and I got a sense of competent leadership.
Focus on own priorities or that of the larger system	~	It became necessary to focus on the priorities of the Work Package I was working within due to the growing lack of cohesion (after Year 1) between the different Work Packages and ultimately the collective meaning of the overall project. There was significant and growing confusion and lack of clarity and common purpose in the project team about what BIOSSAM was intended to deliver as time progressed. Most Work Package teams eventually focused on their own priorities. From my own perspective – despite strenuous attempts to intervene, it was extremely difficult to influence the process to encourage some cohesion and common purpose, despite the logical necessity for doing so. I eventually felt compelled to focus on my own priorities (i.e. delivering on the Work Package I was responsible

Guiding aspect	Positive experience √ | ~ | ×	Comments
		for) in isolation of the broader project goals.
Tolerance for uncertainty and ambiguity	x	Although the technical project manager (in the latter stages of the project) evidently felt that he was steering a coordinated and commonly agreed process, in reality there was huge uncertainty and confusion amongst the project team members of how everything (the different work packages) should fit together and the ultimate outputs. The uncertainty grew towards the latter stages of the project (rather than the opposite which should have been the case). I found the uncertainty within the project management context (not the content of the research) very difficult to work within, and the lack of receptiveness to intervention (on the part of the technical project manager) highly irritating, frustrating and counterproductive to producing a useful and meaningful outcome.
Time orientation: short-, medium- or long term	~	Medium term – *not sure what this item is asking for?*
Activity orientation: 'doing' or 'being' orientation	x	In the project as a whole there was very much a doing orientation – not enough time and attention to reflection of ultimate purpose of the tasks (i.e. the being orientation). My own approach was to try and reach a more balanced focus on doing and being (being = decisions around purpose and meaning).
Attitude towards human nature	x	I think human nature played less of a role than individuals retreating into the terrain of their own disciplines and being defensive about their domain / boundaries. Perhaps human nature in terms of retreating into familiar / safe territory? My experience was that there was a growing tendency towards this behaviour and the defensiveness about territory and "being right" increased towards the end of the project (specifically during the IAP2Energy case study process) which was the only real interactive work by the whole team. My feelings about this behaviour was that it was counterproductive to achieving the goals of the project.
Conflict or harmonious seeking	x	The level of conflict was high during the case study process and reached serious proportions towards the end of the project, where some team members refused to communicate with each other. My experience was that this was directly attributable to a lack of common

Guiding aspect	Positive experience √ | ~ | ×	Comments
		purpose and defensiveness about disciplinary territoriality and a sense that some team members had of holding the "ultimate truth". My colleagues and I in the Work Package we were responsible for, made strenuous attempts to find harmony by encouraging big picture thinking but were unsuccessful in doing so.
Other values of importance to you?	√	Mutual respect, humility, suspending of judgement of other team members, integrity and accountability (to external stakeholders)
Perception of internal organisational culture, and how the BIOSSAM project was experienced:		
Transparency	x	Very little communication – almost no collaborative working within the team. There were members of the team working in different Work Packages who never met or communicated with each other over the entire project duration despite this supposedly being a collaborative effort to produce a coordinated outcome.
Integrity	x	No commitment to finding common ground and common purpose – competitive rather than collaborative
Issue orientation		Maybe – but not steered very explicitly in this project
Inquiry / experimentation	~	There is a general trend (intellectually) towards opening up to transdisciplinary sustainability orientated thinking – rather than remaining tightly in disciplinary silos. But the emotional commitment is developing slowly – there is still a fear of stepping fully into the transdiciplinary way of working and thinking.
Accountability	~	Too much focus on accountability (or rather responsibility) to the RAP, PG, the overall organisational expectations and no regard for accountability to external stakeholders. Specifically: stakeholders who were engaged in the IAP2Energy case study testing process were drawn into a badly designed and truncated process that raised expectations and then they were just left hanging. So the project team got what they needed (to some extent) but the stakeholders merely had information extracted from them and got nothing back.
Team work	x	Not good – no coordination, very little communication and much of what did occur was adversarial. Some team members never met nor even communicated.
Open to risk	x	Risk averse
Other organisational culture traits?	x	Insufficient attention paid to reorientation / regrouping / refocusing when project managers were changed. Not enough attention to the team becoming familiar with

Guiding aspect	Positive experience √ | ~ | ×	Comments
		each other and ways of working up front (assumptions) and not enough joint planning / finding common ground and purpose. Very few face to face working sessions or even meetings to discuss process, progress, problems, etc.
Perception of organisational structure, and how the BIOSSAM project was experienced:		
Hierarchy-free communication	**x**	Definitely not hierarchy free. Quite authoritarian and sometimes quite adversarial and blunt. Particularly administrative project management was experienced in this way, but also at times technical project management. Not conducive to working together in a spirit of cooperation and joint accountability.
Joint planning, including questions and goals	~	There were moments in the project where joint planning and attempts to find common ground did occur, but these were few and far between. Only at the very beginning was an overall concept provided, but as the project progressed there were no further refocusing / re-planning sessions. A lot of assumption that everyone on the team should "know" what they had to do, and where they fitted in to the process and overall goals.
Good management mediation	**x**	Experienced very badly. Split management of the project (administrative and technical) caused significant trauma and knock on effects on the overall team, especially towards the end of the project. Unwillingness to learn or be exposed to different ways of thinking and knowledge (risk aversion) and a lack of humility / flexibility, and defensiveness on the part of the key team members including the technical project manager, caused serious conflict and damaged working relationships. Mediation had to be called for from line management (outside the project team) although this was not forthcoming and the situation remained unresolved.
Equality of members / stakeholders	**x**	Hierarchical organisational structure for the project team. But also some members of the team evidently perceived themselves to know more than the others (i.e. hold the "ultimate truth") and so especially during the case study there was much conflict, contestation and judgement rather than collaboration on an equal footing in an environment of mutual respect.
Other organisational structure characteristics?	~	Working across lateral boundaries between the work packages was challenging. There was no sense of working within a team on equal terms.

Other comments/reflections on the BIOSSAM project as a transdisciplinary R&D effort:

The main issue I believe, is that the project was not explicitly conceptualised from the outset as a transdisciplinary research effort. If it was, then this was not clearly communicated to all team members and was therefore not internalised by everyone. It was therefore easy for the different teams working on the different work packages to retreat into their disciplinary domains (comfort zones) rather than to consciously engage with the transdisciplinary nature of the work of the project as a whole. Perhaps it would have been helpful to have a scene setting workshop at the beginning (with at least annual refreshers) where transdisciplinarity and integrative thinking and focus were emphasised as the points of departure. This would include engaging with the different worldviews / perspectives of each of the team members. Being aware of these up front rather than to discover them the hard way through conflict and contestation in the project work, would have significantly improved the productivity and outcomes of the project.

Researcher 3:

Guiding aspect	Positive experience √ | ~ | ×	Comments
R&D team member's own values, and how the BIOSSAM project was experienced:		
Acceptance and expectance of power distribution	√	
Focus on own priorities or that of the larger system	√	Larger system focus at project level (project coordinator) and with a systems view of bioenergy
Tolerance for uncertainty and ambiguity	~	Timeframes and limitations on funding men that uncertainty could not always be indulged or explored. This may have hampered innovative thinking
Time orientation: short-, medium- or long term	long	Part of ongoing research interest in sustainable bioenergy
Activity orientation: 'doing' or 'being' orientation	doing	Interacting with clients, hoping to achieve implementation and impact
Attitude towards human nature	~	Humans are out of harmony with nature and the over-exploitation of natural resources will be their demise
Conflict or harmonious seeking	harmonious	
Other values of importance to you?		Honesty and trust
Perception of internal organisational culture, and how the BIOSSAM project was experienced:		
Transparency	~	Some lack of project and team integration may have given clouded transparency.
Integrity	~	
Issue orientation	√	Some lack of clarity in an evolving, transdisciplinary project
Inquiry / experimentation	√	More workshops needed
Accountability	×	Dynamic research team and internal policy made accountability unclear
Team work	×	The transdisciplinary nature made this difficult (logistics etc)

Guiding aspect	Positive experience √ | ~ | ×	Comments
Open to risk	~	Limited time and funding with an evolving research project was sometimes a risk
Other organisational culture traits?		Time-focussed instead of product oriented research (negative consequence of the rigid time-accounting in the CSIR)
Perception of organisational structure, and how the BIOSSAM project was experienced:		
Hierarchy-free communication	√	Lack of hierarchy was sometimes to the detriment when a strong management decision needed to be taken
Joint planning, including questions and goals	~	Goal-orientated approach in terms of the project deliverables meant that there was not always opportunity to explore this important task sufficiently.
Good management mediation	×	Tansdisciplinary nature and complexity require comprehensive briefing, good management and excellent facilitation and mediation. This was not always the case
Equality of members / stakeholders	~	
Other organisational structure characteristics?		Researchers were mostly established and were specialised in their fields. This made the identification of common goals and values sometimes difficult. There was also some inherent reluctance to work in true transdiciplinary manner that shapes mutual understanding with the result that some of the research efforts were ad-hoc multi-disciplinary and therefore failed to build a common understanding.

Other comments/reflections on the BIOSSAM project as a transdisciplinary R&D effort:

The BIOSSAM project was a very exploratory project and therefore evolved through the 3 years. The research leader and team also changed during this which made for poor coherence. The large multi-disciplinary research team made cohesion difficult and researchers tended to work independently. The geographically spread nature of this large research team also mean t that organising meetings was problematic the logistics and added burden.

Researcher 4:

Guiding aspect	Positive experience √ | ~ | ×	Comments
R&D team member's own values, and how the BIOSSAM project was experienced:		
Acceptance and expectance of power distribution	√	• There was acceptance on the equality of power distribution across gender, age, education, birth, and race • Each individual in the team was expected and given opportunity to contribute to the ideas, quality, learning and success of the project. As a result, a PhD and a Masters study were among the outcomes of such an opportunity given to all

Guiding aspect	Positive experience √ | ~ | ×	Comments
		in terms of contributing to ideas and success of the project. Thus it was a positive experience on the power distribution
Focus on own priorities or that of the larger system	√	• The focus was on the larger system. Looking at the project, it was divided into three work packages in the first two years and in the third year; an additional work package was introduced. From the first year of the project, it was more of exploratory and an attempt was made to identify how the outputs of the different work packages could be linked together. However, there was limited connection / linkages between the different work packages outputs. Despite the limited connection / linkages, my own values was to provide deliverables of the allocated work package with the goal of ensuring the success of the BIOSSAM project as a whole • BIOSSAM project brought a lot of learning and acquisition of new ideas in each year of the project lifespan
Tolerance for uncertainty and ambiguity	√	• I was able to tolerate the uncertainty and ambiguity that arose from the project. From the onset, the project did actually display itself as handling an "ill-defined" problem where clarity on many issues was identified in the course of the project lifespan. There were divergent opinions and adjustments to wide situations. For instance, in year 1, there were a number of modelling approaches that were proposed for work package two. However, in year two, all the other modelling approaches were dropped and the focus was only on system dynamics. Another example is on the tolerance to the changes in human capital during its entire project lifespan • BIOSSAM portrayed itself as an open-ended learning project where the ideas and thinking was not confined in a box but rather organized in a way that it allowed thinking outside the box
Time orientation: short-, medium- or long term	√	• The orientation of the project was long-term. This is due to the understanding that the impact on the project would be way long after the formal lifespan of the project which was three years. The BIOSSAM portal is a great example to indicate that the benefits of the project were not meant to be for the three year period of the project but has a long-term focus. The other example is the experience and the learning from the project which will require putting into practice the application of holistic view in planning for sustainable development. From a transdisciplinary point of view, this is a transformation knowledge which does require a long-term focus.
Activity orientation: 'doing'	√	• The experience of BIOSSAM was "being"

Guiding aspect	Positive experience √ | ~ | ×	Comments
or 'being' orientation		orientation. It was a problem-oriented and challenging project aimed at facilitating planning for sustainable development. As a team member, I was strongly motivated to contribute to the team in order to ensure the success of the project
Attitude towards human nature	√	• It was good, which was as a result of the constant control and discipline among the team members
Conflict or harmonious seeking	√	• Harmonious seeking; achieving the BIOSSAM project was very important and valuable and an attempt was made to ensure that the project's objectives are met
Other values of importance to you?	√	• Being part of the BIOSSAM project from its onset was valuable to me and gained experience and exposure with different team members and different stakeholders ranging from local communities to the policy makers. There was a lot of learning that was gained from the project which is still alive. The challenge is now to put these lessons learnt into practice to improve planning for sustainable development
Perception of internal organisational culture, and how the BIOSSAM project was experienced:		
Transparency	√	• BIOSSAM project objectives were communicated and what was expected in each work packages of the project was also highlighted. The information on the project status was also regularly provided, that is: the project schedule and budget. This enabled the understanding of which work packages are on track or behind the track and on how the budget of the project is being spent and in which work packages. In addition, the deliverables from each of the work packages was communicated.
Integrity	√	• There was clear communication about the expectations and intentions of the BIOSSAM and opinions on the work that need to be done • There was also communication on the budget when it did not correspond to the deliverables and a discussion among the team on what action plans need to be done to correct the situation • The progress and status report of the project also kept the team informed and aware of what is on track and what needs intervention
Issue orientation	√	• Project orientation occurred in each of the financial year. This informed the team of where the project is so far, what changes need to be undertaken and the expectations for the project. For instance, in year 2, other modelling tools that were part of work package 2 were excluded and it was agreed that the focus would be with systems dynamics. Another example is in year 3 where an additional work package was added into the project.
Inquiry / experimentation	√	• The BIOSSAM project was more of an

Guiding aspect	Positive experience √ | ~ | ×	Comments
		exploratory project and as the project progressed new and interesting ideas came up. There was a tendency to accommodate the changes resulting from the new ideas but at the same time keeping the overall goal of the project in mind. • Thus, there was regular updates in each financial year to ensure that all the team are on the same page and working towards the overall project objective
Accountability	√	• At kickoff, it was stressed the need to work together as a team • The goals and its deliverables were measurable e.g. publications, models and project portal • Team members were accountable to one another to ensure that the project was a success
Team work	√	• The project consisted of teams who were organized according to the work packages. The team members were required to work closely to towards achieving the work package deliverables which in turn contributes to the overall objectives of the BIOSSAM project. • There was a designated person who was reporting on behalf of a team (Work packages) and there was also a project manager responsible for consolidating the information from all the work packages. Working as a team made this possible. • The huge experience gained mainly was working within the team allocated. There was a limited experience working across the different teams. This mainly resulted from the limited linkages on the use of the outputs from the other teams
Open to risk	~	At some situations, BIOSSAM was open to risk due to the following situations: • Loosing key human capital to the BIOSSAM project which meant that there was need to change the management of the project • Incorporation of new work package in the third year of the project which affected the budget allocation for all the other previous work packages, which affected the extent of deliverables • Different ideas and suggestions for the Case Studies for the different work packages which limited the integration of information / outputs between the work packages The risk of losing the key human capital was however contained by sub-contracting the key human capital for the entire project life-span
Other organisational culture traits?		
Perception of organisational structure, and how the BIOSSAM project was experienced:		
Hierarchy-free	√	• There was hierarchy-free communication which

Guiding aspect	Positive experience √ | ~ | ×	Comments
communication		ensured easy communication and sharing of ideas without following a structured protocol. This also ensured openness within the project
Joint planning, including questions and goals	~	• In the first and second year of project, there was a joint planning and discussion on the project. However, in the last year, the planning was mainly within the work packages rather than joint planning with other work packages. An example of an experience that did not support joint planning in the third year was where there was a mismatch of budget allocation compared to the output required by the different work packages
Good management mediation	√	There was a good management mediation concerning the following issues: • Budget allocation among the work packages • Budget overspending • Performance / deliverable issues / project status
Equality of members / stakeholders	√	• Generally, there was equality of members and stakeholders. For instance, the project was open to contributions from all team members since failure for one team is a failure for the project as a whole. It was also open to ideas and contributions from stakeholders of all levels – e.g. communities / civil society and policy-makers
Other organisational structure characteristics?		

Other comments/reflections on the BIOSSAM project as a transdisciplinary R&D effort:

While at the onset on the project it was not explicitly indicated that the project is transdisciplinary, the experience of the project and as the project progressed clearly showed that it was a transdisciplinary study. This is because it was dealing with a problem that is outside the academic domain – that is – planning for sustainable development, aimed at advising policy- and decision-makers. Planning for sustainable development is an “ill-defined” problem because no definitive formulation of sustainable development exists as yet. Planning for sustainable development will also require divergent stakeholders

The project made use of the different methodologies throughout its lifespan ranging from static models such as balance sheet and multi-criteria to dynamic approaches such as system dynamics. This is a clear indication that there was no conclusively single “best” methodology and that these methodologies actually do complement each other than being in conflict. This process that was followed in BIOSSAM can be linked to the transdisciplinary research design which moves to respective research designs (e.g. disciplinary, multi-disciplinary and interdisciplinary) in search of suitable methodologies for application. This was made possible by having people from different disciplines and fields of experience working together in the BIOSSAM project.