Natural building in South Africa: Assessing the niche-regime relationship through a 'latent niche' mediation

By

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Declaration

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Date: March 2015

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Abstract

In this thesis I examine the natural building movement in South Africa in an attempt to determine the systemic influences that appear to confine it to a small market operating at the very edge of the mainstream building sector. I make use of the conceptual framework of the multi-level perspective to explore the interrelationships between natural building as a technological niche and the mainstream building sector as the dominant regime. I extend the concept of a technological niche by appending the term '*latent*' to form the term '*latent technological niche*', to describe a technology with sustainability credentials that fails to break into the mainstream market, despite achieving technological maturity and constant though minimal market share.

The research objectives of this thesis are to: identify pathways for the natural building niche to move beyond its latent state; to determine how the translations of natural building practices to the building sector might occur; and how this might transform the building sector regime. I explore how action research involving knowledge sharing between multi-stakeholder, niche and regime actors might stimulate debate and subsequent action to overcome entry barriers; and serve as a catalyst to advance a latent technological niche beyond its confined market. I present an action research method, a '*latent technological mediation*', of facilitated 1st and 2nd order social learning. This is used as a mechanism of tapping into the immediate knowledge of actors in the socio-technical regime. The purpose being to identify the external forces and internal processes of a latent technological niche.

The status of a latent technological niche is assessed by comparing these processes in the context of external forces against seven processes, presented in this thesis. These seven processes are considered crucial for a technology to break into the mainstream market and are adapted from the internal processes of success, described in the literature on strategic niche management and the characteristics of a successful 'bounded socio-technical experiment' (BSTE) described in the conceptual work on BSTE's. The potential for natural building systems to enter the mainstream building sector, particularly in South Africa, is used as a case study to apply the latent technological mediation method.

The findings of this research suggest that the mainstream building sector is undergoing a transition following the path of socio-techical transformation. The uncertainty introduced by the parallel system of informal settlement, which may drive transition along the more dramatic technological substitution or de-alignment and re-alignment transition pathways is briefly explored.

Opsomming

In hierdie tesis ondersoek ek die natuurlike gebou beweging in Suid-Afrika in 'n poging om die sistemiese invloede te bepaal, wat neig om dit te beperk tot 'n klein mark teen die rand van die hoofstroom gebou sektor. Ek maak gebruik van die konseptuele raamwerk van die multi-vlak perspektief om die onderlinge verband tussen natuurlike geboue, as 'n tegnologiese nis, en die hoofstroom gebou sektor, as die dominante regime, te verken. Ek brei die konsep van 'n tegnologiese nis uit, deur die aanbring van die word 'latente' om die term 'latente tegnologiese nis' te vorm. 'n Latente tegnologie nis het volhoubaarheid potensiaal maar slaag nie daarin om in die hoofstroom mark in te breek nie, ten spyte van die bereiking van tegnologiese volwassenheid en 'n konstante maar minimale mark aandeel.

Die navorsing doelwitte van hierdie tesis is om: roetes te identifiseer waarlangs die natuurlike gebou nis buite sy latente toestand kan beweeg; om te bepaal hoe die 'vertalings' van natuurlike gebou praktyke aan die gebou sektor kan voorkom; en hoe dit die gebou sektor regime kan verander. Ek bestudeer hoe aksie navorsing waarby kennis tussen verskeie belanghebbendes, nis en regime betrokkenes gedeel is, kan debatteer en die daaropvolgende aksie stimuleer inskrywing hindernisse te oorkom; en dien as 'n katalisator om 'n latente tegnologiese nis te bevorder buite sy beperkte mark. Ek bied 'n aksie-navorsing metode, 'n 'latente tegnologiese bemiddeling' van gefasiliteerde 1st en 2de order sosiale leerervaring aan. Dit dien as 'n meganisme van deling in die onmiddellike kennis van die spelers in die sosio-tegniese regime. Die doel is om die eksterne kragte en interne prosesse van 'n latente tegnologiese nis te identifiseer.

Die status van 'n latente tegnologiese nis is beoordeel deur hierdie prosesse te vergelyk in die konteks van eksterne kragte teen sewe prosesse, wat in hierdie tesis aangebied is. Hierdie sewe prosesse word beskou as noodsaaklik vir 'n tegnologie om in die hoofstroom mark in te breek en is aangepas uit die interne prosesse van sukses, soos beskryf in die literatuur oor strategiese nis bestuur en die eienskappe van 'n suksesvolle 'begrensde sosio-tegniese eksperiment' (BSTE) beskryf in die konseptuele literatuur oor BSTE. Die potensiaal vir natuurlike gebou stelsels om die hoofstroom gebou sektor te betree, veral in Suid-Afrika, word gebruik as 'n gevallestudie om die latente tegnologiese bemiddeling metode toe te pas.

Die bevindinge van die navorsing dui daarop dat die hoofstroom gebou sektor 'n verandering ondergaan op die pad van n sosio-tegniese transformasie. Die onsekerheid veroorsaak deur die parallelle informele nedersetting, wat 'n meer dramatiese tegnologiese substitusie, of ontsporing en herbelyning kan veroorsaak, word kortliks ondersoek.

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List of Acronyms and Abbreviations

	Full text
BSTE	Bounded socio-technical experiment
CETA	Construction Education and Training Authority
CO_2	Carbon dioxide
CSIR	Council for Scientific and Industrial Research
DBSA	Development Bank of Southern Africa
DCAT	Development Center for Appropriate Technology
DoH	Department of Housing
DoHS	Department of Human Settlements
DTI	Department of Trade and Industry
GBCSA	Green Building Council South Africa
IBT	Innovative Building Technology
LTM	Latent technology mediation
MEC	Member of the Executive Council
MLP	Multi-level perspective
NB	Natural building
NBR	National building regulations
NHBRC	National Home Builders Registration Council
NRCS	National Regulator for Compulsory Specifications
RDP	Reconstruction and Development Programme
SABS	South African Bureau of Standards
SADC	Southern African Development Community
SANS	South African National Standards
SASFA	South African Light Steel Frame Building Association
SETA	Sector Education and Training Authority
SNA	Social network analysis
SNM	Strategic niche management
TC60	Technical Committee for Standards that address National Building Regulations
UNEP	United nations environment programme
USA	United States of America

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Chapter 1: Thesis Introduction

1 Background

The growing awareness of the unsustainable development path of current human activities has raised questions about the sustainability of all sectors within the economy. Of particular concern is the mechanisms by which they might undergo a socio-technical transition to follow a new sustainable development trajectory (Kemp, Schot & Hoogma 1998; Geels 2002; MEA 2005; Doppelt 2010; Stern 2010; Swilling & Annecke 2012). The building sector has been highlighted as a major contributor to environmental impacts due to unsustainable rates of material, energy and water consumption, the wastes it produces and the ecosystems that are degraded or destroyed through its activities. The building sector contributes a significant percentage to annual landfill waste and greenhouse gas emissions through both the construction and operating phases (UNEP 2011). The built environment and the building industry that services it, is tightly integrated with practically every other socio-technical system; urban infrastructure, agriculture, energy, water, mining and transport. It is improbable that the building sector could undergo a single socio-technical transition. It is more likely that it will be incrementally transformed over time by cumulative influence as numerous innovative technologies are adopted. These technologies might offer alternative solutions, with sustainability credentials, to existing needs and bring with them new ways to configure the building sector.

2 Rationale for the Study

The wider adoption of natural building systems incorporating ecological design in South African urban areas appears constrained despite persisting at the fringe of the building construction industry for over a decade. The aim of this research is to explore mechanisms whereby the unrealised or 'latent' potential of natural building systems as alternative, sustainable technologies can be realised. While this research focusses on natural building systems it is suggested that the same mechanisms might be applied to realise the potential of other latent sustainable technologies. The theoretical frameworks of strategic niche management (SNM) (Kemp, Schot & Hoogma 1998) and the multi-level perspective (MLP) (Geels 2002) are adopted in this research.

3 Research question

The problem of wider adoption, or lack thereof, of natural building systems contextualised within the conceptual frameworks of SNM and the MLP is encapsulated within the following research question:

(i) Can a facilitated process of social learning of natural building systems including regime-actors, niche-actors and external actors identify pathways for the natural building niche to move beyond its latent state; and
(ii) What kinds of socio-technical translations are available to the natural building niche and how might they transform the building sector regime?

To address this question this research has three objectives. Firstly to determine how 'latent' sustainability technologies are addressed within prevailing transitions theories. Secondly to determine how their conceptual frameworks might be extended to include latent technologies and thirdly, to apply the conceptual framework and mechanisms of intervention to the natural building systems as a case study. Considering that socio-technical transitions occur over a period of decades (Kemp, Schot & Hoogma 1998:82; Loorbach 2007:81) the above research question may be considered overly ambitious for a short term research project. It is useful however for an exploration study, by being both specific about its aims yet non prescriptive about the temporal or quantitative measure. It allows room for the question to be redefined through the participative process from which new questions and formulations of the original research question may be discovered. This research examines the usefulness of an experiment in shared learning to activate the latent natural building niche and co-produce strategies for socio-technical translation of its norms and practices to the building sector regime.

4 Methodology

I apply two methodologies for examining the status and possible socio-technical translations of natural building in South Africa; on the premise that it is located in what I term a '*latent technological niche*'. The two methodologies are described in the format of articles. The first, a critical literature review is discussed in Chapter 2 and describes natural building as a latent technological niche. The second, an action research experiment, is discussed in Chapter 3 and describes the mixed method approach to identify the possible socio-technical translations for natural building.

Chapter 2 (Journal 1) comprises a literature review of transition theory and natural building systems (NBS) describing them in terms of MLP as a niche and more specifically a latent technological niche. The niche-regime relationships and the influence of landscape pressures, together with the tensions in the regime are explored. This chapter explores the typology of transition pathways, suggest possible transitions pathways for the building sector, describes the idea of practice translations, and the means that NBS practises may be translated to the regime.

Chapter 3 (Journal 2) motivates for action research, documents the co-research process, describes the method of identifying organisations and participants, and discusses the far richer understanding gained through co-research. The research design of the action research experiment provides for both methodological and data triangulation. The themes identified from interview transcripts are compared to issues and strategies raised at a focus group meeting. The overall conclusions for this thesis are discussed in Chapter 4.

5 Delimitations of overall study

The selection of participants for the action research excluded social actors located outside of the province of Gauteng of South Africa due to logistical and budgetary constraints. Future research into natural building systems should include the Western Cape and Eastern Cape provinces where it is expected there are a greater number of practitioners and home owners committed to natural building.

Chapter 2: Natural Building: latent technological niche (Journal 1)

1 Introduction

Awareness of the unsustainable practices of the building construction sector has opened a market for alternative and innovative building technologies and products. Systems for constructing houses from natural materials such as soil, timber and straw have attracted the attention of environmentally conscious home builders, designers and owners. This search for alternative building systems is motivated by a desire to avoid the unsustainable rates of material, energy and water consumption; the wastes produced; and the ecosystems degraded, or destroyed through current practices in the building sector.

A dispersed community of natural building practitioners has existed at the fringe of the building construction industry in South Africa for over a decade. A number of pioneers have experimented with what may be termed '*modern natural building systems*' in South Africa for twenty years or more. These modern natural building systems include traditional forms of construction using soil, timber and straw that have been rediscovered by environmentally conscious communities or movements that emerged in Europe, the United States of America, Australia and to a lesser extent in developing countries since the 1970's.

Modern natural building systems strive to produce buildings that satisfy contemporary building performance requirements in terms of thermal comfort, durability, convenience and aesthetic appeal while utilising natural soil, timber and fibres. The natural building movement also promotes the use of recycled materials such as '*urbanite*' (demolition waste) and material from agricultural and manufacturing waste streams. While there is no clear distinction between traditional natural building methods and modern natural building systems, the latter typically involves a greater degree of engineering input in construction detailing and structural design; particularly for commercial projects. Innovation, research and development over decades has culminated in a recent surge in the publication of guideline documents, building codes and regulations, and academic research in support of modern natural building systems. An assessment of a selection of this literature is discussed in this paper.

The fringe status of natural building remains unchanged and the wider adoption of modern natural building systems in South African urban areas appears constrained, despite growing interest in natural building due to concerns around sustainability. The status of natural building within the established building sector can be readily analysed through the conceptual framework of transition theory. Transition theory proves useful for analysing natural building as a grass roots movement in South Africa with respect to the apparent barriers to wider adoption.

Scholars concerned with the unsustainable nature of existing economic, technological and social systems recognise that a transition towards a sustainable development trajectory requires the reconfiguration of these systems (Kemp, Schot & Hoogma 1998; Geels 2002). It is further realised that sustainable technologies and social practices, those that steer development along a desired trajectory for future social and ecological benefits will not necessarily be selected above unsustainable options offering immediate financial rewards (Kemp, Schot & Hoogma 1998). Three complementary theories, strategic niche management, transition management and the multi-level perspective, that have developed over the past two decades propose some form of intervention to create conditions conducive to the incubation and emergence of sustainable socio-technical systems. To understand the state of natural building and its interrelationships with the building sector, it is essential to gain an understanding of the socio-technical system within which is developing.

The aim of this research is to explore mechanisms whereby the unrealised potential of modern natural building systems as alternative, sustainable technologies can be realised. This paper explores the unrealised or latent sustainability potential of modern natural building systems as non-proprietary, grass roots, community orientated and open source socio-technological innovations. The shortened term '*natural building*' is used to improve legibility.

2 Methodology and methods

The methodology for this research comprises a critical review of literature on natural building and transition theory. With the objective of establishing what key technical and non-technical barriers constrain natural building to its niche, this literature review examines; (1) the national building regulations, (2) the current institutional regime of the South African building sector, and (3) socio-cultural issues and perceptions, that influence the acceptance and implementation of natural building.

International literature is examined where natural building has enjoyed successes in entering domestic mainstream building sectors. The status of natural building is analysed utilising the conceptual framework of transition theory. Transition theory describes technological transitions as occurring within dynamic socio-technical systems comprised of actors and influences, operating at multiple scales over time, through a process of co-evolution enabled through: innovation; knowledge diffusion; and social learning (Geels 2002; Kemp, Loorbach & Rotmans 2007; Schot & Geels 2008). Literature on transition theory, developed to understand and promote socio-technical transitions towards sustainable development trajectories, is reviewed. Potential transition pathways will be identified, according to the typologies described by Geels (2002) and further expanded together with Schot (2007), that natural building in South Africa might follow to transfer practices

(Smith 2007) to the building sector regime; to realise its sustainability potential.

3 Transition theory

The term “socio-technical” as a construct emerged from organisational management in the latter half of the twentieth century. It explicitly acknowledges that within organisations the social relationships and practices recognisable as social systems influence and are in turn influenced by the technical systems; the machines and mechanical equipment employed in the organisation to carry out it's purpose. In the seminal work on strategic niche management (SNM) the term '*socio-technical change*' is used to denote a shift in a technological regime and is loaded with the import of the social context in which a technology is embedded (Kemp, Schot & Hoogma 1998). Similarly Geels proposes that an understanding of innovation systems must consider the social realm that encompasses the social functions, the human agents and the social groups that inform their behaviours, perceptions and norms (2004). He proposes the concept of a socio-technical system where technology and society co-evolves from one system to another.

SNM, developed by Kemp, Schot and Hoogma (1998) and revisited by scholars of transition theory, proposes to create protected spaces or 'niches' within dominant socio-technical regimes. Later work focuses on steering the internal processes of sustainability technologies from within the niche (Schot & Geels 2008:538). Transition management (TM), developed and regularly revisited since the year 2000, follows a similar approach of creating an enabling environment for sustainable technologies (Rotmans, Kemp & Asselt 2001; Kemp, Loorbach & Rotmans 2007; Loorbach 2007). The TM approach differs by proposing that authorities adopt a managed process of gradual structural change to achieve sustainability by shaping short term policy to align with long term sustainability objectives (Rotmans, Kemp & Asselt 2001). Loorbach emphasises the importance of visioning process using '*transition arenas*' that should precede and guide experiments in sustainability technologies (Loorbach 2007).

Geels developed a framework, the multi-level perspective (MLP), to describe the systemic influences on a socio-technical system undergoing change, occurring at three levels: at the '*niche*' level being the '*protected space*' discussed in SNM; the '*regime*' level being the socio-technical regime; and a higher '*landscape*' level of exogenous influences (2002). The MLP provides a useful conceptual framework for understanding and describing the complex relationships and tensions between actors operating at the niche and regime levels of evolving socio-technical systems in response to pressures from the landscape level (Geels 2002; Geels & Schot 2007; Schot & Geels 2008).

However simply populating a MLP schematic with niche and regime actors, landscape pressures

and niche-regime interrelationships does not adequately describe the dynamic transformation socio-technical systems undergo during transition. A typology for socio-technical transition pathways is proposed by Geels and Schot suggesting four types of transition: transformation, reconfiguration, technological substitution, and de-alignment and re-alignment (2007). The typology of transition pathways is influenced by a combination of the alignment and timing of interactions at each level, and the characteristics of the interactions between levels. Unless there is sufficient tension created by pressure from the landscape level the regime remains stable and niche level innovations are unable to emerge. Transitions in a stable socio-technical regime simply reproduce technologies that meet the same sets of rules. The practices of radical innovations remain in the niche as the regime transition follows a *reproductive* path without transition. The four transition pathways proposed are summarised hereafter (Geels & Schot 2007).

1. Transition is said to follow a *transformation* path when a landscape factor exerts a moderate disruptive force on the regime to which it must react. At the same time there is no well developed niche level innovation to challenge the regime and introduce new practices or rules. The socio-technical regime responds to external alerts and changes from within to follow a modified path.
2. Where the landscape exerts a significant and sudden disruptive force on the regime the regime actors may fail to respond and the regime may start to collapse. Without a well developed niche innovation to step in, the window of opportunity results in an explosion of multiple niche innovations that coexist and compete. With multiple innovations leading along multiple and divergent trajectories comes uncertainty as the multiple sets of rules conflict creating a situation with no stable rule set. Only after one innovation succeeds and creates a new socio-technical regime does stability return. The authors refer to this transition path as *de-alignment and re-alignment*.
3. The third transition path, *technological substitution*, occurs where a well developed niche level innovation is ready to take the place of a socio-technical regime destabilised by a significant disruption from the landscape level.
4. Where the regime is undergoing a transformation, practices of niche innovation may be adopted to replace or solve minor problem components. Their adoption may lead to additional adoption and experimentation with more radical niche level practices. Instead of transformation the regime follows a path of *reconfiguration*.

Recent literature on SNM and the MLP recognises that despite its sustainability potential, a socio-technical niche may not replace or even significantly transform the existing regime. Rather it may succeed only in transferring some of its lessons, norms, rules and practices. This is acknowledged by scholars of transition theory (Geels & Schot 2007; Smith 2007; Schot & Geels 2008) which explore the niche-regime relationships and the partial adoption by the regime of rules and practices from the niche. Smith describes this transfer as socio-technical '*translations'* between niches and regimes and identifies three kinds of translations that have direct bearing on this study (Smith 2007).

Scholars attempting to understand and describe the circumstances or mechanisms that enable the emergence of sustainability technologies have suggested practitioners in successful innovative technologies will have mastered three key internal processes: well articulated *shared expectations*; well developed *broad and deep social networks*; and multi-dimensional *1st and 2nd order learning processes* (Kemp, Schot & Hoogma 1998:186; Schot & Geels 2008:540–541). Research has also focussed on understanding long term systemic factors such the interplay between internal expectations and external developments on technical trajectories (Geels & Raven 2006). Another direction of research attempts to understand and thereby improve the internal niche processes by exploring so called '*bounded socio-technical experiments*' (BSTE) (Brown, Vergragt, Green, *et al.* 2003). Social network analysis (SNA) has been applied to propose a means to decipher the structure and functioning of social networks (Caniëls & Romijn 2008).

Scholars of transition theory appear to share a common objective, that is to steer technological development along a sustainability trajectory. They propose that the environmental conditions supporting technological innovation should be modulated to enable sustainability technologies to succeed. Technologies whose rules and practices are informed by long term objectives that may not be valued above the short term economic offerings of competing technologies. While these scholars implicitly and in some instances explicitly advocate for direct involvement by researchers to steer technological development through action research, there appears to be limited literature demonstrating that this has occurred.

Literature on BSTE, where the authors have documented technological experiments, suggests they have participated in the processes of knowledge diffusion and social learning (Vergragt & Brown 2004; Brown & Vergragt 2008). However the purpose of their research was to document the characteristics of knowledge diffusion and social learning and not the research method of enabling or steering these processes. Their research method stopped short of action research.

Nonetheless the BSTE concept offers a useful framework for interpreting a particular new or innovative technology. It borrows from the conceptual framework of socio-technical systems and the implied understanding of the transitions dynamics that play out between regimes and niches from the literature on SNM and MLP (Brown, Vergragt, Green, *et al.* 2003). It draws on the discourse of innovation, particularly social learning and knowledge diffusion as a means to apply this thinking to individual case studies. These studies involve specific technologies and rely on immediate access to the actors involved in the evolution of the technology. BSTE is proposed as a framework appropriate to examine the evolution and diffusion of innovative technologies at a lower level than the niche, at a scale the authors term '*socio-technical experiments*' (Vergragt & Brown 2004; Brown & Vergragt 2008).

A BSTE case study or experiment has certain characteristics that enable it's boundaries to be described. It comprises of a loose and diverse coalition of actors including users, businesses, technical experts, educational institutions and government. Where at least some of the actors are cognisant that their technological innovations are experimental; involving hands on trial and error tests, and experimentation with new strategies and technologies to constantly improve. This bounding of a new technology allows for an assessment of the social learning that takes place, the behaviour of the actors and the diffusion of ideas from the 'experiment' to other technological projects. This focus on a 'bounded experiment' and on the process of social learning and diffusion of ideas, distinguishes the BSTE approach from that of SNM. Where SNM focusses rather on policies to create “protected spaces” or niches that contain and possibly isolate a particular technology from other technologies that may benefit from the learning (Brown, Vergragt, Green, *et al.* 2003).

The authors Brown, Vergragt, Green, *et al.* stress the importance of the core actors striving for a vision of long term sustainability and the expectation that once successfully embedded in society it will reconfigure the particular technology or service. And further that this new socio-technical configuration will diffuse into other socio-technical systems. They offer four criteria to measure or assess the success of a BSTE (2003) that complement the SNM internal process of successful niches:

1. Diffusion of the experiment results to produce a commercial success,
2. Attracting interest of new participants and resources,
3. Branching out and seeding new experiments, and
4. Occurrence of higher order learning within and beyond the experimental group.

An analysis of the state of natural building within the socio-technical regime of the building sector and the possible transition pathways available to it, is discussed in Chapter 2 Section 5 utilising the conceptual frameworks from transition theory discussed above. Abstract contextualising of natural building, or any technology niche, within transition theory informed by literature alone does not provide the detail necessary to guide the future actions of niche and regime actors. A method for undertaking action research is outlined in section 6 to capture and interpret the rich data that accumulates through the dynamic interactions of social actors in response to landscape pressures and the tensions between them. It is proposed that this rich and current data will aid in identifying the factors that contribute to the latent state of the natural building niche and the strategies necessary to translate radical niche practices and rule sets to the building sector regime.

4 Modern natural building systems

There appears to be little or no academic literature documenting primary research on the extent of natural building in South Africa. The limited literature that is available has either an anthropological

perspective (Perry 2012) or critiques by Zami and Lee of government policy on low cost housing for the urban and rural poor (Zami 2010, 2011; Zami & Lee 2010, 2011). Popular literature on contemporary natural buildings in South Africa, reflected in magazines, websites and 'blogs' on the Internet, suggests the existence of a number of natural building practitioners, and numerous natural buildings having been built in South Africa. Natural buildings have been built using innovative adaptations and relearned skills in earth building methods such as cob, rammed earth, adobe, compressed earth blocks, earthbags and straw bale.

4.1. Review of natural and conventional building systems

There is a greater awareness and urgency for all societal activities to adopt sustainable practices. The global and local economies and the business sectors operating within them will experience pressures to change. The building sector; which is considered to be one of the largest users of non-renewable, and natural resources as well as a major contributor to ecosystem degradation, CO_2 emissions, and waste to landfill; will experience the same pressures to transform. These pressures will be exerted through the interaction of institutional policy changes, consumer choices and increasing costs of scarce resources.

Evidence of this pressure and transformation of practices, is the emergence of green building councils and their rating systems (GBCSA 2008), and a large variety of alternative building systems for walls (Agrément South Africa 2003, 2011; NHBRC 2009, 2013), roofs, lighting, water management and integrated building systems. Most if not all introduce new technologies or hybrids of building methodologies enchained to the industrial manufacturing assumption that there exists a technological fix for all problems. Most perpetuate the systemic flaws of the industrial manufacturing model developed with the assumption of limitless resources and infinite sources of cheap energy. In most instances raw materials are sourced from the 'market' at the cheapest price, processed at one or more locations in factories and then transported over any distance that is financially acceptable and delivered to the site where the house is assembled out of these disparate components. This '*green technology*' approach represents one, admittedly popular, response to the increasing environmental pressures.

An alternative response is the emergence of *natural building movements* in the 1970's that is gaining greater exposure in current mainstream media. Chiras observes in his introduction to his book on natural building that " *... a new generation of builders is emerging to challenge the 20th-century notions of shelter*" (2000). This alternative generation of builders, but also designers and home owners, continually ask how to build homes that are appealing, comfortable and spiritually enriching; with little or no lasting impact on the environment. This generation is a collection of grass roots communities, many having formed movements, in their respective natural buildings systems

that satisfy a very different set of values and approaches in response to the unsustainable practices and the apparent disconnect between society and natural systems.

The green technology movement is embedded in, and its practices are dictated by the rule set centred on the profit motivation of the market economy. In contrast the rule set that guides the practices of the natural building movement places as much or greater importance on non-financial values; quality of life, social well-being, minimum environmental impacts, and equity for all: people, earth's species, and generations.

Natural building relies on empirical knowledge of the materials and methods of construction, knowledge that is specific to the characteristics of the local materials (Evans, Smith, Smiley, *et al.* 2002). Construction methods and techniques have evolved through constant learning and experimentation to master the particular attributes and qualities of locally available materials. This empirical knowledge can be shared, learnt and taught and over time perfected (Chiras 2000; Evans, Smith, Smiley, *et al.* 2002; Easton & Wright 2007; Hall, Lindsay & Krayenhoff 2012). However unless codified into a standard this knowledge is not readily available or even accepted within the regime of national building regulations, building standards, and scientifically quantifiable and measurable tests.

A recent development influencing alternative building systems is the confirmation by the South African government through a cabinet decision in August 2013 and announced by the Council for Scientific and Industrial Research (CSIR) early in 2014 that 60% of the three year budget for new social infrastructure must use 'innovative building technologies' (IBTs) (Burger 2014). This decision effectively creates a 'small market niche' (Kemp, Schot & Hoogma 1998) in terms of financial resources ring fenced for IBT's. By definition natural building systems are non-conventional and may qualify as IBT's. However they would first have to receive Agrément certification or be recognised through a national standard. Ironically government has created a 'protected space' for innovative and alternative building technologies, however the cost of performance testing according to the specified process is only viable for propitiatory systems. Natural building systems are largely non-propitiatory and therefore do not generate rents for individual businesses to invest in performance testing; to capture market share through certification.

There is an important distinction to be made between green technological innovation, as a business venture to capture market share for profit; and grass roots innovation, that is not motivated by rents instead actively shares knowledge. The former may be expressed as the practices of a market economy versus those of a social economy (Seyfang & Smith 2007). Natural building not only presents radical technological innovation, it also challenges the prevailing assumption that surplus funds must be generated through rents derived from proprietary

technologies. This is a disadvantage where institutions in the socio-technical regime are configured around the assumption that a portion of the applicants' future rents can be levied to fund the organisations such as certification bodies that strive to stabilise the current socio-technical regime.

Natural building systems are also at odds with the economically driven demands of productivity and efficiency and associated financial cost; all measured in terms of production time with the implicit understanding that “time is money”. Natural building advocates enjoy a more sophisticated understanding of the value of time. While the relationship between time and financial cost is appreciated, so is the value of activity one is engaged in over time. The time invested in transforming freely available materials into a home, is measured against the cost of earning a salary and the burden of repaying a large bond over decades; to cover the cost of a house constructed by others (Evans, Smith, Smiley, *et al.* 2002:40–44). Natural builders are wary of the cost of using industrially produced components; assembled by a chain of outside suppliers all following the mantra of maximising profit at the expense of the home owner.

The institutional regimes within the building sector effectively discourage non-standardised, non-industrial building materials and systems. This is due to the enforcement of building standards premised on the assumption that all buildings are constructed of masonry, or timber (Hammitt, Belsky, Levy, *et al.* 1999; Eisenberg, Done & Ishida 2002; Morel & Pkla 2002; Henderson 2006; Niroumand, Zain & Jamil 2013).

The natural building approach promotes the use of locally sourced natural materials. It is generally accepted that earth built houses enjoy reduced embodied energy in the materials used, and avoid the transport cost and energy to deliver materials to site (Ley & Widgery 1997; Fewins 2006; Cristelo, Glendinning, Miranda, *et al.* 2012). As a result natural building has attracted interest as a more sustainable alternative to the highly regulated conventional approach to building.

5 Building sector from the multi-level perspective

The practices and innovative technologies of the natural building practitioners as niche-actors and the challenges they face to achieve wider adoption in the building sector regime are readily described using the framework of the multi-level perspective. Sustainability, a catch-all term for ecological degradation and increasing resource scarcity, acts as an exogenous factor exerting pressure from the landscape level. This is driving innovation in search of resource efficient and low environmental impact technologies at the niche level while creating tension at the regime level. This tension increases as the unsustainable practices of the modern building sector become increasingly apparent.

Concerns with sustainability create a window of opportunity that is aligned with the practices and

rule set of the natural building movement. Despite this the practices of the natural building movement remain incompatible with practices and rule sets of the established building sector. The institutional systems stabilising the building sector are reinforced through satisfying not just technical performance but expectations of low risk, certainty in financial investments and a range of social needs: safety; comfort; convenience; privacy; and aesthetic appeal. The relationships between the radical technologies of natural building with respect to the actors and their stabilising institutions is reflected in Figure 2.1.

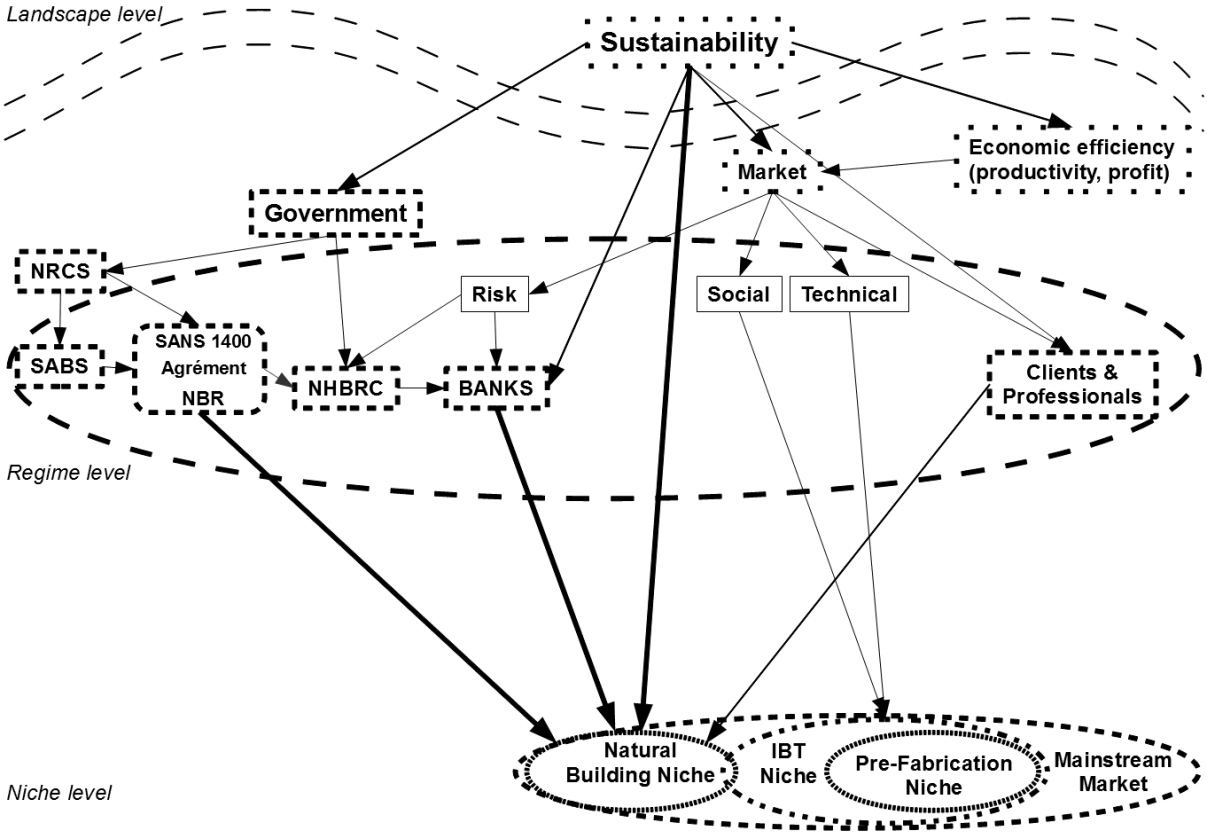

Figure 2.1 MLP interpretation of the building sector interrelationships

5.1. Natural building a latent niche

A niche for modern earth buildings is created by a loose network of natural building practitioners often living in earth buildings they have built on farms, in small rural towns or in enclaves for environmentally conscious communities. They exist in areas where building regulations are not strictly enforced or are out of sight of building control officers. Government “protection” is a result of omission, turning a blind eye, rather than supportive policies. Where natural buildings are constructed within urban areas or at the periphery they are undertaken for middle-class families or businesses with the financial means to cover the additional cost to achieve compliance.

A second niche is provided by the rural poor that continue to construct their homes using earth or soil according to traditional customs, using wattle and daub or compressed earth blocks primarily in the former Transkei areas of what is now the Eastern Cape and in KwaZulu Natal. The socio-economic circumstances and actors of these two niches are very different and support different earth building practices with very different expectations. This research focusses on the former niche, modern natural buildings.

5.2. Institutional actors

Actors in the building sector regime and in natural building include individual clients, property developers, property portfolio managers, and the built environment professionals. Collectively they form a self referencing decision-making system that favours the familiar to avoid the risk associated with uncertainty. Contractors, including both construction project managers and specialised subcontractors, will carry out the work as specified by their clients and the professional team. This group of clients and professionals influence the type of building systems used in a project and will respond quite rapidly to market demands. It is presumed that as home buyers and property investors become more sensitised to the environmental issues, the demand for properties with low construction and operational impacts on the environmental will increase. Clients and their professional teams, depending on their appetite for the innovative solutions, may readily adopt alternative building systems including natural building. However their options to adopt natural building systems are determined by larger regulatory and financial institutions.

The institutional bodies that have a dominant influence on the building sector are: the Department of Trade and Industry (DTI), which has the mandate to administer the National Building Regulations and Building Standards Act No. 103 of 1977 (as amended) (DTI 2011); the CSIR Boutek, that researches and assists government in preparing policy for the built environment; Agrément South Africa; and the NHBRC. With the majority of houses being purchased through mortgages the banking sector together with the insurance sector play a deciding role in the adoption of natural building systems. Other actors, although crucial to the debate on natural buildings, have less influence on the adoption of natural building systems.

5.3. Barriers to non-conventional building systems

The radical practices of innovative and alternative technology niches are often incompatible and may contrast strongly with the stabilising processes of the established socio-technical regime (Geels 2002, 2004, 2005, 2010; Smith, Voß & Grin 2010) of the building sector. This incompatibility and inability of the socio-technical regime to readily adopt the radical practices of the niche may be perceived as entry barriers by niche actors. An analysis of the literature on natural building

identifies a number of re-occurring themes of niche-regime incompatibilities that present barriers to the mainstream adoption of natural building systems. They can be grouped into four broad categories: (1) social acceptance; (2) technical or engineering performance criteria for habitable buildings; (3) legislation, regulations and by-laws; and (4) financial, in terms of funding and risk management. These incompatibilities are discussed hereafter according to the four category themes.

5.3.1. *Social acceptance*

The academic literature on natural buildings typically addresses the issue of social acceptance in the introduction statement or threaded throughout the text, while focussing on institutional and technical matters (Evans, Smith, Smiley, *et al.* 2002; Fewins 2006; Easton & Wright 2007; Hadjri, Osmani, Baiche, *et al.* 2007; Rosie 2010; Zami & Lee 2011; Hall, Lindsay & Krayenhoff 2012; Thuysbaert 2012; Yarrow 2012). Books dedicated to one or more natural building systems highlight the issues that affect social acceptability and seek to convince readers that these concerns can and have been addressed through correct material selection and detailing (Evans, Smith, Smiley, *et al.* 2002; Easton & Wright 2007; Hall, Lindsay & Krayenhoff 2012).

Issues of social acceptance can further be divided by experiential, perception, and performance related issues. Experiential issues include the stigma of living in a mud building; that is dirty, ugly, gloomy, cold, and damp. Advocates of natural building argue that these concerns are unfounded and that properly designed, constructed, and maintained buildings offer the opposite experience of being warm, cosy, inviting, aesthetically pleasing, and having a positive influence on the mood of the occupants (Evans, Smith, Smiley, *et al.* 2002; Easton & Wright 2007).

Social acceptance is also influenced by negative perceptions of the durability, structural stability, safety, thermal comfort, and higher maintenance requirements of natural building systems. These are discussed in the next section. The Development Center for Appropriate Technology (DCAT) after failing to find formal studies, undertook a survey to better understand the influence of technical and non-technical barriers related to building codes. They invited responses from code officials and people seeking approval of green building projects. The DCAT analysis of the responses suggested that non-technical factors are equally likely to influence approval as technical factors (Eisenberg, Done & Ishida 2002).

5.3.2. *Technical building performance*

Building regulations and consumer protection legislation (DoH 1998; DTI 2011), the national building standards SANS 10400, and supporting standards specify the performance of standards, for building envelopes, building systems and building components and materials in terms of their

durability, structural stability, fire safety, thermal comfort, moisture ingress, compressive strength, and health risks due to mould or rotting of fibres.

The performance of natural buildings is currently measured in terms of criteria and tests developed for masonry and timber buildings which are often inappropriate to the construction methods of natural building systems. There has been an increase in quantitative research on the performance of earth or soil based building systems. Most of this is directed towards masonry-like building systems such as rammed earth, adobe and to a lesser extent straw bale construction. Research on rammed earth and earth stabilisers appears to dominate the field (Gravina da Rocha, Consoli & Rosa Johann n.d.; Hall & Djerbib 2004; Lam, Liu & Yan 2005; Burroughs 2008, 2009; Maniatidis & Walker 2008; Bui, Morel, Venkatarama Reddy, *et al.* 2009; Venkatarama Reddy & Prasanna Kumar 2010; Bui, Hans, Morel, *et al.* 2011; Reddy & Kumar 2011; Cristelo, Glendinning, Miranda, *et al.* 2012; Bui, Bui, Limam, *et al.* 2014; Bui, Morel, Hans, *et al.* 2014).

Research literature on straw bale construction is less prolific (Hecht 2009; Adedeji 2011; Ashour, Georg & Wu 2011; Hartman 2011) while research on adobe blocks and the related compressed earth blocks, either stabilised or stabilised, is also quite extensive (Bolton & Burroughs 2001; Morel & Pkla 2002; Reman 2004; Vilane 2010; Williams, Goodhew, Griffiths, *et al.* 2010; Aubert, Fabbri, Morel, *et al.* 2013; Ipinge 2013). What can be summarised from the literature both from popular sources and peer reviewed journals is that a better understanding of soil as a construction material is necessary, whether derived through empirical or scientific testing methods. Also important is the understanding of appropriate soil mixes and detailing, to conform to performance expectations; both social and building regulations.

As more owners in urban areas consider building their homes according to natural building principles they are confronted by the need to comply with building regulations and standards that do not cater for natural building methods. Invariably they follow one of two routes. The first option is to compromise either; by “industrialising” the construction materials and methods, such as adding Portland cement to earth materials; or accept increased costs to provide satisfactory evidence and professional endorsement to satisfy building control officials. The second option is to circumvent the legislation either building illegal structures or by treating the natural build as an extension to an existing brick and mortar building. The extension requires building inspector approval but does not require NHBRC approval.

5.3.3. *Financial*

Building regulations impose another indirect barrier to natural building. Risk averse lending and insurance institutions are hesitant to fund or insure residential projects that do not comply with the building regulations and cannot provide bonds without NHBRC approvals. The legal obligations of

lending institutions in South Africa in terms of Section 18 "*Obligations of mortgagees, conveyancers and MEC*" of the "*Housing Consumers Protection Measures Act 95 OF 1998 (as amended)*" are clearly stated (DoH 1998):

> "*No financial institution shall lend money to a housing consumer against the security of a mortgage bond registered in respect of a home, with a view to enabling the housing consumer to purchase the home from a home builder, unless that institution is satisfied that the home builder is registered in terms of this Act and that the home is or shall be enrolled with the Council [NHBRC] and that the prescribed fees have been or shall be paid*".

Wishing to limit their risk banks require owners to acquire home owners insurance. Insurers in turn wishing to reduce their risk require home owners to provide the NHBRC warranty. The NHBRC in turn requires that residential buildings be constructed by home builders registered with the NHBRC. Home builders must adhere to the national building code to avoid claims against the five year NHBRC warranty. This measure, intended to protect consumers in the low cost and affordable housing bracket, has a ripple effect throughout the major institutions involved in the building sector.

Home owners interested in natural buildings either have to self-fund or find innovative ways to access loans to fund the construction of their homes. Should they later decide to sell their homes, the requirements of lending institutions limit the number of potential buyers.

5.3.4. *Legislative barriers*

The national building regulations (NBR) of South Africa require that all buildings above a certain minimum area and all buildings that are to be occupied must be approved by the building control department of the local municipal authority. The NBR specifies that authorisation must be signed by a competent building inspector and sets out the criteria for of competence. A building can comply with the NBR via three routes; (1) following the 'deemed-to-satisfy' route, (2) rational design by a competent person, and (3) by complying with Agrément SA certified building systems and components.

It is impractical for a natural building design to follow the 'deemed-to-satisfy' route since the relevant standard, SANS 10400, presumes, in Part K (KK3.2), that all buildings are constructed of masonry or timber. The third route using an Agrément SA certified system or component is limited to the selection of building systems. Agrément SA certified systems utilising soil are limited to stabilised compressed earth blocks, bitumen emulsion stabilised earth blocks and earthbag buildings. Home owners wanting a rammed earth, cob, adobe, or straw bale house have the option of following the rational design route. This route increases the cost of natural building as each building has the added expense of a bespoke, detailed structural design prepared by an engineer;

who must be adequately rewarded for taking full professional responsibility for an “experimental” design and the associated risk should it fail.

This conflict between the industrial building approach and the natural building principles is being played out in most countries that adopted scientifically based building regulations and standards (Niroumand, Zain & Jamil 2013). Practitioners of natural building systems have acknowledged that in order to promote wider adoption of natural buildings within the current institutional regime, compliance with building regulations is necessary. This is evidenced by the establishment of natural building organisations that advocate for natural building codes and standards. There have been a few success stories; official standards for earth building have been developed in New Zealand, Zimbabwe, and New Mexico USA. Jiménez Delgado and Guerrero list a growing body of national and academic reference documents and guidelines for earth building (2007:238). South Africa has no approved standard for earth building, with the exception of the Agrément SA certificates mentioned above.

5.3.5. *Summation*

A window of opportunity is created by concerns around sustainability together with other social issues not explored in this paper. Currently these pressures are moderate, though growing in intensity, and have resulted in internal modifications within the building sector. The concept of 'innovative building technologies' has been formalised and its transformation potential is being tested through dedicated government spending on social facility buildings. The current transition in the building sector regime is best described as following the *transformation path* (Geels & Schot 2007) that is being determined from within the regime.

True to South Africa's predilection with parallel systems, besides the formal NBR compliant building sector lies the informal housing system where legislative compliance is essentially irrelevant. The informal housing situation, considered a social problem, has persisted despite significant efforts and financial investment by government over the past two decades. This parallel system resembles what Geels and Schot term a transition path of *de-alignment and re-alignment* (Geels & Schot 2007). Where the landscape pressures are so significant that the regime collapses, spawning a multitude of innovative niche technologies following divergent trajectories. While the building sector regime remains apparently unaffected by the existence of a growing informal housing sector, the informal sector may reached a critical mass and exert a pressure on the regime that would require the regime to adjust or face being overwhelmed.

The challenge for the multitude of innovative building technologies including by definition natural building systems, is that the practices of the formal building sector are determined by a strongly entrenched stabilising system that is codified in national legislation. While routes for innovation are

provided, through rational design or use of Agrément SA certified systems, these routes introduce a cost threshold that limits wider adoption of particularly grass roots innovations. The natural building movement will remain a latent technological niche until; at least its technical practices, the natural building materials and methods, are incorporated into the NBR.

The natural building movement is presented with an alternate, though more unpredictable and less desirable transition path. One where the formal building sector regime is eventually overwhelmed by the growing parallel informal sector, leading to a transition following paths of either *de-alignment and re-alignment* or *technological substitution*. The probability of this route is linked to the future trends in the informal housing sector, interwoven with other social issues that have gained an impetus similar to external landscape pressures; such as the housing backlog, growing resource demand from an increasing urbanising population, high levels of income inequality, unemployment, and poverty. The adoption of natural building along these alternate transition paths cannot be guaranteed since the social needs, after a collapse of the regime, may not necessarily favour the norms, values and practices of the natural building movement.

6 Capturing rich social and technical data of the niche-regime dynamic

The dynamic interactions of social actors in response to landscape pressures accumulate a rich set of data that is remembered and refreshed through the relationships, practices, norms, rules, and codes of social actors within the natural building movement and the organisations that collectively reinforces the *status quo* within the building sector. A researcher wishing to access this constantly evolving data, with the aim of modulating technological innovation along a particular trajectory, might apply the methods of action research.

The objectives of this research project; firstly, strive to explore the source of the barriers experienced by natural building that delegate it to a status of latency; and secondly, identify mechanisms to realise the potential of modern natural building systems as alternative, sustainable technologies. Applying the methods of action research may enable transition research to have a proactive influence on modulating technological development along a sustainability trajectory. That action research is particularly suited to this project is clear from a definition provided by Bradbury Huang in an article titled "*What is good action research?: Why the resurgent interest?*" (Bradbury-Huang 2010):

> "*Action research is an orientation to knowledge creation that arises in a context of practice and requires researchers to work with practitioners. Unlike conventional social science, its purpose is not primarily or solely to understand social arrangements, but also to effect desired change as a path to generating knowledge and empowering stakeholders*".

I propose an action research approach to explore the interactions of social actors within and acting on a latent technological niche, with the additional potential of stimulating the development of the latent niche. This approach is termed a '*latent technology mediation*' (LTM). The proposed LTM adopts the multi-level and multiple dimensional approach of the MLP; utilises the internal niche process of success from SNM as *process criteria* to analyse the status of a latent niche; adopts the characteristics of a BSTE to bound the research scope and augment the SNM process criteria; employs SNA to identify social dynamics within social network of the niche; and incorporates Smith's (2007) concept of socio-technical translation of practices.

The methodology for an LTM must satisfy the criteria of both action research and a BSTE. A latent technology, striving for a sustainable development trajectory, that has the potential to benefit from a LTM would exhibit the four key characteristics of a BSTE. Firstly it must occur within a recognisable niche, preferably a small market niche, where competition and user expectations for sustainability have driven the innovation process. The authors Hegger *et al* stress the importance of striving for sustainability (2007:733):

> "*The value of social experiments lies in the fact that they are initiated by actors who are not part of the establishment. These experiments often constitute a social niche: the people involved are intrinsically motivated citizens with a more than average degree of environmental commitment; because of this, they use different criteria to judge a new technology and future profitability might be less important for them than it is for a market actor. These initiatives often do not focus on the implementation of a certain technology, but are mostly based on a broader vision of what sustainable development entails*".

Secondly, there must be evidence that the actors have identified entry barriers, have attempted to overcome them, and the lessons learnt must be readily accessible. Thirdly, it must be possible to map the actors within the coalition including the network of relationships between them. Finally, there must be a reasonable expectation of involving actors located outside the coalition who have influence within the private and public institutions perceived to be responsible for the entry barriers (Hegger, Van Vliet & Van Vliet 2007:734).

A suitable candidate for employing LTM would exhibit a recognisable coalition of diverse niche-regime actors; where some are cognisant of the experimental nature of their technological innovations in advancing sustainability. It is important that the coalition, or a viable subset, can be bounded to assess: the social learning that takes place, the behaviour of the actors, and the diffusion of ideas from the 'experiment' to other technological projects. The bounding of the coalition and experiment is dictated by the capability of the researcher(s) to engage with the number of actors within the coalition.

6.1. Maintaining the integrity of LTM as an action research project

To maintain the credibility of 'research' as a process the LTM methodology must address six key issues (Wittmayer, Schäpke, Feiner, *et al.* 2013:6–10).

1. ***Self-reflection of the researcher*** - to make explicit one's own assumptions, biases and choices.
2. ***Ethics*** – through co-ownership of the process and results and formulation of an ethical code that address issues of anonymity and confidentiality.
3. ***Researcher's role*** – roles of the researcher, process facilitator and participants should be clarified and agreed with participants upfront as should any necessary changes to these roles.
4. ***Creating an open and communicative space*** – the researcher must establish legitimacy and work to ensure participants are able to express diverse views, gain mutual understanding and alignment of agendas.
5. ***Managing the communicative space*** – the researcher must be aware of and consciously balance contrasting aims of the process: defined purpose versus openness to change, format of participation, leadership versus ownership of the process, open-ended structure versus chaos, and a focus on practical solutions versus power relations.
6. ***Managing power dynamics*** – the researcher must be cognisant of the power relations within the group and the larger political context, allow all voices to be expressed equally, and be ready to be a power relationship manager.

6.2. Proposed stages of the LTM

The objectives of the mediation of latent technological niche such as the natural building movement are to:

1. Identify the location of the niche with respect to the socio-technical regime(s) it challenges;
2. Identify the external source and characteristics of landscape pressures that gave rise to the niche innovations;
3. Describe the radical practices (norms, values, rule sets, and innovations of the niche);
4. Asses how the niche practices complement or contrast with those of the dominant regime;
5. Assess the internal process against the SNM process criteria to identify deficiencies:

   (i). Extent of shared expectations among social actors,

   (ii). Depth of the niche to regime social network including external actors, and

   (iii). Degree of both 1st and 2nd order social learning; and
6. Identify preferred transition paths and methods of translating niche practices to the socio-technical regime, encapsulated in short and long term strategic actions.

It is proposed that LTM objectives can be achieved by undertaking the following four research stages:

1. Comprehensive and critical literature review of the latent technological niche and the socio-technical regimes it challenges;
2. Interviewing social actors within, and external actors associated to, the niche and regime;
3. Facilitated focus group sessions; and
4. Participant survey.

6.2.1. *Stage 1: Literature review*

Undertaking a critical review of pertinent research on the niche technology, including relevant industry documentation and reports. The aim is to assess the characteristics of the latent technology and probable entry barriers it faces. The results of the literature review will aid in identifying the key participants, within and outside of the latent niche, that should be approached and invited to participate. It will identify potential issues to be raised with participants.

6.2.2. *Stage 2: Interviewing social actors within and associated to the niche and regime*

This stage involves interviewing participants to establish a baseline of their worldview on sustainability and the latent technology. Participants should be encouraged to discuss concerns and issues within the latent technology that may not have emerged from the literature review. Insights from the interviews are expected to highlight: unforeseen external pressures, expectations and practices, apparent entry barriers, and the extent of development of niche processes. The interview responses are expected to provide insights on the typology of the transition pathways the socio-technical regime may be following.

These interviews should take the form of unstructured conversational interviews (Roulston 2008) guided by key topics and possible scenarios emerging from the literature review, that are most likely to encourage a broad range of responses from the interviewees. The interviews should ideally be captured by audio recordings with the express consent of the interviewees.

The audio recordings should be transcribed in preparation for thematic analysis to identify key issues, concerns, relationships, perceived entry barriers, unrealised innovations and possible mechanisms to overcome entry barriers. These should be compared to the results of the literature review as a first step in verifying the relevance and importance of both methodologies. The key themes identified should be presented to the participants of subsequent facilitated focus group sessions. These key themes should ideally include both areas of convergence and areas of divergence in thinking among the interviewees.

6.2.3. *Stage 3: Facilitated focus group sessions*

The next stage of the LTM involves one or more facilitated focus group sessions, attended by the

selected actors previously interviewed. These actors would ideally include as diverse a selection of actors within the coalition as can be achieved, and as many actors as can be accommodated from the private and public institutions influencing the emergence of the latent technology. The researcher(s) should participate as co-researchers with the same privileges as the other participants. A process facilitator with the ability to maintain a distance from the issues should be engaged, ideally someone that is familiar with the technology.

The focus group format, objectives, and processes would be dictated by: the research context, the expertise and communication skills of the participants, the power relationships between participants, and a range of dynamics that cannot be anticipated let alone prescribed here. However the democratic, structured yet flexible and open format of the Open Technology Space (Owen n.d.; Thakadipuram & Stevenson 2013) approach is ideally suited to separating the personalities and agendas of participants, from the potentially contentious issues. The focus group sessions should attempt to generate both qualitative and quantitative content; working in breakaway groups, alternating between both convergent and divergent objectives and perspectives. Contributions to the group should ideally be cumulative rather than attempting to achieve consensus. Contradictory views, objectives and strategies should be encouraged.

6.2.4. *Stage 4: Participant survey*

All participants should be invited to complete a survey form, a short period after the participation stages have been completed. The purpose is to gather quantitative data of participants shared learning experiences, whether of the first or second order, and the extent of their participation in passive or active knowledge diffusion subsequent to the participation stages of the research.

The results of the four data collection processes: literature review, participant interviews, focus group meeting proceedings, and survey offer the opportunity to triangulate the findings. This proposed research design provides for both data triangulation and methodological triangulation using qualitative and quantitative findings from four sources (Lisa A. Guion 2011).

7 Conclusion

This paper examines the movement in modern natural building systems with the aim of exploring and formulating mechanisms to activate and release the, as yet unrealised potential for sustainability, of this latent technological niche. Natural building is more readily associated with grass roots innovation, being community orientated, non-propitiatory and predisposed to sharing knowledge akin to the principles of open source technologies. These characteristics of grass roots innovations contrast with the sustainability technological niches located in the market economy, typically assessed by transition theory (Seyfang & Smith 2007). This non-conformist approach

limits the surplus profits from royalty based rents, relied on by proprietary systems, to overcome the cost thresholds of certification. These relatively high thresholds are determined by institutions configured on the assumption that a portion of applicants' future rents can be levied.

The status of natural building with respect to the established building sector, as a socio-technical regime, is analysed utilising the MLP conceptual framework and the typologies of socio-technical transition pathways (Geels & Schot 2007). The findings of this analysis suggest that the building sector is following a path of transformation. The building sector has responded through internal modification to accommodate 'innovative building technologies' with their potential currently being tested through dedicated government spending on social facility buildings.

While compliance routes for natural building are available, through rational design or use of Agrément SA certified systems, these routes introduce a cost threshold that limits wider adoption. It is suggested that the natural building movement will remain a latent technological niche until its technical practices are incorporated into the NBR as standards or Agrément SA certificates.

The incomplete socio-economic transformation of South Africa leaves it with numerous parallel systems one of which is the informal housing sector that shadows the legislation compliant formal building sector. The informal housing system for which legislative compliance is irrelevant resembles what Geels and Schot term a transition path of *de-alignment and re-alignment* (Geels & Schot 2007). The size and influence of the informal sector is closely linked with the ability of the government to address larger social problems such as the housing backlog, income inequality, poverty and unemployment; all of which persist despite great investment of financial, administrative and political resources.

The uncertain future of the informal housing sector presents an alternate though more unpredictable and less desirable transition path. One where the formal building sector regime is eventually overwhelmed by the growing informal sector; leading to a transition following paths of either *de-alignment and re-alignment* or *technological substitution*. How this scenario benefits the natural building movement is uncertain, since the social needs of the informal sector, after a collapse of the regime, may not necessarily favour the norms, values and practices of the natural building movement.

Since abstract contextualising of natural building informed by transition theory and available literature on natural building does not provide the necessary detail to guide the actions of social actors, a method for action research is proposed. It is proposed that this action research approach, termed a latent technology mediation, will extract rich and current data on the factors that contribute to the latent state of the natural building niche. It is expected that the participation of actors from the niche, regime, and external institutions will generate strategies to translate natural

building practices to the building sector. Undertaking further research into natural building by applying the LTM approach is expected to provide rich and current, qualitative and quantitative, data; with the added benefit of allowing research to exert a proactive influence on modulating technological development along a sustainability trajectory.

Chapter 3: Latent technology mediation: A case study of modern natural building systems (Journal 2)

1 Introduction

The suite of '*modern natural building systems*' is examined as a case study for the application of action research to activate the potential of this latent technology. Interest in modern natural building systems has waxed and waned over the last half century, typically increasing in times of energy crisis or economic recessions. Despite sustained interest and a steady flow of new sponsors, with increased levels of interest in the last ten years, natural building systems have only managed to emerge from their niches in a few countries. In South Africa they remain confined to two distinct niches; traditional earth buildings in rural areas, and '*modern earth buildings*' primarily in enclaves of environmentally conscious communities. The latter niche has thus far remained in an indefinite gestation stage, at the fringes of the prevailing building sector socio-technical regime. This latent development may be due to internal niche level factors, temporal misalignment with landscape changes and regime tensions, or being locked-out by the regime.

The stalled processes that have prevented these '*latent technologies*' from entering the wider market may be resolved through the intervention of researchers. Where sustainability technologies exist, but have not yet succeeded in entering the mainstream market, their potential may be awakened through a process of action research informed by the extensive literature on transition processes and niche development. This paper explores the predicament of innovative technologies that despite persisting for decades within '*small market niches*' (Kemp, Schot & Hoogma 1998; Geels & Raven 2006) fail to achieve the critical mass or build effective social networks to break into the mainstream. A proposed action research approach is undertaken as an experiment with the potential to activate the sustainability potential of these '*latent technological niches*' to in turn contribute to the incremental transformation of unsustainable socio-technical systems.

1.1. Theoretical context

Transition theories (TT) provide more than a useful narrative framework for the successful emergence of regime changing sustainable technologies. Through successive case study analyses of successes and failures, TT scholars have identified characteristic processes and attributes of regime-niche interactions that offer lessons for intervention in, or modulation of, latent sustainability technologies (Rotmans, Kemp & Asselt 2001; Geels & Raven 2006; Geels 2007; Hegger, Van Vliet & Van Vliet 2007; Smith 2007; Markard & Truffer 2008; Loorbach 2010; van Bree, Verbong & Kramer 2010; Kern 2012; Whitmarsh 2012). The authors Schot and Geels, expanding on previous work by SNM scholars, suggest that a successful sustainability technology is one that can undergo

the transformation from '*technological niche*', then to a '*market niche*' and finally emergence into the mainstream market. They propose three development processes that the practitioners of a sustainability technology must master to achieve this emergent state: well articulated *shared expectations,* well developed *broad and deep social networks,* and multi-dimensional *1st and 2nd order learning processes* (Kemp, Schot & Hoogma 1998:186; Schot & Geels 2008:540–541). Developing these three process requires a level of collaboration among practitioners together with a collective capacity and willingness to actively engage with regime actors, influential outside parties and potential market adopters. These conceptual frameworks offer little specific or non-theoretical guidance for an emerging community of sustainable technology practitioners. A bridge is required between academic theory of transitions and the real world struggles of practitioners.

Scholars of both transition management (TM) and strategic niche management (SNM) suggest that researchers become more involved, through action research, in steering technological innovation towards sustainable development (Kemp, Schot & Hoogma 1998; Brown, Vergragt, Green, *et al.* 2003; Loorbach 2007; Brown & Vergragt 2008). Intervention in technological innovation introduces dilemmas for the researcher in terms of distorting political, ethical, and power dynamics; particularly where new policies are introduced that provide protected spaces for selected market niches. Questions arise as to which technology is favoured and consequently what type of sustainable development trajectory is established (Schot & Geels 2008:548). However researchers might follow a less contentious route by acting as enablers or advisers to communities of practitioners in an innovative sustainability technology.

1.2. Research question and purpose

The South African building sector is a mature socio-technical system with well established institutions that effectively stabilise the system. The building sector is currently experiencing external pressure to transform its unsustainable practices. In response: green building rating systems have been developed; new energy efficiency standards have been published together with regulations enforcing compliance; and government has determined that 60% of the budget for new social facility projects must be spent on innovative building technologies (IBTs). The building sector has modified its regulations to accommodate these new practices. The practices, norms, values, rule sets and expectations of the natural building movement are closely aligned with sustainability. Despite this apparent window of opportunity natural building practices have not been adopted by the building sector. Modern natural building systems remain at the very edge of the formal building sector as a 'latent technological niche', with their sustainability potential unrealised.

Theories of socio-technical transitions attempt to understand and describe the dynamic processes and transition typologies of radically innovative technologies for sustainability. Transition theories

(TT) such as SNM and the MLP offer useful conceptual frameworks to analyse the building sector as a complex and dynamic socio-technical system whose unsustainable practices are challenged by those of the natural building niche. The literature on TT provides insufficient research methods for delving into and analysing the everyday relationships and processes of technological niches. Particularly those that determine the probability of their successful emergence into the mainstream, and the adoption of their practices by the regime.

The question being addressed in this research project is: whether a facilitated process of social learning including regime-actors, niche-actors and external actors, could identify pathways for the natural building niche to move beyond its latent state. Following on from this, what kinds of socio-technical translation are available to the natural building niche and how might they transform the building sector regime?

This article examines the usefulness of an experiment in shared learning to activate the latent natural building niche and co-produce strategies for socio-technical translation of its norms to the building sector regime. An assessment of the literature suggests natural building systems in South Africa have remained latent due to internal processes, temporal misalignment and regulatory lock-out. The experiment will have demonstrated a level of success if the niche and regime actors highlight these three areas of deficiency and co-produce strategies or actions to overcome them.

2 Methodology and methods

This paper discusses the action research approach undertaken to access the constantly evolving data being generated through the niche-regime interactions of the natural building movement and the building sector. Also discussed is the effect of action research to stimulate a latent technological niche to develop its internal processes; with the aim of transferring its sustainability practices to the regime. The study involved a participatory process and an experiment in shared learning. This study is conducted in the spirit of transition management (TM) of assessing and conducting experiments to achieve both knowledge acquisition about socio-technical transitions and to influence social change (Rotmans, Kemp & Asselt 2001; Loorbach 2007).

This experiment being initiated as a research project borrows elements from action research methods. The research design incorporates both data triangulation and methodological triangulation using qualitative findings from three sources (Lisa A. Guion 2011): a literature review; interviews with sixteen participants; a facilitated focus group, comprised of fourteen participants including niche and regime actors; and a survey completed by the participants.

2.1. Triangulation

Data triangulation (Lisa A. Guion 2011) was achieved by including twenty participants with a diverse range of backgrounds. Participants with experience in the building sector were selected using the snowball sampling method (Morgan 2008) while ensuring that the following expert experience criteria were reflected; natural building systems (design and construction), national building regulations (policy advice and enforcement), institutional (knowledge and funding institutions), property development, and building performance (structural risk and standards). Eight of the participants have practical experience with design and construction using one or more natural building methods. Between them the participants have current and long term working experience at senior management level with the following institutions or organisations: the City of Tshwane Building Control and the Environmental Regulatory Services, the National Home Builders Registration Council (NHBRC), the Council for Scientific and Industrial Research (CSIR) Boutek, Agrément South Africa, the Development Bank of Southern Africa (DBSA), one of the top four private banks in South Africa and the National Regulator for Compulsory Specifications (NRCS).

Method triangulation (Lisa A. Guion 2011) was achieved by utilising a mixed method approach including qualitative data sourced from a literature review, semi-structured interviews, a focus group and quantitative data sourced from a survey completed by the participants. Themes and perceptions of barriers to natural building systems were collated through a literature review of international journal articles, topic specific books and text books. These were compared with a thematic coding of the transcribed audio recordings of interviews and research notes and further with the notes and findings of the focus group.

All participants were invited to complete a survey form distributed a short period after the focus group took place, to assess whether participants had experienced shared learning of the first or second order (Grin & Graaf 1996; Vergragt & Brown 2004; Brown & Vergragt 2008; Loorbach 2010; Bos, Brown & Farrelly 2013), and if they had subsequently engaged in passive or active knowledge diffusion (Vergragt & Brown 2004).

The natural building movement is interpreted in terms of the multi-level and multi-dimensional approach of the MLP. The internal niche processes proposed by SNM as being characteristic of technological niches that have successfully entered mainstream market are adopted as criteria to analyse the status of natural building as a latent niche. The characteristics of a BSTE are used to inform the bounding of the research scope. Smit's conceptual language of socio-technical translation of practices (2007) informs the description of the niche-regime interrelations of the natural building niche. The SNM internal niche processes of success augmented by characteristics of a BSTE, have been expanded to seven internal processes. These seven processes are used to

assess the natural building movement as a latent technological niche.

3 Data capturing

Research data was captured from four sources; a critical literature review, interviews, focus group session, and a participant survey.

3.1. Literature review

An extensive literature review was undertaken that included a review of technical and regulation related articles, topic specific books and textbooks on the most familiar types of natural building. Themes were identified that addressed characteristics that influence both social acceptability and overall engineering performance. Over fifty journal articles and books were reviewed to discern construction techniques, practices, principles and values associated with rammed earth, adobe brick, cob and straw bale building systems. The following key themes are relevant in South Africa and in developed countries experiencing a revived interest in natural building: (1) social acceptance; (2) technical engineering performance criteria for habitable buildings; (3) legislation, regulations, codes and by-laws; and (4) financial implications, in terms of funding and risk management.

The literature review revealed issues and barriers facing natural building systems. While social perceptions create issues around acceptability of natural building systems, those issues which translate into *immediate barriers* can be described in terms of the relationships between practitioners of natural building systems and regulatory and institutional authorities. Typically the perception of barriers is due to a contrast or misalignment between the practices and rules of the natural building approach and those established by the legislative, academic and professional institutions of the building sector. As discussed in this article transition theory attempts to describe and understand the relationships between radical technological systems and the dominant socio-technical regime; such as natural building that challenges the mainstream building sector.

The outcome of the literature review of transition theories is a set of process criteria adapted from SNM (Kemp, Schot & Hoogma 1998:186; Schot & Geels 2008:540–541) and BSTE (Brown, Vergragt, Green, *et al.* 2003) that are used to assess the status of the natural building movement, as a latent technological niche, and assess the success of the action research experiment. The internal processes that a successful technological niche must master include:

1. Well articulated shared expectations;
2. Well developed broad and deep social networks;
3. Attraction of new participants and resources;

4. Multi-dimensional 1st and 2nd order learning processes;
5. Occurrence of higher order learning within and beyond the experimental group;
6. Diffusion of the experiment results to produce a commercial success; and
7. Branching out and seeding new experiments.

3.2. Participant interviews

This section describes the interview process and discusses the purpose, participant selection, the interview format, and data capture. The purpose of participant interviews was to increase the range of identified natural building issues beyond those documented in publicly accessible formats and to counter researcher subjectivity. The data captured though the interviews is used for later triangulation in the data analysis. More importantly the interviews are considered an essential phase of the social learning process.

The process of participant selection was guided by the purpose of the research, which is focussed on an experiment on the niche-regime relationship in natural building systems. This determines the criteria of suitable candidates to recruit as participants. General representation was not the objective. Rather candidate identification was guided by the need for participants with knowledge and experience in the building sector related to the particular location of the experiment. Three broad areas of experience were sought: building regulation; natural building systems; and influence on building sector practices by external institutions (primarily finance, insurance and property development).

The number of active participants had to be controlled with the expectation that no more than twenty could participate due to the limited time for interviews, transcribing and analysis of interviews, and facilitating a focus group meeting within the time frame of the research project.

The original intention was to limit the experiment boundary to the Gauteng province in South Africa more specifically the City of Tshwane metropolitan municipality. This proved impractical for two reasons. Firstly, there are too few natural building practitioners active in Gauteng. Secondly, most of the institutional or regime-actors, while located within the City of Tshwane, act at a national level. As a result the experiment gained more of a national scope.

The literature review suggests that the immediate barriers experienced by practitioners of natural building systems can be explored in the relationships between them and the regulatory and institutional authorities. The success of the experiment required that participants have a depth of experience in one or both; natural building systems and regulation of building performance.

Transition theory is useful for describing the relationships between practitioners and regulators, in

terms of regime-actors and niche-actors. In addition the theories of SNM (Kemp, Schot & Hoogma 1998; Schot & Geels 2008), TM (Loorbach 2010) and BSTE (Brown, Vergragt, Green, *et al.* 2003; Vergragt & Brown 2004; Brown & Vergragt 2008) emphasise the value of introducing external actors that can provide support or potentially create a 'protected space' for innovative technologies.

The selection of candidates to participate in the experiment deliberately used non-probability sampling (Saumure & Given 2008) through purposive (Palys 2008) and snowball sampling (Morgan 2008), in other words the candidates although selected for their particular expertise and experience of working within key institutions and organisations, do not represent either those organisations nor any semblance of a peer group or discipline.

The initial process of candidate identification relied on extensive searchers on the Internet for practitioners, regulatory bodies and influencing institutions. This produced a very small pool of candidates of especially practitioners operating within or close to Gauteng. Those identified were invited to participate by email and, where contact numbers were available, by telephone. Further selection relied on snowball sampling where previously selected candidates were asked to suggest other candidates operating within the study area. Eventually there were no new referrals that fit the selection criteria; with all suitable referrals pointing back to previously identified candidates.

Many new referrals lead to practitioners in either the Western Cape or Eastern Cape, suggesting there may be larger pools of practitioners in these provinces than in the Gauteng province. However the logistical constraints and cost precluded inviting them. One exception was made to include a candidate from Cape Town whose name continued to be recommended and who has been actively involved in attempting to resolve issues and barriers for natural building.

Identifying candidates with regulatory experience offered even less flexibility but also made use of referrals to serve both as introductions and confirmation of the relevance of potential candidates. Regulatory bodies were contacted with requests to speak to persons involved in building regulations, particularly those with experience in natural building systems or innovative building technologies. Invariably the two approaches converged on the same few suitable candidates.

The selection of institutional candidates was more subjective and relied on referrals from the existing candidate pool based on their previous involvement in industry related forums. The selection process was also constrained in terms of the researcher's access to larger institutions particularly financial and insurance institutions.

Interviews were semi structured and guided by a list of topics and scenarios drawn from the themes and sub themes identified through the literature review. Respondents were allowed a large degree of leeway in their responses, and discussions often followed topics raised by the

respondents in an open structured format. Audio recordings were made of interviews after respondents gave their consent. Hand written notes were captured by the researcher in the form of keywords and bullet lists.

The audio recordings of the interviews were transcribed by the researcher and an outsourced supplier. Key themes and sub themes were identified from the transcribed interviews and research notes using the thematic analysis method. Sub themes are grouped under the key themes which serve as theme categories. The themes were filtered early on and off topic themes were not analysed at a deeper level, as the purpose of the interviews was to capture the worldviews on sustainability of respondents, and to identify key issues associated with natural building systems that influence its incorporation in the mainstream building sector.

The theme categories and sub themes identified from the thematic analysis are discussed under Section 5 on data analysis. The theme categories are listed in Table 1

Table 1: Theme categories identified through the thematic analysis of interview transcripts

Interview Theme Categories		
Acceptability	Drivers of change	Market niche
Appropriate regulations	Housing provision	NBR* Compliance
Appropriate technology	Ideas influencing transition	Network development
Barriers to market	Influencers	Overcoming barriers
Business case	Innovation processes	Transition to sustainability
Dilemmas	Knowledge diffusion	Value chains

** NBR stands for national building regulations*

3.3. Focus group meeting

The participants interviewed in the first phase were invited to attend a focus group meeting. Twelve of the sixteen who were interviewed confirmed they could attend, two cancelled due to other commitments the day before the meeting took place. The core participants recommended other candidates to join the focus group. Those that met the research criteria were invited and four additional participants brought the number of focus group participants to fourteen.

The preliminary themes identified from a cursory review of the interview transcriptions were presented by the researcher at the focus group meeting, to provide the focus group participants a similar level of awareness of the broad natural building issues.

One of the participants with experience in workshop facilitation was requested to facilitate the focus group while the researcher took on the role of scribe and observer. The focus group meeting comprised of four “brainstorming” sessions followed by feedback to the main group. Feedback to

the group was captured in the form of a bullet list by the researcher on a flip chart visible to the entire group.

For the first session of approximately half an hour the main group divided into pairs who were instructed to take turns listening to and taking notes while their partner described what natural building means to them. This session concluded with each participant having an uninterrupted opportunity to report on the issues or topics their partner raised. The partner feedback is summarised in AppTable 1 to AppTable 4 in Appendix B. A second round of feedback was invited where participants could raise new issues or perspectives from their own point of view, summarised in AppTable 5 to AppTable 8 in Appendix C.

The purpose of the exercise was two fold; firstly, to capture new issues or views on natural building from all participants in an open and inviting format. Secondly, to familiarise the participants with the 'workshop rules'. These rules; explicitly avoided debate during feedback to the main group, ensured feedback is reported on a turn by turn basis without interruption, considered all ideas equally valid, and did not require consensus.

The second session required the main group to divide into three breakaway groups. The participants joined groups according to their closest association with one of three categories; natural building practitioners, regulators or institutional backgrounds. The institutional group was the default group for those participants not closely associated with either the practitioners or the regulators.

The task of each group was to review the issues raised in the previous session and identify the top ten issues from their group's perspective. This formed three rankings of all issues raised allowing the focus group to concentrate on those considered most important by all participants. The duration of the session was also approximately half an hour. The session concluded with a representative from each of the groups reporting their ranked list of issues back to the main group. These were captured on the flip chart by the researcher in three adjacent columns. A summarised list of the issue ranking for the three groups is included in Appendix D with a side by side summary provided in Error: Reference source not found while AppTable 9 to AppTable 11 provide the issue ranking per group with an explanation of the bullet notes. Issues raised during the first and second session are summarised according to thirteen key themes in Table 2.

Table 2: Key natural building themes raised in focus group session

Key natural building themes	Sub themes
1. Efficient production and standardisation	• Develop methods to modularise natural building systems. • Noted shift in building construction from traditional to industrial technologies. • Noted counter shift back towards traditional technologies. • Speed of construction is an important issue.
2. Establish standards and / or Agrément certificates	• Standards for natural building must be adopted. • Standards and norms must be created, that satisfy minimum requirements of the NBR; there are none to simply adopt. • Develop suitable methods for testing natural building systems. • Bonds for natural buildings dependent on standards. • Without standards its difficult to practice, constrains the industry. • Legislation is there to protect the public. • Institutions like control, natural building cannot be controlled without standards. • Standards required so skills and expertise gained through training are recognised by CETA. • Lack of norms and standards result in poor perceptions of natural building. • Need a better fit than current aim for 1st world standards, one that fits the needs and requirements of the majority living the 2nd world reality.
3. Prove the technical performance	• Perception of financial institutions & local authorities is that natural building is unproven. • Examples of durability of modern natural buildings required. • Establish demonstration projects for people to enjoy tangible experience. • Research required to improve and develop the durability and structural integrity of unstabilised Earth Building. • Determine life span of natural buildings. • Determine maintenance requirements. • Match building technology to site conditions: soil and climate. • Acknowledge diversity of technologies of SA cultures; wattle & daub; to sun dried bricks. • Technical knowledge gap between traditional earth builders and brick & mortar professionals; produce inappropriate solutions and poorly constructed buildings. • Failures in especially traditional earth buildings attributed to professionals who have recommended modern, cement based solutions. • Is there sufficient knowledge to construct multi storey buildings using natural building technologies?
4. Establish sources of funding & external resources	• Funding of research to demonstrate and improve knowledge of system performance. • There is no funding to advance natural building systems. • Funding is required for research and development to develop the standards and unlock other barriers. • Government support required for research & development, knowledge dissemination, and promotion of natural building.
5. Non-technical values and practices	• Practitioners need to be rewarded for knowledge sharing. • Cannot afford to provide endless free advice. • Paradigm shift is necessary in established beliefs and standards. • Practice of natural building closely associated with cultural

Key natural building themes	Sub themes
	background. • Skills of both communities and professionals influence how natural building is implemented. • Often community effort is closely associated with natural building. • Suitable for rural communities to employ locals skills and labour to build local facilities. • Projects owned by communities can harness cheap or under-utilised labour within communities and convert this into social assets. • Natural building through community creates a fertile space for social development. • Community needs and expectations can be supported and developed with access to modern best practice, to unlock this potential. • Community built projects offer a process to transfer skills and provide training in earth and conventional building. • Transition is required to ensure sustainable methods for a post carbon economy. • Clash of technologies, materials and aspirations for different material characteristics between conventional and natural building. • Social issues are not second to technical issues.
6. Real and perceived institutional barriers	• Resistance from authorities, municipalities, to approve natural buildings. • General resistance to the new and unfamiliar practices. • Constrained by economic barriers due to vested economic interest, e.g. cement industry.
7. Market expectations and demand	• Is there a demand? • Demand for natural buildings, larger than the take up, limited to clients with cash on hand not requiring a bond. • False perception that natural building is cheaper. • Limited familiarity with natural building complicates meeting clients expectations for different natural building systems. • Natural building can be a mix / hybrid of conventional and natural technologies. • Perceptions due to an absence in the public domain of established best practice and knowledge. • Address social acceptance and awareness to increase demand.
8. Managing risk	• Number of variables that result in a high level of risk, environmental, social, and financial risks. • Alleviate risk through construction guidelines and instructions. • Establish and place standards and guidelines in the public domain to reduce risks through familiarity. • Social, economic, and environmental doubts; only a perception. • Source of environmental impacts due to uncontrolled soil excavations. • Downstream impacts and benefits of natural building (technologies, environmental and social) must be determined. • Working directly with the community avoids distracting political issues.
9. Knowledge dissemination and available experts	• Share knowledge particularly among professionals. • Large number of people have received training. • Few with expertise to design and build without external supervision or advice. • Education of the general public and relevant institutional, professional, and government decision makers necessary to change perceptions. • Critical skills lacking at community level and within built environment professions.

Key natural building themes	Sub themes
	• Availability of guidelines on how to construct natural buildings.
10. Key drivers of change	• Financial cost a key driver, cheaper solutions are preferred over environmental benefits. • Project objectives determine budget allocation which affects choices on natural building projects.
11. Organisational structure and actions	• Availability of a register or list of skilled natural building practitioners. • An institute or association of natural building practitioners is required. • Must change expectations to fit reality of established systems. • Why no positions on natural building from the built environment institutions? • Clear strategy for natural building is missing. • Strategy must addresses the realities of the construction sector and the country's priorities. • Driven by a collective of independent thought (no unity).
12. Value chain	• Add external costs and benefits to the equation. • Value proposition must be demonstrated using cost benefit analysis or life-cycle assessment. • No clear picture of how it fits into a value chain. • Natural building systems must change to fit the world reality of a conventional building industry with an established delivery chain.
13. Dilemmas	• Lack of funds; to develop standards and unblock barriers which constrain natural building adoption and limit funding. • Access to finance will require broader promotion and proven social acceptance of natural building.

The third session aimed to develop strategic actions. Participants were requested to offer recommendations in the form of actions or strategies that would address the previously ranked issues. Participants offered their recommendations on a turn by turn basis without debate or negotiation. Recommendations were captured chronologically in the order contributed by the participants. These actions and strategies are summarised in Appendix E in AppTable 13. A summary of the recommend strategic actions is provide in Table 3.

To wrap up the focus group meeting, the participants were requested to indicate whether they felt their perception of natural building had changed after having participated in the focus group sessions. Six of the participants felt their perception of natural building had not changed. Of these four are actively involved in and committed to natural building. The fifth participant is from a building standards background and added that there is hope for natural building. The remaining eight participants felt their perceptions had changed. They included statements that the focus group sessions had provided more confidence in, provided a better understanding of, or provided a clear direction for natural building.

Table 3: Focus group recommend strategic actions

Key Actors	Actions
Establish a Natural Building industry association or interest group	• This group must secure funding and develop acceptable standards for natural building systems. • These standards must incorporate all performance criteria required by professional engineering team not just structural. • Prioritise lobbying government structures for support, financial and access to government institutions. • Identify and prepare a register of demonstration projections. • Specifically include in organisational mandate and scope, projects of all scales from single to multi building developments. • Determine where natural building adds value, then target government and institutional projects and programmes where those “values” are integral to their success. Such as greening of the economy, green procurement and the National Development Plan. • Organisation must focus on understanding the governance and development processes for national standards and norms. • Understand the established process and follow correct procedures to introduce a new works item through the TC60. • Make use of existing networks to learn how the processes and procedures work. • Develop a public relations and marketing strategy that address the question – “Why natural building systems?”. • Develop an advocacy and education programme that targets professionals, communities, and government. • Develop a clearly defined value chain within the natural building industry, integrated with existing values chains in the conventional building industry. • Raise broad awareness and credibility by providing free training, using funds available from the SETA's. • Grow partnerships and arrange for completed natural buildings to be opened as demonstration projects for awareness raising visits. • Learn how other organisations in the building sector, such as the Green Building council and the Construction Industry Development Board, managed to get funding. • Learn from the experiences of the South African Light Steel Frame Building Association (SASFA) that developed SANS 517. They dealt with accreditation of members, monitoring to ensure consistent quality, developed a manual. • Actively identify areas of risk or perceived risk and develop strategies to reduce risks. • Present a clear value chain proposition for natural building in the South African context.
New technical committee established, TC60 is the overarching body for the national building regulations.	• An introductory meeting with TC60 can be arranged. • Propose / motivate for a natural building work team for SABS with natural building seat.

3.3.1. *Summation*

The focus group session generated in a very short time over eighty unique issues relevant to the status of natural building in South Africa. These can readily be grouped according to thirteen key themes:

1. Efficient production and standardisation;
2. Establish standards and / or Agrément SA certificates;
3. Prove the technical performance;
4. Establish sources of funding and external resources;
5. Non-technical values and practices;
6. Real and perceived institutional barriers;
7. Market expectations and demand;
8. Managing risk;
9. Knowledge dissemination and available experts;
10. Key drivers of change;
11. Organisational structure and actions;
12. Value chain; and
13. Dilemmas.

When it came to developing recommendations for strategic action, the group identified two key actors: the recently established technical committee the TC60 (overarching body for the national building regulations); and the natural building organisation (to be established). By far the majority of actions, seventeen of the total of nineteen, where assigned to the still to be established natural building organisation.

3.4. Survey

Approximately two weeks after the date of the focus group meeting, a survey form was circulated to all participants including those that had participated in only the interviews or only the focus group meeting. Ninety percent (18 respondents) submitted their responses. The responses show good to strong support in favour of natural building systems. The responses also indicate that shared learning of the first order took place with further indication that technological knowledge diffusion is occurring.

The survey was divided into four parts. Part 1 established the participants strongest area of association with either natural building practitioner, building compliance regulator or institutions. This part assesses the participants level of confidence in natural building for construction of

houses.

Part 2 and Part 3 assess the respondents experience of the interviews and focus group meeting in terms of the effectiveness of the events at raising issues, and in the case of the focus group, increasing social learning and addressing internal niche processes. Part 4 aims to assess the extent of knowledge sharing beyond the natural building niche, to external social networks. The results for each part are discussed hereafter.

3.4.1. *Part 1*

The respondents overwhelmingly supported the wider adoption of natural building. Over ninety percent believed natural building can be functionally and socially satisfactory. Slightly less than ninety percentage believe natural buildings should be readily accessible. A lower percentage of respondents yet still above eighty percent support wider adoption of natural building. Table 4 provides percentage scores for each question based on a total of eighteen respondents.

Table 4: Percentage score for Part 1 survey questions

Survey questions	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	NA
Natural building systems can satisfy the functional and social attributes required of a building.	0%	6%	0%	33%	61%	0%
People should be able to acquire a natural building as easily as one of brick and mortar.	0%	0%	11%	33%	56%	0%
You believe more buildings should be constructed using natural building systems	0%	6%	11%	39%	44%	0%

3.4.2. *Part 2*

Part 2 is targeted at respondents that where interviewed prior to the focus group meeting. Fourteen of the eighteen survey respondents participated in the interview stage of the research project. One hundred percentage felt comfortable raising issues during the interview, ninety three percent agreed the interview format enabled them to raise the issues they consider important, while two thirds felt the topics raised provided them with a broader perspective of natural building. One third were neutral, of these 4 of the 5 respondents are actively engaged in natural building and may only be expressing their already extensive perspective on natural building. Table 5 provides percentage scores for each question based on a total of fourteen respondents that were interviewed.

Table 5: Percentage score for Part 2 survey questions

Survey questions	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	NA
You felt comfortable raising issues.	0%	0%	0%	21%	79%	0%
The interview format enabled you to raise the natural building issues you consider important.	0%	0%	7%	14%	79%	0%
The topics discussed gave you a broader perspective on natural building systems.	0%	0%	36%	36%	29%	0%

3.4.3. *Part 3*

Part 3 is targeted on respondents that attended and participated in the focus group meeting. Thirteen of the eighteen respondents participated in the focus group stage of the research project. One hundred percentage felt comfortable raising issues and felt there was enough opportunity to raise issues important to them during the focus group meeting. Just over three quarters agreed the meeting format enabled them to raise the issues they considered important.

Slightly more than two thirds agreed they had become aware of new issues, while just over sixty percent agreed their view on one or more issues had changed due to the meeting. Only forty three percentage agreed their appreciation of natural building had increased due to the meeting discussions. Over ninety percentage agreed the strategy recommendations produced by the focus group session addressed the most pressing issues, while eighty eight percent agreed the meeting achieved the objectives stated at the start. Table 6 provides percentage scores for each question based on a total of thirteen respondents that attended the focus group meeting.

Table 6: Percentage score for Part 3 survey questions

Survey questions	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	NA
You felt comfortable raising issues.	0%	0%	0%	38%	62%	0%
There was enough opportunity for you to raise issues important to you.	0%	0%	0%	38%	62%	0%
The issues you raised were considered by the group.	0%	0%	15%	31%	46%	0%
You became aware of new issues you had not considered before.	0%	23%	8%	38%	31%	0%
Your view on one or more issues on natural building changed as a result of the workshop.	0%	15%	23%	46%	15%	0%
The workshop discussions increased your appreciation of natural building systems.	0%	15%	31%	38%	15%	0%
The format of the workshop ensured that the most important issues were addressed.	0%	0%	15%	31%	46%	0%
The strategy recommended by the group covered the most pressing issues facing the natural building industry.	0%	0%	8%	31%	62%	0%
The workshop achieved the objectives stated at the start.	0%	0%	8%	38%	46%	8%

3.4.4. *Part 4*

The aim of part 4 is to establish whether the respondents have either passively or actively engaged in discussions with members of their social networks on natural building. The purpose is to determine the extent of further knowledge sharing and diffusion of knowledge of natural building. More than three quarters confirmed they have had discussions with their social networks while the majority had initiated discussions on natural building. Table 7 provides percentage scores for each question based on a total of eighteen respondents to the survey.

Table 7: Percentage score for Part 4 survey questions

Survey questions	Yes	No
In your discussions with colleagues or peers has the topic of natural buildings arisen?	78%	22%
Have you initiated discussions on natural building with colleagues or peers?	56%	44%

Part 4 includes questions that allow respondents to elaborate on any actions they or their organisation have, or may take, to promote natural building. The majority noted actions that fall within their normal working and organisational activities. One participant is clearly a champion for natural building and had undertaken numerous activities to promote natural building and has intentions to take advantage of the invitation to gain access into the standards generating organisations.

The three questions are listed below:

- Please describe what action you have taken to promote natural building systems since participating in the research. Type none if no action was taken.
- What action has or can your organisation take to be more accommodating of natural building systems?
- Can you name any building technology with sustainability credentials that faces similar issues to that of natural building systems?

4 Data analysis

This research project being an experiment in action research draws on primarily qualitative data comprising the views and shared experiences of selected research participants operating in the South African building sector. The research design incorporates data and methodological triangulation (Lisa A. Guion 2011) to check whether the findings reflect the current situation of natural building in South Africa.

Data triangulation is achieved by drawing on the individual views and experiences of research participants from key stakeholder groups: natural building practitioners; regulators; and external, yet influential institutions. A thematic analysis of the cumulative data captured from the interview transcripts identifies not only important themes but also how the positive and negative experiences, and views, of individual participants can be understood through the conflicting interrelationships, practices, and rule sets of stakeholder groups. The findings of the thematic analysis are described in section 5 using the language and conceptual framework of transition theory.

The findings from the four methods of data capture used in this research are compared in section 6.1 to firstly assess their validity according to the approach of methodological triangulation and secondly to support the argument in response to the research objectives discussed in sections 6.2

and 6.3.

5 Thematic analysis of interviews

In this section the key themes identified through the thematic analysis of the interview transcripts are discussed. Sub themes are grouped within theme categories to reflect similar relationships with other components within the socio-technological system of the building industry and to provide structure for reporting. The MLP framework is used as an aid to further guide the narrative. While the sub themes and theme categories were not devised to align with the MLP, they tend to fit comfortably within the three levels; *landscape*, *regime* and *niche*.

5.1. Landscape level themes

Natural building is seen by all participants to be a type of building construction and therefore necessarily subject to the same demands and expectations of any other building system. It is not surprising that two qualities or qualifiers, *cost* expressed as “time and money” and *risk*, although dominant issues; cannot be separated out as distinct themes since they permeate multiple themes.

The interview conversations highlight three dominant global and one domestic exogenous influence on the building sector that appear to be creating tensions within the regime, see Table 8.

Table 8: Landscape level themes

Landscape level themes	
• **Financial performance** drives focus on: • Priorities for system selection; • Affordability; • Value for money / cost benefit; and • Cost reduction first and environment second.	• **Housing provision** • Prominent dualities: • formal | informal - settlements • enforce | disregard - regulations • self | contract – build; • rural | urban • natural | industrial – materials & processes • construct | assemble – building optimisation • customised | modularised - productivity • Solving subsidised housing backlog intrudes on building technology debate. • Wealth creation through home ownership.
• **Resource scarcity and increasing cost** drives: • Search for alternative resource sources & technologies; and • Search for resource efficient solutions.	• **Sustainability** • Environmental motivation drives awareness of: • Resource degradation; • Restoring balance in socio-ecological systems; • Life cycle assessment for sustainability; and • Market demand for green solutions. • Environmental pressure drives: • Institutional change; • Investment in social capacity to adapt; • Legislation & policies for sustainability; and • Demands sustainability criteria for standards.

Financial performance measured in terms of revenue growth, profitability, optimised productivity and efficiency has been the dominant influence on the building sector for decades. The greater awareness of environmental limits has introduced new external influences: resource scarcity and consequent cost increases; and pressure to achieve sustainable development. Government's commitment to housing provision, a domestic pressure, has developed over the past two decades into a dominant influence on the building sector.

5.1.1. *Financial performance*

The financial cost of buying, building or renting a home consumes a large part of any household's income. As has become an international norm in counties following the Western economic model, the main source of funding for home buying or building in South Africa, is through a bank financed bond. A second source of funding is government spending on housing subsidies. These subsidy funds are also directly or indirectly sourced through banks. The international financial system is so well established that from the perspective of the South African building construction industry, not to mention the much smaller natural building movement, it has the same unassailable influence as other landscape level forces. The financial system heightens the sensitivity of all actors within the building industry to the two underlying qualifiers mentioned earlier; cost and risk. As a result the South African building construction industry is highly commercialised with well developed supply chains and a high level of specialisation, as businesses seek to optimise financial performance and reduce risk sources.

The relatively high cost of home building and a heightened cost sensitivity influence the choice of building systems in terms of affordability, perceptions of '*value for money*', lifestyle priorities and eventually socio-ecological concerns. Affordability is related to a buyer's access to funds and their specific accommodation needs. As construction costs increase so the cost of satisfying those needs increases, eventually to a point were the buyers can no longer afford their desired house and have to downgrade. Where affordability is an issue cost sensitive buyers tend to compromise on non-utilitarian qualities such as aesthetics and out of sight social and environmental impacts. In these situations the cheapest price rules as one respondent put it "*... ship it from China at one ridiculous rate. ... at a cheap price, and sell it at a high price, and it looks pretty, then you're sold. No one questions beyond that*".

The cost factor has many permeations including buyers' expectation of receiving '*value for money*'. Buyers with funds enough to include luxuries will consider the relative price of alternative materials that satisfy their expectations. However they are likely to compromise on environmental qualities when faced with a large price discrepancy. The higher learning costs and lower economies of scale

of natural building systems add a cost premium that may deter buyers otherwise attracted to the environmental benefits.

5.1.2. *Resource scarcity and cost*

A new driver of change that is visibly influencing the building industry is the suite of global environmental pressures, lead by climate change. These environmental pressures are expressed through increasing resource scarcity and the consequent increasing financial cost of resource consumption: energy; water; transport fuel; harvested and extracted building materials; land; and food.

The first, *resource scarcity*, has a direct influence. As resources become scarce and demand continues to rise, the cost of resources increases. Tension builds as the building industry *regime* fails to re-align with changing environmental conditions at the *landscape* level, creating space for alternative, cheaper, solutions in the market. Ironically these alternatives are not necessarily more environmentally benign.

5.1.3. *Sustainability*

Global environmental pressures influence the building industry in three ways; increasing costs, market shift for green solutions, and green legislation. The first, resource scarcity and cost is discussed above. The second influence is more indirect, key actors raise awareness of the sources of environmental pressures and through lobbying of influential stakeholders create new expectations; expectations, both in the environmental performance of buildings, and the environmental impacts of construction activities. This creates a market demand for green solutions. These new expectations cascade through the supply chain driving product innovation. Eventually green alternatives become available to satisfy the new demand. The supplier response to the green rating tools of the Green Building Councils is a good example of this effect. The main paint manufacturers started to offer paints with low volatile organic compounds (VoC) within a few years of the release of the Green Star SA Office Design V.1 rating system (GBCSA 2008).

The third, is the delayed response from large public and private institutions where awareness of environmental degradation and consequent threats to social stability drive policy and eventually legislative changes. New standards and regulations are published that introduce environmental and resource efficiency benchmarks; forcing even the unresponsive suppliers to change their products and practices. The SANS 10400 XA for energy efficiency and the City of Tshwane's proposed Green Building by-laws, developed to give effect to the Tshwane Vision 2055, are precursors to a potential suite of new environmental building performance codes.

Natural building systems have been strongly associated with alternative lifestyles that value self

sufficiency, environmental and community consciousness and debt avoidance. This places the practices of natural building in close alignment with the pressure for sustainability but in stark contrast with established norms in the building industry. Participants actively involved in the construction of, or greatly interested in natural building systems voiced their resignation to the need to compromise to enable natural building systems to be adopted within the established system. They do hold out the hope that environmental pressures will shift the system to appreciate the practices of natural building.

A tipping point for natural building systems may be realised when, as one interviewee envisions it, legislated building performance criteria advance to the point where all building materials and methods must meet minimum sustainability standards, such as maximum embodied energy or full life cycle carbon emissions. A counterpoint to that is the question, raised explicitly or hinted at by respondents, of “how sustainable are the different natural building systems”, particularity earth building systems, in the long term if scaled up to meet mainstream demand. A question that is best resolved through a full life cycle assessment of each building system.

A final expression of the increasing awareness of the environmental degradation associated with conventional building construction is the need raised by a number of interviewees for a radical paradigm shift. From mere efficiency and reduced environmental impact, to regenerative design to restore the past imbalances in socio-ecological systems; a call raised by leading academic thinkers in the built environment (Birkeland 2008:4; du Plessis 2012).

5.1.4. *Housing provision*

The backlog in government subsidized housing despite being a domestic social issue has acquired the impetus of a *landscape* level trend. After significant financial investment over the past two decades resulting in over two million homes (SAnews.gov.za 2014) and over three million 'housing opportunities' being delivered to low income households, the housing backlog of low income households remains high at 2.3 million (DoHS 2014). One has to unpack the issue to understand how profoundly the housing backlog influences the probability of a successful emergence of natural building systems.

The housing backlog has gained the status of a wicked problem that appears to have no easy remedy. At the core is government's commitment to provide housing to low income households who would otherwise not be able to acquire property and build wealth. A number of social issues together have ensured the number of low income households has continued to increase despite government's significant financial investment in housing projects. Coupled with that, interviewees familiar with the political dynamics of the housing programmes suggest there are expectations by beneficiaries of receiving a *modern home* backed by real threats civil protest at any sign that

inferior products are being provided.

Government wary of poor quality construction yet faced with increasing unit costs for conventional modern buildings and the need to deliver more housing units at a faster pace has had to look for alternatives to conventional brick and mortar construction (Burger 2014). The market responded by offering a wide array of innovative building technologies ranging from alternative materials for monolithic walls to pre-fabricated panels for rapid on site assembly. To mitigate the risk of unproven technologies government requires all innovative building technologies (IBTs) to comply with the National Building Regulations and SANS 10400 or acquire an Agrément SA certificate.

Government's commitment to allocate 60% of the social infrastructure budget to IBT's (Burger 2014) can benefit natural building systems that are by definition IBT's. The only condition is that an Agrément SA certificate will have to be obtained for each natural building system; considered an onerous process by those natural building participants who have attempted this route without success.

The importance of the housing backlog is indicated by how regularly the topic was raised by interviewees from all disciplines. For respondents directly involved in housing delivery, through policy development or building regulations enforcement, the issue of how to get ahead of the housing backlog is a fundamental departure point in apparently all discussions to do with house building systems. Often the promise of quicker, modularised, pre-fabricated IBTs is raised as the only viable technological solution; once the issue of social acceptance is addressed. For these interviewees, natural building systems are not a radical alternative; they are just another IBT hopeful with none of the advantages of rapid installation. While all interviewees were supportive of natural building systems and could see their environmental benefits, the outlook of those involved in social housing seemed dominated by the issue of the housing backlog.

5.2. Stabilising themes at the regime level

The building sector can be described as a socio-technical regime, a self stabilising system with established rules and practices (Geels 2012). The following discussion attempts to tease apart the multiple issues around natural building and align them with the relationships, practices and rule sets of the socio-technical system. Theme categories set out in Table 9 reflect concerns or perceived barriers identified through the interviews. Themes that are largely associated with organisations that provide the stabilising functions for the building sector regime are discussed hereafter.

Table 9: Theme categories at the regime level

Regime level themes	
• **NBR[1] Compliance** • Possible with Agrément certificate • Financing condition • Local standards have South African context • Only local standards can be measured	• **Barriers to market** • No NBS[2] standards or Agrément certificates • NBS do not satisfy National imperative of SABS[4] • Cost threshold for Agrément Certification too high • Compliance premium • Perceived institutional resistance • NHBRC[3] Gate keeper for financing
• **Influencers** • Social development banks: Financing criteria drive change • Government: Legislation & policies for sustainability • Industry: Client, consultants and contractor specifications	• **Overcoming barriers through** • Cash projects avoid constraint of NHBRC risk aversion • Pooling of resources to overcome threshold barriers • Financial resources • Increase & consistent technological investment • NBS standards for market access
• **Acceptability** • Influence of changing aspirations • Improved performance of engineered NBS • Examples offer interactive experience • Ongoing promotion of NBS benefits & successful implementations • Social acceptability essential for success • Managing risk Crucial to NBS success • Technology resistance / support relies on familiarity	• **Business case** • Agrément process assumes patent rents cover application cost • Increasing market share can produce green wash • Incumbents protect *status quo* and profits • Corporate response to market drives sustainability actions • Cost versus benefit, and NHBRC's capability to implement mandate questioned
• **Transition to sustainability through:** • Behaviour change through training • Changing building sector • Changing institutional behaviour and policies • Managing differing ideas of what to sustain • Investment for long term benefits	• **Ideas influencing transition:** • Higher standards improve building performance • Progress assumptions dominated by efficiency and productivity • Transitions take decades • Require system design not product design • Towards pre-fabrication & assembly • Institutional capability lacking • Short term and vested interests impede change

[1] *NBR refers to national building regulations*

[2] *NBS refers to natural building systems*

[3] *NHBRC refers to the National Home Builders Registration Council*

[4] *SABS refers to South African Bureau of Standards*

5.2.1. *National building regulations*

The decision whether or not to comply with the "*National Building Regulations and Building Standards Act, 1977 (Act 103 of 1977)*" as amended for the "*introduction of amendments to the national building regulations to introduce requirements for energy usage in buildings*" (DTI 2011), hereafter referred to as the '*national building regulations*' or (NBR), determines the legal status of a

construction project. To be considered “legal” a building must be constructed in full compliance with the NBR and associated standards and regulations and be approved by the local authority building inspector. Being legal enables the owner to; qualify for a bond, insure the building, sell it on the market and operate with limited risk. A building that does not comply is considered “illegal”. The owner and other parties involved in its construction and operation are fully exposed to risks and are responsible for costs from any damages. An illegal building cannot receive a bond, cannot be insured or at least a claim will likely be rejected, and cannot be sold on the open housing market. It is in the best interest then of a home owner to ensure the building complies with the NBR.

A problem arises where the home owner wishes to build using one or other of the natural building systems; rammed earth, cob, straw bale or adobe among other systems. Of the three available routes to achieve compliance with the NBR only one is suitable for natural building systems. The deemed to satisfy route considers masonry and timber structures. The second route is to use an Agrément SA certified system, however there is currently no certificate for the typical natural building systems. The remaining route is through rational design. This has two implications; firstly, increased design and construction costs. Design costs for an engineer's bespoke structural design, and construction costs to construct redundant structural elements, to duplicate the structure provided by non-standardised construction materials and methods. The second implication is that not all local authorities have experienced inspectors and many may be reluctant to accept the unfamiliar natural building systems despite the submission of a structural engineers design. Building inspectors are necessarily conservative and might not accept any but a local standard which means the engineer cannot not refer to international standards or best practice; but must instead demonstrate, through countless tests, that the design is sound.

5.2.2. *Barriers to market*

Practitioners and home builders using natural building systems report constant frustration at what they perceive to be reluctance or even resistance to approve “unconventional” buildings; from officials and organisations responsible for ensuring compliance with building regulations and allied legislation. The two institutions immediately identified are the building control officers of local authorities and the National Home Builders Registration Council (NHBRC). These tensions arise due to conflicting expectations between the natural building movement and the established building sector. The understandable view from these two institutions, and the national government bodies that develop the legislation and standards they enforce, is that the public must be protected from unsafe construction practices.

Obtaining NHBRC approval is regularly raised as an onerous and uncertain process. The NHBRC being a hybrid building compliance regulator and insurance organisation is considered excessively

conservative. The NHBRC is seen as unwilling to accept a natural building project even if it has a comprehensive engineering design and has local authority approval. This presents a serious barrier for most prospective home owners who view the NHBRC as an unnecessary gate keeper. Without NHBRC approval they are unable to secure funds through a bond to construct their homes, since banks are prevented by law from providing home finance without NHBRC approval (DoH 1998).

The institutions suggest there are no barriers and refer to three routes of compliance, two of which allow for innovation and non-standard building systems. However members of the natural building movement are frustrated by the high cost thresholds of following the alternative routes. The tensions remain; driving individuals to find legal and less than legal routes to circumvent the legislation. These tensions are not unique to the natural building movement and are evident in the behaviour of low income households, both those in informal settlements, and in so-called RDP houses. The “temporary” structures or shacks of informal settlements that are permanently occupied are effectively illegal, yet the practice of informal settlement persists. In formalised RDP settlements houses are upgraded and sold informally to avoid the delays, and for poor people the high costs, associated with compliance with building and town planning regulations: title deed registration, conveyancing, transfer fees, and planning requirements (Napier quoted in Donnelly 2014).

The lack of standards for natural building systems effectively increases the construction cost and increases the uncertainty of obtaining local building inspector approval. To mitigate these costs the natural building movement can establish either new standards or apply to Agrément SA to assess and certify each natural building system. While these routes are theoretically available, the cost associated with establishing either a new standard or achieving Agrément SA certification are significant; values suggested by interviewees ranged from a conservative hundred thousand rand to over four hundred thousand rand. The natural building movement is comprised of a loose coalition of individual home owners and practitioners all operating independently. It is improbable that any one individual would be willing or able to invest the financial capital necessary to have a building system standardised or certified. These routes are effectively blocked unless the natural building movement is able to pool resources; or the cost thresholds are reduced.

A potential hurdle for the adoption of a national standard for one or more natural building systems is the intended scope of national standards. That is national standards are developed to address situations that have national impact. The tiny market share of the natural building movement and its limited integration with other industrial supply chains, suggest it may have difficulty in making the case that natural building is of national importance. This need not be a limiting factor as the raw materials for natural building include straw, urbanite and up-cycled waste products. Allying with

businesses in agricultural and municipal solid waste management may provide the necessary national credentials.

5.2.3. *Overcoming barriers and gaining market access*

Currently home owners and natural building practitioners are able to work around or circumnavigate barriers, more easily with local building inspectors through the rational design route than the more risk averse NHBRC. The NHBRC approval is viewed as an absolute impediment to natural building. The accepted means to bypass this impasse is to treat the natural build as an extension or renovation project on an already approved building. Currently renovation projects do not have to be enrolled with the NHBRC. However this may change given the recent, August 2014, public outcry over construction worker fatalities due to the collapse of a house undergoing renovation (Yandisa 2014).

Ultimately the natural building movement will have to pool financial and administrative resources and develop either standards through the SANS suite or Agrément SA certification to gain access to the housing market within the formal building sector.

5.2.4. *Acceptability*

Acceptance or the acceptability of natural building systems has multiple dimensions that can broadly be divided into technical performance, social expectations and risk due to uncertainty. The social expectations versus perceptions around natural building have by no means been settled. However gaining widespread social acceptance will not lead to wider adoption until natural buildings can be constructed in compliance with the NBR, NHBRC and banking requirements; without a significant cost premium. Interviewees engaged with natural building construction suggest that the demand for houses constructed using natural building systems is larger than those eventually constructed, due to a high defection rate where approval delays, high costs for compliance and lack of bond financing dissuade potential clients.

5.2.5. *Competing ideas informing transition pathways*

In a myopic system conditioned to seek cost reduction through efficiency, higher productivity and externalising costs; technology innovation in the building sector is tending to pursue greater levels of industrial processing: pre-fabrication, automation, and modularisation. This trend, the shift from building construction to building manufacture and assembly was noted to a greater or lesser degree by all interviewees. This creates a larger chasm for natural building systems to navigate in order to align with and become adopted within the mainstream market. The pervasiveness of the productivity mindset is evidenced by the interviewees actively involved in the construction of

natural buildings all raising the issue of the slowness of natural building systems and the need to innovate to increase productivity.

While natural building practitioners are frustrated at the cost premium for NBR compliance through the rational design route, another theme associated with cost thresholds was raised directly and indirectly by interviewees. That gradually increasing building performance standards and regulations for the conventional house may eventually establish a minimum building cost that is above the affordability threshold of a large proportion of South Africa's lower income households. This could potentially aggravate the housing backlog and increase the size of the informal housing sector.

Of the natural building practitioners interviewed, a number shared their experiences of attempting to promote natural building and of being impeded and excluded from dissemination forums, by individuals and organisations which they perceive to have vested interests. This is a key characteristic of a socio-technical system where the incumbent businesses and institutions block any threat to their profit making activities (Rotmans, Kemp & Asselt 2001; Geels 2004; Geels & Schot 2007). These vested interests and associated short term thinking are protected in another manner; the social and ecological costs of producing building materials and operating buildings are externalised. Natural building practitioners suggest that to establish a level playing field, where the environmental benefits of using natural materials are recognised, requires that standards include benchmarks associated with social and ecological costs.

5.3. Themes influencing the niche level

Theme categories as set out in Table 10 reflect the issues identified by interviewees that deal with the complementary and contrasting niche level practices with respect to those of the socio-technical regime.

5.3.1. *Internal niche processes*

Most practitioners enter the natural building movement after having realised that current human activities and building practices are unsustainable. They share an appreciation and respect for the natural world, for the right of all people and species to exist and to thrive. They have a desire not just to reduce the impacts of building construction on their lifestyles but to assist others to do the same. Modern natural building is promoted as exhibiting better performance to conventional construction methods; using locally available natural materials, that are non- toxic, and reusable if not renewable. The value system of the natural movement places as much importance on social well-being and a healthy ecology as it does on financial value. As a result they are more willing to share their knowledge freely; often their labour too, through work parties. They are often non-

conformist and less likely to see the need to establish representative organisations.

Table 10: Theme categories and the niche level

Niche level themes	
• **Appropriate regulations** • "Unfair" regulations circumvented • Affordability gap • High standard greater affordability gap • Poor quality / illegal construction • Too stringent excludes innovative tech**nologies**	• **Appropriate technology** • Context: technological, social, climatic and geographical • NBS: use local labour & materials • Novel sources • Performance testing
• **Market niche** • Close quality and location association - NBS & rural • Government provided • NHBRC adopting gov policy	• **Innovation processes include:** • Funding of IBTs • NBS contribution to sustainability • Determine the need - necessity "mother of invention" • Novel sources • Practical experimentation • Productivity improvement
• **Knowledge diffusion** • Increase investment in open research • More willing to consider alt. green tech • Spark innovation • Technology defection	• **Network development** • Outside influencers • Relationship density • Weak social network
• **Value chains** • Aggregating as Design & build product • Grow and disaggregate • In-source entire VC to secure income	• **Dilemmas** • R&D funds - "unproven" limited interest to "prove" it • Skills development – expertise pool limits response to demand constrains skills development

Members of the natural building movement have similar expectations based on their common worldviews. They may each have their preference among the natural building systems, some prefer straw bale, others cob, adobe or rammed earth but they are usually familiar with all of the systems. As there is no active natural building association the expectations of the natural movement is not well defined or articulated. Each practitioner disseminates their own unique message.

The social networks within the natural building movement and networks linked to external stakeholders in the building sector may be considered narrow and of limited extent. Networks are typically structured around a few long time practitioners and the students that they have trained or mentored over the years, or alternatively clients of practitioners. In some instances these networks are anchored in environmentally friendly and alternative lifestyle communities. Social networks that extend beyond the natural building community have been developed by individual practitioners during the course of their careers and business activities. A number of practitioners established an

organisation to advance the interests of natural building, however it's activities are extremely limited due to lack of financial and human resources; to the extent that only one of the interviewees, who is a board member, was aware of its existence. All attempts to promote natural building and lobby for adoption are driven by individual practitioners who are at a disadvantage of having limited resources and no industry mandate.

An important avenue through which the natural building movement attracts new advocates of natural building is through training courses. The attendance of training courses by prospective home builders and architects, interested in natural building for its environmental credentials, appears to be the primary means of maintaining the flow of financial investment in natural building.

Courses on natural building are typically intended to teach practical construction skills. This 1st order social learning leads to 2nd order social learning (Brown, Vergragt, Green, *et al.* 2003; Brown & Vergragt 2008; Schot & Geels 2008) where participants gain an appreciation of wider social and ecological implications of lifestyle choices through the training format and the associated practices. With the recent interest in green building rating systems, practitioners have taken advantage of opportunities to promote natural building systems at conferences, seminars, and conventions. This exposure has raised the general awareness of natural building and sparked interest among individuals located within the stabilising institutions of the building sector regime. This signals a new potential for extending, broadening and deepening the social networks of the natural building movement.

5.3.2. *Market niche*

The natural building movement exhibits the characteristics of a technological niche with expectations, values, practices and cognitive rules that contrast with those of the dominant building sector regime. These characteristics align closely with the external landscape level pressures exerted at the regime level. Over the past decades the natural building movement in South Africa has gradually developed its technologies and established a very small market niche among communities searching for alternative “environmentally friendly” lifestyles. A parallel niche exists within rural areas of South Africa where non-governmental organisations work in partnership with rural community leaders to share knowledge of natural building systems, through the construction of schools and other community buildings.

A more significant market niche has grown with government support for what are termed innovative building technologies (IBTs). This market niche is enabled through: legislation, the Agrément SA certification process to recognise IBTs, together with recent commitments by government to reserve a sizeable portion of the social facilities budget for building constructed using IBTs (Burger 2014). Despite this support interviewees familiar with the IBT programme suggest adoption of IBTs

is limited.

5.3.3. *Dilemmas and Value chains*

Natural building practitioners operate in what they perceive to be an artificially constrained market. At some point as practitioners decide to earn a living from their knowledge of natural building they encounter the very different rules of the market economy. They discover and have to reconcile numerous conflicts between the grass roots community orientated practices of the natural building movement and commercial expectations: slow building pace versus emphasis of productivity and rapid installation; on site material sourcing, processing and construction versus product supply chains for on-site assembly; and knowledge of a master craftsman versus codified instructions for unskilled component assembly.

The inconsistent market for natural building projects means the practitioner has to have diverse income streams. Typically this includes revenue from construction work, consulting, speaking events, training and sales of books and guideline documents. Natural building practitioners face a dilemma in the mature market of the building sector: on the one hand the “rules of success” dictate specialisation and value-add within an extended supply chain; and on the other the natural building practitioner finds it necessary to keep as much of the “production” in house to mitigate against highly volatile income. The practitioners interviewed where in many instance overwhelmed by the large burden of satisfying all the roles in the value chain; often working on risk and functioning in survival mode due to the modest revenue. For a few, the high personal sacrifice and minimal reward has forced them to leave natural building and enter other business sectors.

Since the technological knowledge of natural building is a shared resource, there is no patent and no person or organisation receiving revenue from royalties or other rents. There is no surplus revenue to be invested in opening up the market or breaking down barriers. The uncertain market for natural building services, with volatile income and limited profits, together with the individualistic attitude of practitioners creates a dilemma. As a loose coalition there is no structure to pool resources to breakdown and remove market barriers, leaving them confined to a small market of cash flush sponsors. Until the members of the natural building movement are able to pool resources or access external resources to open the market for natural building, their situation will likely remain unchanged.

A second dilemma related to the first concerns the pool of expert practitioners. Due to the constrained market, few practitioners can make a living. When new clients look for local experts they are unable to find any due to the small expert pool. The clients decide not to build natural and

potential income for the niche is lost, perpetuating the cycle of a constrained market share.

5.3.4. *Appropriate technologies and regulations*

The idea of using appropriate materials and construction methods has high standing among natural builders who value local materials, to construct buildings designed to respond to local climatic and geographical conditions (Chiras 2000:11; Evans, Smith, Smiley, *et al.* 2002:36; Magwood, Mack & Therrien 2005:17). This contrasts with the contemporary approach of universal solutions regardless of context. Interviewees with a background in natural building expressed mixed views on the idea of standardising natural building including some resistance, as it is assumed this will stifle local innovation and context sensitive solutions. Through either reluctance to comply with overly standardised compliance requirements or frustration with the onerous and the seemingly unnecessary effort to achieve compliance, members of the natural building movement find legitimate ways to circumvent regulations.

An opportunity to introduce a national standard for rammed earth was pursued in 2012 by one of the interviewees in partnership with an expert and author on the subject (Keable & Keable 2012). The SABS has not introduced a national standard for rammed earth despite the standard being accepted as a SADC harmonised standard. SABS's failure to pursue a national rammed earth standard was initially perceived to be a result of a veto from vested interests, however may instead have been due to an incorrect application process. Whatever the reason, this is a clear signal to the natural building movement to invest in deeper links to and understanding of the standards development process.

5.3.5. *Summation of thematic analysis*

Figure 3.1 illustrates the pressures exerted on the actors within the socio-technical system from the landscape level factors and the consequent interrelationships between the regime and niche levels. For decades the natural building movement has operated in a socio-technical regime with a narrow view on financial optimisation combined with the assumption that only brick and mortar buildings offer durability. Changes at the landscape level see increased awareness and responsiveness to issues of sustainability. Added to this is the wicked problem associated with government subsidised housing that has opened a window of opportunity for innovative building systems. An opportunity that the natural building movement has tried to capitalise on by promoting the environmental and social benefits of natural building.

The natural building movement faces barriers relating to; market acceptance, it's (in)compatibility with assumptions of economic efficiency, and its practices and rules that contrast to those of the

building sector regime. The natural building movement perceives the legislation and standards developed and enforced by the established institutions, tasked with stabilising the current practices and rules of the building sector, as being the main impediment to their access to the mainstream market.

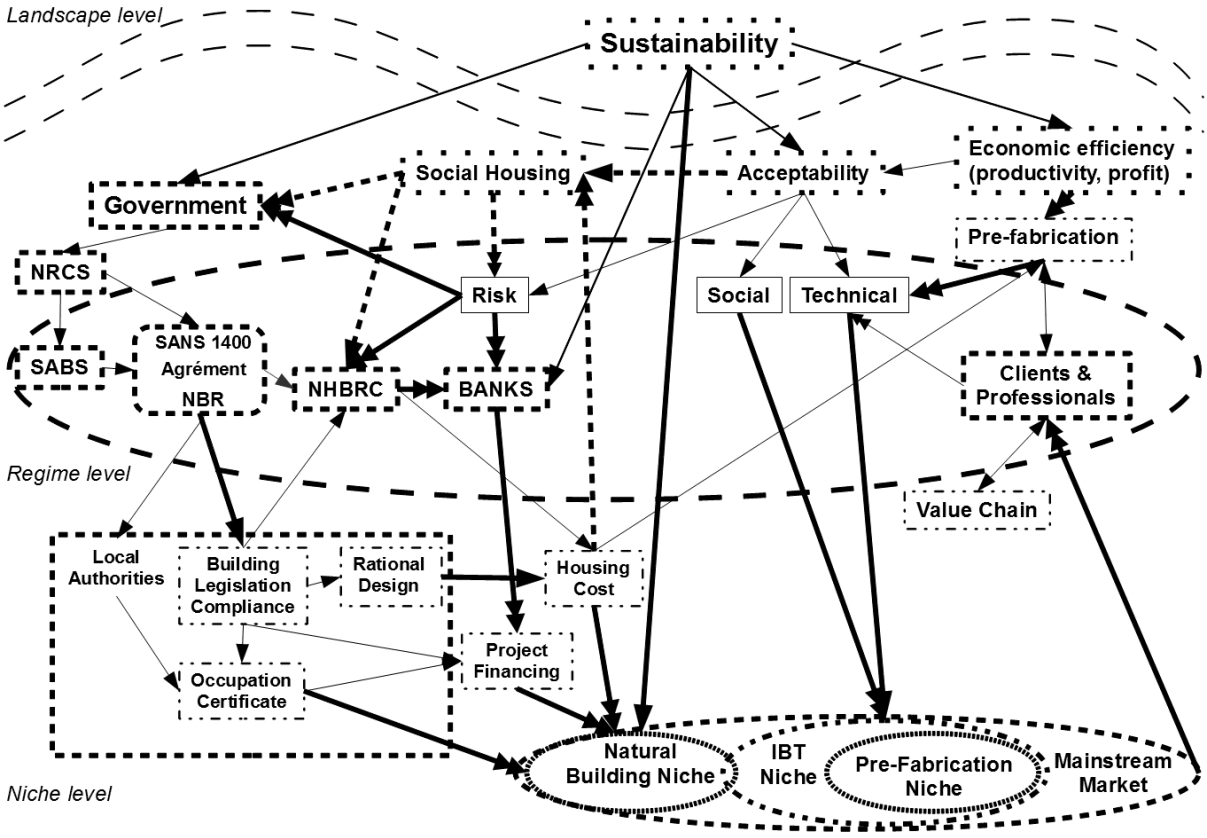

Figure 3.1: Natural building niche-regime relationships

The status of the natural building movement when viewed in terms of the multi-level perspective is that of a technological niche. The fact that is has persisted for decades and has continued to improve and 'modernise' its techniques suggests it has the potential to acquire a share of the building market. However it has not successfully emerged into the mainstream market, and its potential remains 'latent'. An analysis of the interview transcripts when compared with the internal processes of a successful technological niche, discussed in section 3.1, offers insight into the possible causes on this latent state.

Table 11 summarises the readiness of the natural building movement in terms of the level of development of its internal processes; considered indicative of a successful technological niche. While the legislation and standards do present barriers to the emergence of the natural building movement, the probable reasons for the continued latent state may rather be ascribed to poorly

developed internal processes vital to overcome barriers. Most importantly the lack of a proactive representative organisation to pool resources, develop shared expectations, develop deep and broad networks, lobby for change and overcome thresholds that act as entry barriers for individual practitioners.

Table 11: Development of natural building movement's internal processes

Technological niche: internal processes of success	Process development of Natural Building Movement
• Well articulated shared expectations	• ***Undeveloped*** – poorly articulated, fragmented among individual practitioners.
• Well developed broad and deep social networks	• ***Undeveloped*** – shallow and isolated networks within movement and limited links to broader building sector actors.
• Attraction of new participants and resources	• ***Weak*** – attracts new participants despite the institutional barriers but of limited impact due to limited pool of experts and projects.
• Multi-dimensional 1st and 2nd order learning processes	• ***Good*** – technical and cognitive learning takes place during training.
• Occurrence of higher order learning within and beyond the experimental group	• ***Weak*** – well established within group and with a number of individuals from influential institutions however the instances outside the group are very limited.
• Diffusion of the experiment results to produce a commercial success	• ***Undeveloped*** – the movement is prevented from accessing the mainstream market due to lack of approved national standards.
• Branching out and seeding new experiments	• ***Good*** – the movement continues to explore new material sources and technologies; learned from local innovations and international examples.

6 Research findings

6.1. Methodological triangulation of data

A comparison of the themes identified through the literature review and those identified through the interviews and refined by the focus group session, illustrates the value of action research in providing a richer more relevant and current data set. The literature study provides a reasonable and comprehensive overview of the natural building niche and its location within the larger dynamic socio-technical system of the building sector. It is lacking however in the diversity of viewpoints and perspectives of social actors that exposes the compounding and mitigating effects as niche-regime relationships overlap and influence one-another.

The four theme categories from the literature research explode into eighteen key theme categories with a short-list of over eighty sub-themes identified in the analysis of the interview transcripts. These are discussed in some detail in Chapter 2 Section 5. The focus group session generated a

similar number and range of themes and sub-themes. The points raised during the “brainstorming” sessions of the focus group meeting echo many of the themes identified through the thematic analysis of the interviews. There is a reasonable degree of overlap and confirmation of key themes when comparing the outcomes of the literature research, the thematic analysis of the interviews, and the issues raised by the participants of the focus group meeting; as summarised in Table 12.

Table 12: Methodological triangulation of themes

Literature Themes	Interview Themes	Focus Group Themes
Social acceptance technical engineering performance criteria for habitable buildings	Acceptability	Market expectations and demand Prove the technical performance Managing risk
	Appropriate regulations	
	Appropriate technology	Non-technical values and practices
	Business case	
	Technological transition	Efficient production and standardisation
financial implications in terms of funding and risk management	Dilemmas	Establish sources of funding & external resources Dilemmas
	Drivers	Key drivers of change
	Barriers	Real and perceived institutional barriers
	Housing provision	
	Influencers	
	Innovation	
	Knowledge diffusion	Knowledge dissemination & available experts
	Market	
	Market niche	
legislation, regulations, codes and by-laws	NBR Compliance	Establish standards and / or Agrément certificates
	Network development	Organisational structure & actions
	Sustainability	
	Value chains	Value chain

The focus group meeting generated recommendations to remove barriers, of which the majority are assigned to a driven natural building association; one that does not yet exist. The type of actions, and the allocation of the majority to the natural building movement, has three implications. Firstly, each of the actions can be restated as a deficiency in one of the seven internal processes outlined in Table 11. Secondly, weaknesses in developing the internal processes can be attributed to the lack of a representative organisation or any organisational structure within the movement. Third and most encouraging, that the organisations responsible for stabilising the building sector

appear comfortable to adopt the conditioned or re-purposed natural building technical practices.

The two actions assigned to the new technical committee provide opportunities for the natural building movement to strengthen their social network and gain access to the inner workings of the standards generating bodies.

6.2. Benefits of action research to activate latent technological niches

The thematic analysis of the interview transcripts, discussed in this article, achieves two objectives: firstly, it offers insights as to the cause of the latent state of the natural building movement; and secondly, provides a baseline to assess the effect of the facilitated focus group sessions.

This paper proposes that a latent technological niche might start to advance beyond a latent state through a sequence of three stages, as it recognises and develops its seven processes:

- **Stage one** - where its members become aware of their internal processes of success and recognise the level of development or lack thereof;
- **Stage two** - where clear development strategies are articulated; and
- **Stage three** - where there is evidence of actions leading to positive development of under-developed processes.

Following this line of thinking, the seven internal process of success, hereafter referred to as the seven processes, are used to gauge the effectiveness of the focus group sessions and subsequent survey responses.

6.2.1. Focus group recommendations: indicators of process development

The nineteen recommendations of the focus group, see Table 3, are discussed hereafter as indicators of a *stage one* and *stage two* advancement. Table 13 illustrates the alignment of the recommendations to the seven processes. The single most important recommendation of the focus group is that the natural building movement establish a natural building association or interest group.

The acuity of facilitated multi-stakeholder social learning is indicated by how closely the focus group pinpoints the deficiencies in the seven processes of the natural building movement. The three internal process that are undeveloped attract the greatest number and detail of recommended actions: shared expectations, social networks, and diffusion for commercial success. The responses from interviewees indicates that the movement recognises the value of developing the remaining four processes. Two are weakly developed primarily due to lack of

resources; attracting new participants and resources; and promoting higher order learning beyond the group.

Table 13: Strategic recommendations indicate value of facilitated social learning

Internal processes of success	Recommended actions
• Articulated shared expectations	• Develop acceptable standards for natural building systems. • Standards that incorporate all performance criteria required by professional engineering team not just structural. • Specifically include in organisational mandate and scope projects of all scales from single to multi building developments. • Determine where natural building adds value, then target government and institutional projects and programmes where those "values" are integral to their success. • Develop a clearly defined value chain within the natural building industry integrated with existing values chains in the conventional building industry. • Identify areas of risk and develop mitigation strategies. • Present a clear value chain proposition for natural building in the South African context.
• Develop broad and deep social networks	• Lobby government structures for support, financial and access to government institutions. • Make use of existing networks to learn how the processes and procedures work. • Learn from the experiences of the South African Light Steel Frame Building Association (SASFA). • Learn how other organisations in the building sector, such as the Green Building council, the Construction Industry Development Board, managed to get funding. • Take advantage of the offer of an introductory meeting with TC60. • Propose / motivate for a natural building work team for SABS with natural building seat.
• Attract new participants and resources	• Secure funding. • Grow partnerships and arrange for completed natural buildings to be opened as demonstration projects for awareness raising visits.
• Encourage multi-dimensional 1st and 2nd order learning processes	
• Encourage higher order learning within and beyond the experimental group	• Understand the governance and development processes for national standards and norms. • Develop an advocacy and education programme that targets professionals, communities and government.
• Promote the diffusion of the experiment results to produce a commercial success	• Identify and prepare a register of demonstration projects. • Understand the established process and follow correct procures to introduce a new works item through the TC60. • Develop a public relations and marketing strategy that address the question – "Why natural building systems?". • Raise broad awareness and credibility by providing free training, using funds available from the SETA's.
• Branch out and seeding new experiments	

6.2.2. *Survey responses:* indicators of process development

The survey responses from participants from the natural building movement indicate a greater awareness of the seven processes and the importance of developing them. This may be considered evidence of the benefits of action research in achieving stage one advancement in stimulating latent technological niches. The participant from Cape Town, who actively promotes natural building, plans to implement a number of actions informed by the recommendations including:

- initiate discussions on natural building with colleagues or peers,
- prepare a "value proposition" for Natural Building, and
- start discussions for the launch of an earth building association and hosting a natural building conference.

Other natural building practitioners voiced their intentions, quoted hereafter, that indicate an increased awareness of the value of developing the seven processes:

- "*I suppose beef up the marketing on NB* ...",
- "*... collaborate in a NB forum/org to aim at putting standards together and get them adopted by industry on NB*",
- "*...because I am involved with rammed earth buildings, we promote it on an ongoing basis. ... we should be speaking to the mines*",
- "W*e are fully accommodating*", and
- "*Raising funds*".

The value of the action research in developing broader and deeper social networks, is evidenced by the responses of participants from the standards development and enforcement institutions to the question on action their organisation can take:

- "*Assist in developing regulations as well as SANS within SANS 10400*",
- "...*discussion with clients on* [terms of reference] *for structures and procurement processes and terms and conditions. be more aware and try to influence clients and projects to accommodate* [natural building methods]",
- "*More research*",
- "*Include it in the Green Building Development by-law and policy when it is revised*",
- "*Integrate natural building systems into policy strategy and business processes",* and
- *"Norms and standards".*

The responses from natural building practitioners and participants from regulatory and external

institutions demonstrate the potential of action research to stimulate actions leading to positive development of under-developed processes and potentially nudge latent technological niches out of stasis.

6.3. Transition pathways beyond the latent niche

Geels and Schot described four broad typologies of technological transition besides the that of regime reproduction (2007): transformation, de-alignment and re-alignment, technological substitution, and reconfiguration. The strategic recommendations of the multi-stakeholder focus group meeting and the subsequent survey responses suggest the most probable transition pathway available to the natural building movement is of regime transformation. In effect the building sector institutions adopt the technical practices of one or more natural building systems; codified according to the building sector rules and practices.

An alternative scenario emerges when taking a broader view; of the of city infrastructures rather than building systems alone. The possibility exists that the adoption of natural building practices by the building sector regime is not an isolated event; and is instead one of many adoptions of radical niche level practices. The regime may be following a path of reconfiguration in response to broader debates on green building, green economy, resource efficiency, and sustainable cities.

A longer term view might consider the possibility of natural building systems finding a window of opportunity to *translate* (Smith 2007) more than its technical practices into the regime. Where significant landscape pressures produce the de-alignment and re-alignment transition pathway. In this scenario the movement continues developing and improving natural building technologies ready to step in should a significant landscape level event destabilise or cause a collapse of the current socio-technical regime. This exploration may include active innovation and technology improvement through involvement in self build structures in informal and rural settlements.

7 Conclusion

In this paper it is proposed that the natural building movement is in a latent state, due to under-development of it's internal processes of success, and therefore occupies a latent technological niche. The multi-level perspective framework is used to interpret the interrelationships, pressures and responses of actors within the larger socio-technical system, where the dominate regime is the building sector. This experiment was undertaken to determine the value of action research in gaining a clearer understanding of a latent technological niche and, through a facilitated process of social learning, identify pathways to move beyond this latent state.

The action research experiment comprised of three methods of interaction with participants:

interviews, a focus group meeting, and a participant survey. A critical literature review informed the approach and content of the research experiment and examined the technical status of modern natural building and theories of technological transition. Seven internal processes where identified from the literature on transition theories that are considered crucial for successful market penetration by a niche bound technological innovation.

Five key findings of the interview stage have important implications for understanding the latent state of the natural building movement in South Africa and offer insights into the possible translations of its practices to the building sector. Firstly, members of the natural movement appear not fully cognisant of the importance of developing the seven internal processes; instead remain frustrated by compliance barriers. Of the seven processes three were found to be undeveloped and two weakly developed.

Secondly, concerns around the unsustainable practices of the built environment have created opportunities for innovative green building technologies, including natural building systems. City visions and development strategies are increasingly informed by sustainability concerns as cities aim for the elusive 'sustainable city' status.

Thirdly, social housing has acquired the impetus of a landscape force that exerts pressure on all government and private sector actors operating within the building sector; creating windows of opportunity for innovative building technologies like natural building, while introducing new institutional barriers established to mitigate financial and building performance risks. The NHBRC has a key role in mitigating risks and is consequently the cause of great frustration for those attempting to implement natural building projects. The NHBRC as an insurer of risk and therefore understandably risk averse, is viewed as applying a particularly conservative interpretation of building regulations and standards that seems to impede the implementation natural building projects and block access to home loans.

The fourth finding is that the windows of opportunity created by sustainability concerns and the pressures to provide social housing, combined with the increasing pressure of economic efficiency, have lead to competing technological approaches. While natural building is aligned with sustainability and social housing concerns, there is a growing trend towards industrial pre-fabrication and manufacturing for on site assembly; driven by the still dominant pressure of economic efficiency for profit. The on site material processing and labour intensive nature of natural building systems may be disadvantageous in light of this trend.

The fifth and final key finding, is that the mechanisms employed to stabilise the building sector as a socio-technical system, while viewed by the implementing institutions as open and accommodating of any building system, have an inherent bias in favour of proprietary technologies. The setting of

fees by the SABS and Agrément SA, to develop and issue certificates, presumes that the applicant can offset large application fees against future rents from proprietary technologies and exclusive market share. This presumption establishes a cost threshold that is not easily overcome for non-proprietary technologies that cannot rely on royalties or rents from a captured market share. It is this high cost threshold together with the administrative resources required to manage the process that has inhibited the application for SANS standards or Agrément SA certification of natural building systems.

The facilitated multi-stakeholder focus group session produced a range of recommendations for strategic action, including the crucial task of establishing a proactive natural building association. The balance of the recommendations target those weakly or undeveloped internal processes, offering strategies to establish and improve them. The focus of participants on remedying the deficient internal processes is sustained in the responses to the survey; with natural building participants identifying actions they could take to improve internal processes. The positive responses from institutional participants, suggest that the experiment succeeded at creating constructive social links with supportive champions located in the regime institutions and thereby broadening the social network of the natural building movement.

Besides the social benefits of the experiment, the research objectives where largely satisfied. The discussion points and final recommendations raised in the focus group clearly articulated the view of a transition aligned with the transformation pathway. Though when read with broader responses by city authorities to issues of sustainability, the possibility exists that the adoption of natural building practices may be part of a reconfiguration of the building sector regime.

The findings suggest that an informed experiment in action research implemented through facilitated social learning can stimulate latent technological niches to advance beyond their latent state; while adding to academic knowledge. The action research was successful in identifying pathways for the natural building movement to move beyond its latent state. It is acknowledged that the stakeholder composition of the focus group played a crucial role in the recommendations generated; that appear to preference the transformation pathway of transition. The large proportion of participants with backgrounds in institutions responsible for stabilising the current socio-technical regime of the building sector may explain this outcome.

Further experimental research in different regions in South Africa, including both single interest and multi-stakeholder groups should be undertaken. This research should aim to explore the relationship between stakeholder diversity and transition pathway preferences, and the influence of stakeholder diversity on stimulating latent technological niches.

Chapter 4: Thesis Conclusion

1 Research as an exploratory process

This research project followed an evolutionary process. The findings of the literature review and particularly the contributions from participants during the interview stage shifted the understanding of the research problem. This research examined the natural building movement and its radical building systems to understand why it has remained confined to a small market niche despite apparent potential to avoid or mitigate unsustainable mainstream building practices. While this problem statement remained largely unchanged the research question and objectives required revision.

The initial research objectives were founded on the presumption that entry barriers for natural building systems were largely due to a lack of familiarity and therefore acceptance by officials, professionals and the market. That this could be resolved through knowledge sharing and social learning between natural building practitioners and these actors. Greater familiarity, it was assumed, would allay fears and uncertainty. To meet the initial objectives the desired outcome of the learning process would be a transformation of the socio-technical institutions; evidenced by regime actors' increased familiarity, acceptance and accommodation of natural building systems.

While this process is still relevant and necessary, the more immediate dilemma for the natural building movement is the lack of nationally certified standards for natural building systems. Proving and measuring building performance without national standards is problematic for approving officials and introduces a cost premium that disadvantages natural building systems. This situation is perpetuated by the inability of the natural building movement to secure the financial and human resources required to develop nationally acceptable standards and have them certified. This new insight shifted the context from one where the natural building movement is constrained by external forces, to a more nuanced understanding where the internal dynamics of the natural building movement contribute equally to the lack of advancement. Since it can take years to develop standards and certify natural building systems, measuring this outcome would not be possible within the time frame of this research project.

The research question and the objectives were therefore rephrased to a more neutral position with outcomes that while in line with the problem statement can be measured within the period of the research project. The revised research objectives firstly strive to identify transition pathways for the natural building niche to move beyond its latent state, and secondly to consider how they might transform the building sector regime.

2 Defining a latent technological niche

A central concept of this research is the idea of a 'latent technological niche'. In the language of transition theory, an innovative technology that offers a solution to societal needs that radically contrasts with and often challenges the dominant socio-technical regime is termed the technological niche. The technological niche is closely attuned to new expectations created by new or changing macro environmental factors; more specifically those factors associated with sustainability operating at the landscape level.

I append the term 'latent' to differentiate a particular type of technological niche from that typically discussed in transition theory. This differentiating characteristic is the apparent inability to break into the mainstream market despite achieving technological maturity and constant though minimal market share. By describing a technology as latent, the focus of the research goes beyond determining success or failure. Instead the unsuccessful break into mainstream is acknowledged upfront and effort is focussed on identifying the systemic processes or lack thereof that perpetuate the latent state. The outcomes of this approach are arguably more relevant for practitioners in the latent technological niche searching for guidance on where to focus their limited resources.

3 Broader insights gained from the research project

Undertaking a research project, particularly under the auspices of an academic organisation, produces an aura of credibility and standing. The research project has value in and of itself that provided me access to individuals and organisations that ordinarily may not have availed themselves.

To select participants for the case study, I had through necessity, to resort to snowball sampling. This proved useful not only to include participants with backgrounds in the relevant organisations but more importantly, the participation of key persons, and their introductions encouraged other key people to participate in the project.

The research focussed on the building sector as the dominant regime in relationship with the natural building movement, however a crucial entry barrier is created by another regime; one so entrenched it is a dominant worldview. This is the view and expectation that all organisations must strive to be self funding if not profit driven, including those supposedly established for the common good, like certification bodies. For technology innovators with a propriety product a large upfront capital investment, to secure certification, presents no problem as they expect to reap the rewards through their control and direct benefit from the wider adoption of their product. For non-proprietary building systems this is problematic, since those providing the large upfront investment to secure certification will not control or directly benefit from the wider adoption and are not ensured a return

on their investment. This creates a bias in favour of proprietary systems and discourages systems developed for shared benefit.

South Africa hosts a number of informal or shadow socio-technical systems that operate in parallel to the formal systems developed from first world models. An example is the duality between formal and informal urban settlement and the different rules of each that govern the construction of dwellings. This duality introduces a level of uncertainty in the conclusions of research on socio-technical systems. The conclusion to this research suggests that the building sector is undergoing a transformation or possibly a reconfiguration type of transition. This is true where society complies with the regulations and standards. In the shadow system of informal settlements where the formal building sector institutions have little say, the path of transition resembles more the start of either a substitution, shacks being the dominant building system; or de-alignment and re-alignment, where a dominant accepatble building system has yet to appear.

Two research methodologies where applied in this thesis; a critical literature review, and an action research experiment. Both identified the transformation pathway as the probable transition typology for the building sector and adoption of natural building practices. However the action research experiment produced a richer data set that clearly supported this conclusion. At the same time the production of this data by niche-regime actors directly influenced the future development of the natural building movement. The same cannot be said for the literature review, which is unlikely to have the same influence in modulating the development of sustainability practices in the building sector.

4 Importance of this research

The socio-technical regime as a dynamically evolving system. Regime and niche level actors interpret, implement and revise their respective practices and rule sets in response to one another and the influences of changing landscape forces. Action research involving these actors taps directly into their immediate experiences, knowledge, perceptions and processes that produce the dynamic socio-technical system.

The application of action research methods in the natural building case study produced a number of valuable outcomes. Firstly, the data informing the study reflected prevailing conditions in the relationships between the building sector regime and the natural building niche. Secondly, the factors that have the largest influence in the system in perpetuating the latent state where identified (lack of natural building organisational structure and undeveloped internal processes). Thirdly, niche actors became aware of the internal undeveloped and under-developed internal processes that require attention. Fourthly, these niche-actors intend to act on this knowledge to develop these

process, thereby advancing the natural building movement towards overcoming entry barriers. A fifth outcome, the facilitated social learning increased 1st and 2nd order learning while deepening the social network of the niche to include potentially supportive champions within regime institutions. Finally, this action research experiment provides a useful method for further research to examine and positively influence other latent technological niches.

5 Further research

Further research is required in four areas. Firstly, examination of literature and case studies of alternative building systems employed in urban and rural informal settlements to understand and describe this socio-technical system as a shadow to the formal building sector. Secondly, undertake further research into natural building by applying the proposed latent technological mediation approach in different regions in South Africa, including both single interest and multi-stakeholder groups. Research experiments with single interest, where only advocates of natural building systems participate, are likely to produce different findings. Experiences, principles and views that natural building advocates are more willing to share among like minded people.

Thirdly, undertake life cycle assessments of natural building systems: practices, rule sets, material sources, and processing to establish the extent of their sustainability credentials. Finally, explore the potential benefits of applying the latent technological mediation approach on other technological niches to assess the relationship between stakeholder diversity and transition pathway preferences, and the consequent influence of stakeholder diversity on advancing latent technological niches.

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Appendices

Appendix A: Research Interviews

Interviewees	Representation	Background	Date: Time
Alastair Armstrong	Personal views	AM Solar – natural builder & solar PV	14/02/13 10:00
Sonia Armstrong	Personal views	InSynch - natural builders	14/02/13 10:00
Joanne Reynolds	Personal views	Century Properties - green architect	14/02/14 10:30
Mike Beukes	Personal views	Rammteck – natural builder	14/02/14 13:00
Nick Ralphs	Personal views	Tierra projects – natural builder	14/02/16 11:00
Paimaan Byron	Personal views	NHBRC – Structural engineer (Lab manager)	14/02/17 10:30
Paul Cohen	Personal views	Tlholego Ecovillage – natural builder	14/02/21 10:00
Ilse Kotze	Personal views	City of Tshwane: Deputy Director: Environmental Regulatory Services	14/02/24 10:00
Joe Kondos	Personal views	Professional Valuer of Innovative building technologies (ABSA)	14/02/27 12:00
Llewellyn van Wyk	Personal views	CSIR – Principle researcher building technologies	14/03/04 09:47
Jeremy Gibberd	Personal views	CSIR – researcher building technologies	14/03/04 11:22
Modise Maimane	Personal views	City of Tshwane City Planning: Building control officer	14/03/12 10:00
Andy Horn	Personal views	Eco Design – Architects & Consultants – Natural building architect	14/04/14 11:00
Julie Clark	Personal views	DBSA – Environmental advisor and fund manager	14/04/24 19:19
Glenn Havemann	Personal views	Retired from DBSA – Sustainable development in construction	14/04/24 20:15
Dr Jeffrey Mahachi	Personal views	NHBRC – Advisor special projects – IBT	14/04/29 10:30

Appendix B Issues Capturing - Individual Feedback To Group

AppTable 1: Partner reported issues (Sheet 1 of 4)

Indirect reporting - partner issues	SHEET (1) OF (4)
Text as captured on sheet	**Explanation of issue**
• MODULARISATION	• Methods to modularise Natural Building systems are needed.
• CERTIFICATION – NB	• Certification of Natural Building systems is required
• TESTING NB	• Methods suitable for testing Natural Building Systems are required.
• IMPROVE / DEV EB QUALITY (UNSTABILISED)	• Research must be done to improve and develop the quality (durability, structural integrity) of unstabilised Earth Building.
• RESEARCH FUNDING	• Funding must be secured for research into Natural Building systems to demonstrate and improve knowledge of their performance.
• CULTURAL ASSOCIATION – NB	• How Natural Building is practised must be considered as being closely associated with cultural background.
• SKILLS COMM. + PROF.	• Skills of both communities and professionals (currently limited in range and depth) influence the how Natural Building is implemented.
• NB ASSOCIATED WITH COMM.	• The implementation of Natural Building is often a community effort and Natural Building is often closely associated with community effort.
• RESISTANCE (MUN) APPROVAL	• There is resistance among authorities, municipalities, to approve natural Buildings.
• “[ditto] TO NEW	• There is a general resistance to the “New”, to the unfamiliar.
• LIFE SPAN	• What is the life span on Natural Buildings?
• MAINTENANCE	• What are the maintenance requirements for Natural Buildings?
• DEMAND	• Is there a demand for Natural buildings?
•	•

Issues captured in a clockwise direction. Participants reported one or more issues raised by their discussion partner from the prior listening exercise.

AppTable 2: Partner reported issues (Sheet 2 of 4)

Indirect reporting - partner issues	**SHEET (2) OF (4)**
Text as captured on sheet	**Explanation of issue**
• PAYMENT FOR KNOWLEDGE	• Practitioners must be paid for their knowledge.
• NO FREE CONSULTATIONS	• Natural Building practitioners cannot afford to provide endless free advice.
• PERCEPTION – NB IS CHEAPER	• There is a perception that Natural Building is cheaper (this is not necessarily so).
• CHANGE BUILDING STANDARDS → BONDS	• Building standards must be changed urgently to allow clients access to bonds to build Natural Buildings.
• DIFF. MATCH CLIENTS TO NB TECH • FAMILIARITY	• It is difficult to find and match clients with Natural Building technologies, this is a problem of low familiarity with Natural Building.
• ADOPT NB STANDARDS!!	• Standards for Natural Building must be adopted!
• NO NB INDUSTRY. DIFF TO PRACTICE	• There is no Natural Building industry, without standards its difficult to practice.
• VARIABLES = HIGH RISK • (ENV. SOC. FIN)	• Natural Building involves a number of variables that result in a high level of risk, environmental, social, and financial risks.
• LEGIS. TO PROTECT	• Legislation is there to protect the public.
• GUIDELINES / INSTR ALLIVIATE RISK	• Guidelines and or instructions on how to construct Natural Building (methods and materials) can alleviate risk.
• ALIGN TECH TO AREA OF USE (FIT)	• Each Natural Building technology is more or less suited to particular geographical areas in terms of local conditions; soil and climate. Natural Building systems must be used where there is a goof “Fit”.
• PARAD SHIFT (TRAD. + BELIEF + STAND) PERCEIVED NORM	• A paradigm shift is necessary from the traditional beliefs and standards that together maintain a perceived norm.
• KNOWLEDGE CONS. + PROF.	• Knowledge of Natural Building construction must be increased particularly among professionals.
• ENABLING LEGIS. EXISTS	• Legislation exists to allow or enable Natural Buildings to be constructed.
•	•

Issues captured in a clockwise direction. Participants reported one or more issues raised by their discussion partner from the prior listening exercise.

AppTable 3: Partner reported issues (Sheet 3 of 4)

Indirect reporting - partner issues	**SHEET (3) OF (4)**
Text as captured on sheet	**Explanation of issue**
• CULTURAL DIVERSITY	• Debate on Natural Building must take into account the diversity of technologies and expertise associated with the cultures in SA, from indigenous wattle & daub to sun dried bricks in the Cape.
• SHIFT TRAD. → INDUS TECH	• There has been a shift in the construction of buildings from traditional to industrial technologies.
• COUNTER SHIFT ←	• There is also a shift back towards traditional technologies.
• PERCEPTION – FIN. INSTIT + AUTH – UNPROVEN TECH. ESP [AUTH] SCALE	• There is a perception among financial institutions and local authorities that Natural Building is an unproven technology especial at larger scale.
• SOCIAL + ECON ENV DOUBT - PERCEPTION	• The social, economic and environmental doubts associated with Natural Building is only a perception.
• SPEED OF COSTRUCTION!	• The speed on Natural Building construction is an important issue.
• ENV. IMPACTS! - CLAY PITS • - UNCONTROLLED	• The is a concern that Natural Building may result in environmental impacts due to numerous small and uncontrolled excavations of clay pits.
• LACK OF CONTROL! - NB • INSTIT. LIKE CONTROL	• There is no control on Natural Building. Institutions like control.
• ? TRAD. LINK (VS) PROFF KNOWLEDGE • GAP → POOR TRAD BUILDING	• There is a gap between the expertise and knowledge of traditional earth builders looking for advice from professionals who have little or no knowledge of Natural Building methods and offer inappropriate solutions. This has resulted in poorly constructed buildings using traditional building methods.
• NB FIT WELL WITH RURAL COMM. • LOCAL SKILLS DEV. LABOUR	• Natural Building as a way of building fits well with rural communities where locals skills and labour can be used for local to build local facilities.
• USEFUL PROCESS – LEARNING. SKILLS TRAIN	• Natural Building is useful as a process of transferring skills and providing training in earth and conventional building methods.
• NO RECOGNITION NB SKILLS!	• Since Natural Building is not recognised, skills and expertise gained through training are not recognised by CETA.
• LOCAL DEV AVOIDS POLITICAL ISSUES	• Local development projects working directly with the community avoids distracting political issues.
•	•

Issues captured in a clockwise direction. Participants reported one or more issues raised by their discussion partner from the prior listening exercise.

AppTable 4: Partner reported issues (Sheet 4 of 4)

Indirect reporting - partner issues	**SHEET (4) OF (4)**
Text as captured on sheet	**Explanation of issue**
• MIXED CONV. BUILD SKILLS + NB SKILLS (HYBRID)	• Natural Building projects offer opportunities for skills and training development in both conventional and Natural Building construction methods. Natural Building can be a mix / hybrid of conventional and Natural technologies.

Issues captured in a clockwise direction. Participants reported one or more issues raised by their discussion partner from the prior listening exercise.

Appendix C: Additional Issues

AppTable 5: Additional Issues (Sheet 1 of 4)

New issues / perspectives	**SHEET (1) OF (4)**
Text as captured on sheet	**Explanation of issue**
• COST - KEY PROJ. DRIVER • CHEAPER/BETTER COST COMP.	• The financial cost of projects is a key driver. Cheaper solutions are preferred over comparable ones that are better, for the environment etc.
• ADD. EXT COSTS + BENEFITS	• Must aim towards adding external costs and benefits to the equation.
• HOW MONEY IS USED	• Objectives on how money or spending is directed and to what end affects choices on Natural Building projects.
• DEMONSTRATING BENEFITS	• There is great benefit in establishing demonstration projects for people to enjoy tangible experience of Natural Buildings.
• LARGE DEMAND – DISCOURAGED BY BARRIERS • CLIENTS WITH OWN FUNDS ONLY	• There is a demand for Natural Buildings, larger than the take up. However there are barriers that only clients with cash on hand who do not require a bond can overcome.
• SKILLS EXIST – EXPERTISE LACKING	• A large number of people have received training in Natural Building methods. However there are only a few people with a depth of knowledge of Natural Building who have the expertise to design and build without external supervision or advice.
• PROFF. APPLY MOD. METHODS MAT TO NB = FAILURES	• Failures in Natural Buildings especially traditional earth buildings can be attributed to professionals who have recommended modern, cement based solutions.
• CLASH TECH. + MAT ASPIRATIONS CHARACTERISTICS OF MAT. CONV + NB	• There is a clash of technologies and materials and aspirations for different material characteristics between conventional and Natural Building.
• NEED FOR TRANSITION AWARENESS + COMMIT. → SUSTAINABLE METHODS POST CARBON	• Greater awareness of and commitment of a transition is required to ensure sustainable methods for a post carbon economy are realised.
• EDUCATION! CHANGE PERCEPTIONS	• Education of the general public and relevant institutional, professional and government decision makers is necessary to change perceptions.
•	•

New observations captured in an anti- clockwise direction. Participants raised new issues or perspectives triggered by previous round of reported issues.

AppTable 6: Additional Issues (Sheet 2 of 4)

New issues / perspectives	**SHEET (2) OF (4)**
Text as captured on sheet	**Explanation of issue**
• FUTURE NB DEMAND – ECONOMIC BARRIERS • VESTED ECON. INTEREST	• Future demand for natural Building is constrained by economic barriers due to vested economic interest, e.g. cement industry.
• POP X2 = DENSIFY → MULTI STOREY BUILDINGS • IS NB READY TO DEAL WITH [THIS]	• Population may double in urban areas will increase urban density and require multi storey buildings. Is Natural building technology ready, is there sufficient knowledge to construction multi storey buildings using Natural Building technologies?
• CRITICAL SKILLS LACKING COMM. + PROF	• Critical skills are lacking both at community level and within the built environment professions.
• WHAT CAN WE FOLLOW?	• What guides are there to follow on how to construct Natural Buildings?
• ? WHERE ARE SKILLS LISTED FOR NB	• Where is the register or list of skilled Natural Building practitioners – designers and contractors?
• PERCEPTION – DUE TO NO NORMS + STANDARDS	• Perceptions around NB are due to there being no norms and standards
• STANDARDS <u>CREATE ACCEPT</u> NORMS NB (MIN REQUIREMENTS) • <u>NOT ADOPT</u>	• Acceptable standards and norms for Natural Building must be created, that satisfy minimum requirements of the national building regulations. There are none in South Africa that can simply be adopted.
• INSTIT. OF NB • HOW DOES NBS CHANGE TO FIT WORLD REAITY DELIVERY CHAIN.	• An institute or association of Natural Building practitioners is required. • This body must determine how Natural Building systems must change to fit the world reality of a conventional building industry with an established delivery chain.
• WHAT IS THE VALUE PROPOSITION (CBA / LCA)	• What is the value proposition of natural Buildings must be demonstrated using Cost benefit analysis or Life-Cycle Assessment.
• PERCEP. ABSCENCE OF BEST. PRAC. KNOW IN PUBLIC DOMAIN	• Perceptions around Natural Building may be due to an absence in the public domain of established best practice and knowledge of Natural Building construction.

New observations captured in an anti- clockwise direction. Participants raised new issues or perspectives triggered by previous round of reported issues.

AppTable 7: Additional Issues (Sheet 3 of 4)

New issues / perspectives	**SHEET (3) OF (4)**
Text as captured on sheet	**Explanation of issue**
• UNCLEAR PICTURE HAPHAZARD • HOW TO FIT INTO A VALUE CHAIN	• The value of Natural Building remains haphazard, there is no clear picture of how it fits into a value chain.
• FOUNDATIONS	• [This point was not clear].
• TECHNICALLY BIASED SOCIAL 2nd	• Discussions on Natural Building are technical biased and place social issues second.
• IMPACTS DOWNSTREAM TECH + SOCIAL + ENV	• The downstream impacts of natural Building in terms of technologies, social and environmental impacts and benefits must be determined.
• BUILT ENV PROF INSIT. HAVE PUT FORWARD NO POSITION ON NB	• Why have the built environment institutions for example the architects put forward no position on Natural Building?

• MISSING CLEAR STRAT FOR NB
  • CONSTR SECTOR
  • COUNTRY PRIORITIES
	• A clear strategy for Natural Building is missing. This strategy must addresses the realities of the construction sector and the country's priorities.

• INDEPT. DRIVEN COLLECTIVE THOUGHT	• Seems Natural Building is driven by a collective of independent thought.
• PUTTING INTO PUBLIC DOMAIN STANDARDS + GUIDE • RISKS + FAMILIARITY • [REDUCE] PERCEPTIONS	• Establish standards and develop guidelines and place them in the public domain to reduce risks increase familiarity of natural Building and dispel perceptions.
• FUNDING NOT THERE	• There is no funding to advance Natural Building systems.

• UNLOCKING OTHER BARRIERS PERCEPTIONS BY
  • STANDARDS
  • FUNDING R+D
  • WHERE FROM?!
	• Other barriers can be unlocked and perceptions dispelled by establishing standards. However funding is required for research and development to develop the standards. A crucial constraint is where is the necessary funding going to come from?

•	•

New observations captured in an anti- clockwise direction. Participants raised new issues or perspectives triggered by previous round of reported issues.

AppTable 8: Additional Issues (Sheet 4 of 4)

New issues / perspectives	**SHEET (4) OF (4)**
Text as captured on sheet	**Explanation of issue**
• ? DURABILITY VS DEMONSTRATE ANCIENT EX.	• Durability remains a concern despite evidence of ancient examples. Examples of modern natural Buildings required.

• DEMAND? WITH NO SOCIAL ACCEPTANCE/AWARENESS
  • R+D BY GOV. →
  • KNOWLEDGE DISEM → PUBLIC BBY GOV.
  • PROMOTION OF NB
	• How will demand for natural Building increase if social acceptance and awareness is not addressed?
	• Government support is required for research and development, knowledge dissemination and promotion of Natural Building.

• FINANCE WILL REQUIRE INSTIT PROMOTION + ACC.	• Access to finance will require broader promotion and proven social acceptance of Natural Building.
• FERTILE SPACE COMM. NB NEEDS/EXP SUPPORTED/DEV. BY ACCESS TO MODERN BEST PRACTISE . UNLOCKING POTENTIAL	• Combining Natural Building with community creates a fertile space for social development possibilities. Community needs and expectations can be supported and developed by access to modern best practice to unlock this potential.
• BETTER FIT BETWEEN 1st STANDARD AND REQUIRES/NEEDS OF MAJORITY REALITY	• Need a better fit than current approach of aiming for 1st world / economy standards. An approach that better fits the needs and requirements of the majority living the 2nd world/economy reality.
• HARNESS CHEAP LABOUR	• Natural Building projects owned by communities can harness cheap or under-utilised labour within communities and convert this into social assets.
•	•

New observations captured in an anti- clockwise direction. Participants raised new issues or perspectives triggered by previous round of reported issues.

Appendix D: Key Issues to be addresses raised by groups

AppTable 9: Issue ranking by Practitioners Group

KEY POINTS	EXPLANATION

• BUILDING STANDARDS
  • APPRORIAT.
  • MINIMUM
	• Building standards are required that are appropriate to Natural Building systems and establish the minimum requirements.

• USE EXISTING TESTS • STANDARDS • BEST PRACTISE • INT. STANDARDS • CUSTOMISE ^ FOR SA	• They must make reference to existing national building standards, use existing standardised tests for earth materials, and follow best practice. The wealth of existing international standards for Natural Building can inform customised standards for South African conditions.

• FUNDING? SOURCE
  • DEV STANDARDS
  • PROMOTION
	• A major stumbling block for Natural Building systems is where to source funding for standards development and promotion of natural Building. Local individual practitioners do not have the financial resources of large corporations.

• DISPEL MYTHS
  • LACK OF KNOW.
  • RISKS
	• It is necessary to dispel the myths surrounding natural building systems. These myths influence social acceptability and confidence in Natural Building as a durable method. Dispelling myths will reduce perceived risks.

• PROF. BODY/IND.
  • RECOGNITION
  • LOBBY/VOICE
	• A professional body must be established to give recognition to the Natural Building industry and provide it with a stronger voice to lobby for change.

• PART Y NBS	• A new standard set of standards for Natural Building systems must be developed called possibly Part Y.
•	•

Key issues raised by the practitioner group comprised of contractors and professionals active in Natural Building projects.

AppTable 10: Issue ranking by Institutions Group

KEY POINTS	EXPLANATION
• STANDARDS/GUIDELINES • FRAG → COMMON	• A common set of standards and guidelines is required for natural Building. Currently it appears fragmented originating from multiple individual practitioners and international references.

• NEW PROF.?
  • BAREFOOT ARCH/Blde
  • INTERMEDIATE ARCH
	• A new profession may be required. Somewhat like the approach of a barefoot architect. Someone that has both design and construction experience in Natural Building systems and can act as an interface between professionals and contractors, consulting to both.

• NHBRC EXPANDED • INCLUDE NBS	• The NHBRC manual must be expanded to recognise Natural Building Systems.

• REVIEW BUS. MODEL
  • VALUE CHAIN
  • LOW COST MAT → HIGH DEMAND
	• The Natural Building “industry” must review the business model and establish how Natural Building fits into the value chain and how by using low cost materials it can create / match high demand for affordable housing.

• GOV. PROC. POLICY • GREEN PROC. NBS	• The Natural Building “industry” must examine government's procurement policy and identify criteria that support Natural Building systems particularly those criteria that are informed by government policies for green procurement.
• GREEN NBS INT./PREF RATES	• The idea of preferential interest rates for Natural Building as a green technology must be explored and promoted.
• DEMONSTRATION PROJECTS	• Real world exemplary Natural Buildings must be identified and used as demonstration projects.
• INCREMENTAL R+D + IMPLEMENTATION • LEARN BY DOING	• An incremental approach should be considered where research and development is applied in an incremental fashion rather than delay implementation until a perfect system is developed. Learn by doing.
• TARGET GOV. SPENDING PROJ.	• The Natural Building “industry” must target government spending, develop solutions that align with and satisfy spending criteria where government is currently committing budgets.
• SUBSIDIES – GOV. • EXIST. SUB. MAT.	• Existing government subsidies for materials should be identified while advocating for new subsidies on natural materials.
• FULL COST ACCOUNTING	• The benefits of Natural Building over conventional solutions can better be demonstrated by means of full cost accounting comparisons between conventional and natural Building solutions.
• INCENTIVES TAX • SUBSIDIES	• Identify and advocate for government incentives, whether tax or subsidies, in favour of Natural Building systems.
• BANKS – PROVIDE RISK MATRIX - FORMAT	• Banks assess risk using risk matrices. The Natural Building “industry” should develop risk matrices with measurable criteria for Natural Building systems, according to the recognised banking format.
•	•

Key issues raised by the institutions group comprised of government, private sector and academic role players that have an indirect influence on the building sector and Natural Building.

AppTable 11: Issue ranking by Regulators group

KEY POINTS	EXPLANATION

• CURRENT LEG.
• AZ4 ADDRESS NBS
  • D-T-S B+M
  • RATIONAL DESIGN
  • FIT FOR PURP AGRÉM
  • NEED D-T-S FOR NBS
	• Current legislation, the AZ4, exists and deals with Natural Building systems.
	• There are three recognised routes for building approval:
	  • deemed to satisfy (based on Bricks & Mortar)
	  • rational design by a competent person, structural engineer or architect, and
	  • demonstration that system or material is fit for purpose through Agrément Certificate.
	• However a deemed to satisfy route is required for Natural Building systems.

• PROTEC H+S PUBLIC
  • R+D
  • TESTING
  • CERTIFICATION
	• The purpose of building regulations is to protect the public in terms of health and safety. This can be achieved for Natural Building systems through research and development, testing of systems and materials and through certification.

• ADEQUATE
  • LIFESPAN
  • MAINTENANCE
  • H+S OCCUP.
  • [REDUCED] CO_2
	• Natural Building systems must deliver buildings with an acceptable lifespan and reasonable maintenance requirements. These buildings must satisfy health and safety requirements for occupation and show reduced CO_2 emissions.

• PERCEPTION
  • NBS IS “GREENIE”
  • → NORMALISATION
	• There is a perception that Natural Building systems is a “greenie” concern. This can be addressed by normalisation, by developing standards, specifications, guidelines etc. as is done in conventional building.

• HAVE X
  • HOW TO DO IT FOR NBS
  • SANS 10400 X?
	• A new standard Y is not required. There exists a part X which addresses sustainability issues. The question is how to accommodate Natural Building systems in the existing framework.
	• What is perhaps required is a new part in SANS 10400 X that addresses sustainability of building materials and would include Natural Building systems.

•	•

Key issues raised by the regulations group comprised of role players that develop or enforce standards and regulations in the building sector.

AppTable 12: Side by side issue ranking of three groups

PRACTITIONERS	INSTITUTIONS	REGULATORS

• BUILDING STANDARDS
  • APPRORIAT.
  • MINIMUM
	• STANDARDS/GUIDELINES
	  • FRAG → COMMON
		• CURRENT LEG.
		• AZ4 ADDRESS NBS

• USE EXISTING TESTS
• STANDARDS
• BEST PRACTISE
• INT. STANDARDS
• CUSTOMISE ^ FOR SA
	• NEW PROF.?
	  • BAREFOOT ARCH/Blde
	  • INTERMEDIATE ARC
		• D-T-S B+M
		• RATIONAL DESIGN
		• FIT FOR PURP AGRÉM
		• NEED D-T-S FOR NBS

• FUNDING? SOURCE
  • DEV STANDARDS
  • PROMOTION
	• NHBRC EXPANDED
	  • INCLUDE NBS
		• PROTEC H+S PUBLIC
		  • R+D
		  • TESTING
		  • CERTIFICATION

• DISPEL MYTHS
  • LACK OF KNOW.
  • RISKS
	• REVIEW BUS. MODEL
	  • VALUE CHAIN
	  • LOW COST MAT → HIGH DEMAND
		• ADEQUATE
		  • LIFESPAN
		  • MAINTENANCE
		  • H+S OCCUP.
		  • [REDUCED] CO_2

• PROF. BODY/IND.
  • RECOGNITION
  • LOBBY/VOICE
	• GOV. PROC. POLICY
	  • GREEN PROC. NBS
		• PERCEPTION
		  • NBS IS “GREENIE”
		  • → NORMALISATION

• PART Y NBS	• GREEN NBS INT./PREF RATES	• HAVE X
•	• DEMONSTRATION PROJECTS	• HOW TO DO IT FOR NBS
•	• INCREMENTAL R+D + IMPLEMENTATION • LEARN BY DOING	• SANS 10400 X?
•	• TARGET GOV. SPENDING PROJ.	•
•	• SUBSIDIES – GOV. • EXIST. SUB. MAT.	•
•	• FULL COST ACCOUNTING	•
•	• INCENTIVES TAX • SUBSIDIES	•
•	• BANKS – PROVIDE RISK MATRIX - FORMAT	•

Key issues identified by groups in breakaway sessions and reported back to to the main group.
* Key issues in table text as captured on flip-chart sheets. See following pages for explanation.
Breakaway groups comprised of participants according to their best fit within three sectors:
Practitioners - *include contractors and professionals active in Natural Building projects.*
Institutions - *include government, private sector and academic role players that have an indirect influence on the building sector and Natural Building*
Regulators - *include role players that develop or enforce standards and regulations in the building sector.*

Appendix E: Recommendations to address Key Natural Building Issues

AppTable 13: Strategies for Key Natural Building Issues

KEY POINTS	EXPLANATION

• EST. BODY INDUSTRY/INTEREST GROUP
  • FUNDING| SECURING BY GROUP
  • DEV/ACCEP STANDARDS
	• Establish a Natural Building industry or interest group. This group must secure funding and develop acceptable standards for Natural Building systems.

• INCORPORATE ALL CRITERIA NOT JUST STRUC • BY ENG PROF TEAM	• These standards must incorporate all performance criteria required by professional engineering team not just structural.
• LOBBY GOV. FOR SUPPORT	• Body to prioritise lobbying government structures for support, financial and access to government institutions.
• DEMONSTRATION PROJ.	• Identify and prepare a register of demonstration projections.

• MANDATE|REF OF BODY
  • ALL PROJ. SCALES
  • SINGLE|MULTI PROJ.
	• The body must specifically include in its mandate and scope projects of all scales from single to multi building developments.
	•

• WHERE IS VALUE ADDED • – ANSWER /TARGET e.g. “GREENING” NDP	• Determine where Natural Building adds value then target government and institutional projects and programmes where those “values” are integral to their success. Such as greening of the economy, green procurement and the National Development Plan.

• FOCUS | GOVERNANCE + DEV. NATIONAL NORM STANDARD
  • PROCESS – FOLLOW EST./CORRECT PROC.
  • TC60 NEW WORKS ITEM
	• The focus of the body must be to understand the governance and development processes for national standards and norms. Understand the established process and follow correct procures to introduce a new works item through the TC60.
	•
	• Make use of existing networks to learn how the processes and procedures work.

• PR + MARKETING STRAT – WHY NBS?	• Develop a public relations and marketing strategy that address the question – “Why Natural Building systems?”.
• ADVOCACY + EDUCATION • PROF. COMM. GOV.	• Develop advocacy and education programme that targets professionals, communities and government.
• CLEARLY DEFINE VALUE CHAIN	• Develop a clearly defined value chain within the Natural Building industry integrated with existing values chains in the conventional building industry.
• BASIC ACCESS|FREE TRAINING SETA'S	• Raise broad awareness and credibility by providing free training, using funds available from the SETA's.
• GROWING PARTNERSHIPS • DEMOMSTRATION PROJ.	• Grow partnerships and arrange for completed Natural Buildings to be opened as demonstration projects for awareness raising visits.
• LEARN FROM GBC, CIDB … • HOW TO GET FUNDING	• Learn how other organisations in the building sector, such as the green Building council, the Construction Industry Development Board, managed to get funding.

KEY POINTS	EXPLANATION

• LEARN FROM SASTF. → SANS 517
  • ACCREDITATION
  • ENSURE CONSIST. QUAL.
  • MANUAL
	• Learn from the experiences of the South African Light Steel Frame Building Association (SASFA) that developed SANS 517. They dealt with accreditation of members, monitoring to ensure consistent quality, developed a manual.

• RISK MANAG. - REDUCTION	• Actively identify areas of risk or perceived risk and develop strategies to reduce risks.

• TC60 OVERARCHING BODY OF NBR
  • INTER|MEETING
  • SABS WORK TEAM
	• A new technical committee TC60 is the overarching body for the national building regulations.
	• An introductory meeting with TC60 can be arranged.
	• Propose / motivate for a Natural Building work team for SABS with Natural Building seat.

• CLEAR V. C. PROP.	• Present a clear value chain proposition for Natural Building in the South African context.
•	•

Recommendations provided directly by participants on a turn-by-turn basis working in a clockwise direction until no further contributions where made.

Appendix F: Focus group meeting - attendance register

ATTENDANCE REGISTER

Mainstream Adoption of Natural Building Systems: A Transition Process

To Be Held On: 2014-05-12 at 08:00 to 12:00

Ulwasi Meeting Room Knowledge Commons CSIR Campus Pretoria

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