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INTRODUCTION

THE STRUGGLE FOR INTEGRATED SUSTAINABLE SETTLEMENTS

By Lisa Thompson-Smeddle (Sustainability Institute) and John Roux

In South Africa, examples of sustainable human settlements, though promoted by government policies, are few and far between. This is primarily due to the continued predominance of old approaches to township planning, infrastructure and housing design, and a lack of cross-sector integration and collaboration. Planners seldom design neighbourhoods with a view to their long-term environmental, social and economic sustainability, and apartheid spatial constructs and financial constraints mostly overrule integrated approaches to holistically designed settlements.

This situation is exacerbated by the fragmentary approach to professional education, where engineers, architects, planners, social scientists and environmentalists are trained in isolation from one another. Few are trained to see settlements holistically as integrated, resource-efficient social and economic systems embedded in natural ecosystems. In most cases settlements are designed and constructed to squeeze as much infrastructure and as many low-cost, stand-alone units as possible out of a limited capital budget. This excludes designs and solutions such as renewable energy options, water and energy efficiency and waste recycling, which can result in significant cost-savings for households and municipalities over time, and can reduce negative environmental impacts and externalized costs.

The transition to more sustainable practices will not be easy, particularly in the low-cost housing sector, though the technologies and models are proven and available. Built environment professionals, government officials and community members all have a vital role to play in making the shift toward building more sustainable settlements and neighbourhoods. Apart from the above constraints, housing delivery agents face other challenges as well. Defining sustainability in settlement and neighbourhood planning can be a confusing and arduous task in itself. In South Africa, sustainable design principles and guidelines are a relatively recent development and there are few local examples that demonstrate their successful implementation and benefits.
Any settlement development or upgrading plan should include not only short-term physical and economic objectives, but long-term social, environmental and economic development goals that are agreed by all stakeholders in the particular context. According to Loots and Irurah (2005),

“… the absence of tools and mechanisms which systematically link sustainability criteria, targets and assessment outcomes with decision-making processes significantly inhibits the transformation from conventional to sustainability practice in the built environment.”

Though there are many challenges in rolling out integrated, ecological developments, things are beginning to change. In September, 2004, the National Department of Housing launched its new housing policy, Breaking New Ground (BNG), which aims to dramatically change the status quo.

BNG introduces a radical shift from the ‘quantity over quality’ mindset entrenched in subsidised housing delivery and points to participative, multi-dimensional approaches which enable people to become participants in creating sustainable human settlements, rather than being mere recipients of an RDP house. Multiple funding mechanisms have also been introduced which enable the purchase of land, the roll out of infrastructure, varied housing finance options, housing typologies, and social facilities for vulnerable communities.

Other national and local responses to the need for the more sustainable design and construction of settlements include:

- Department of Environmental Affairs and Tourism guidelines promoting sustainability in municipal integrated development planning
- the establishment of the South African Green Building Council and packed audiences at national green building conferences
- the keen interest in Australian eco-labelling systems for building materials, which are being explored for adaptation in the South African context
- the increasing availability of green products, goods and services, and their promotion in mainstream media
- increasing numbers of professionals and ordinary citizens interested in sustainable alternatives
THE NEED FOR SUSTAINABLE DEVELOPMENT

There is growing global awareness of the need for sustainable development to address the looming environmental problems of global warming and climate change driven by human activities, emissions and resource depletion. The outcomes of United Nations environment and development conferences include international agreements to implement sustainable development, signed by an overwhelming majority of nations. Sustainable development needs, principles and practices gained global exposure through the Rio Earth Summit in 1992 and were enshrined in the Agenda 21 and Local Agenda 21 Programmes.

Progress in implementing Agenda 21 and LA21 was reviewed and action programmes were drafted at the World Summit on Sustainable Development (WSSD) in Johannesburg in 2002. However, the implementation of legislation, policies and regulations that require sustainable planning and practices, and that hold municipalities, the private sector and consumers accountable for unsustainable practices has been a slow process in South Africa.

DEFINING SUSTAINABLE DEVELOPMENT

The most widely accepted definition of sustainable development is “development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs.” (United Nations World Conference on Environment and Development, 1987).

The UN Commission on Human Settlements states that “Sustainable human settlement development ensures economic development, employment opportunities and social progress, in harmony with the environment.” It incorporates the key principles of the Rio Declaration on Environment and Development (Agenda 21) and of the UN Conference on Environment and Development, i.e.:
• a precautionary approach
• pollution prevention
• respect for the carrying capacity of ecosystems
• preservation of opportunities for future generations.

Production, consumption and transport should be managed in ways that protect and conserve stocks of resources while drawing upon them. Science and technology have a crucial role in shaping sustainable human settlements and sustaining the ecosystems they depend upon. The sustainability of human settlements entails:

• balanced and appropriate geographical distribution in keeping with national conditions
• promotion of economic and social development, human health and education
• conservation of biological diversity and the sustainable use of its components
• maintenance of cultural diversity as well as air, water, forest, vegetation and soil qualities at standards sufficient to sustain human life and well-being for future generations.

Sustainable Development Policies in South Africa

South Africa’s national policy framework (DEAT, 2008) defines Sustainable Development as the: “…integration of social, economic and environmental factors into planning, implementation and decision-making so as to ensure that development serves the present and future generations.” The framework goes on to say that “Sustainable Development that is appropriate and specific to the South African context will entail shared and accelerated growth, targeted interventions and community mobilization to eradicate poverty and ensure the ecologically sustainable use of our natural resources and eco-system services” (DEAT, 2008).

The South African vision is also guided by fundamental principles of democratic governance, social equity and human dignity, fairness and justice (DEAT, 2008). The framework includes the following principles:

• socio-economic systems are embedded in ecosystems
• basic human needs must be met
• long-term sustainability must not be overridden by short-term gain
• natural resources must be used sustainably.

The framework also lists the process principles of innovation, integration, participation and consultation, coupled with phased-in implementation (DEAT, 2008). This framework is rooted in premises of equity and maintaining the integrity of all forms of capital, so that economies, societies and the environment are protected. Key forms of capital are natural (environmental), social, physical (assets), financial and human capital.

DEAT has developed appropriate policies for environmental protection, pollution reduction and sustainable waste management, but implementation at local level has been slow. The Department of Water Affairs and
Forestry (DWAF) has also developed excellent legislation and policies for the management and protection of water resources, and to ensure water services and drinking water quality for all, but again the challenge is local implementation and compliance.

SUSTAINABLE SETTLEMENTS AND NEIGHBOURHOODS

Shelter is one of the most important basic human needs, and throughout history people have built shelters and settlements using local and natural materials. In our globalised world modern technology, transport and access to abundant cheap energy have allowed us to access resources from great distances. However, these methods of manufacturing and supplying goods and services have compromised local social, ecological and economic systems, and have reduced the planet’s ability to sustain the provision of limited natural resources.

Despite technological advances, the human need for shelter has not changed considerably. The modern challenge is to adapt technological solutions to reduce negative environmental impacts, while providing comfort, access to jobs and necessary services.

Sustainable design elements are found in vernacular architecture worldwide. According to the Vernacular Architecture Society of South Africa (VASSA), vernacular architecture is “Building in indigenous styles, constructed from locally available materials, following traditional building practices and patterns, and not architect-designed.”

Simple, tried and tested, age-old principles which today would be termed “sustainable” have been around for centuries. There is a vast difference between old and modern settlements and house designs, but there is little evidence that modern SA settlement planning and building designs are healthier, more comfortable, less expensive, safer or more durable. Our challenge is to rediscover lost principles and select solutions which are appropriate to our climate, culture, ecosystems and social context, and combine these solutions with appropriate modern technological solutions.
In December 2008 the Sustainability Institute and the National Department of Housing signed a Memorandum of Agreement for a joint three year programme to give effect to government’s commitment to implementing its Breaking New Ground policy and sustainable settlement development.

Outcomes of Phase 1 and 2 of this programme include comprehensive skills development via training within provincial and local government, developing and sharing knowledge and experience through planning guides, handbooks, workbooks and other publications, and developing and sharing knowledge in areas of expertise such as:

- how to plan and develop integrated and sustainable communities
- sustainable technologies, construction methods and materials
- how to develop incentives for sustainable technologies
- how to promote sustainable local economic development
- how to measure sustainability

This manual serves as an output for Phase 1 of the above mentioned programme, and provides an overview of processes and interventions in the design and development of sustainable human settlements.
“A house is a home when it shelters the body and comforts the soul.”

Phillip Moffitt

With the backdrop of definitions listed in Chapter 1, how would one define sustainable housing? The Vernacular Architecture Society of South Africa (VASSA) defines vernacular architecture as, “Building in indigenous styles, constructed from locally available materials, following traditional building practice and patterns, and not architect-designed.” (VASSA. 2008). Though this definition is also applicable to sustainable housing design, there are many other considerations when applying sustainability criterion to housing.

Housing is embedded in a set of natural systems that provide key eco-system services. It is imperative that the relationship between housing and natural systems is understood and taken into account when planning...
and building houses and settlements. Daly (1996), for example, emphasizes the difference between growth, defined as an increase in size or quantity (e.g. of populations or resource throughput) and development, defined as qualitative improvement. Growth will ultimately run up against finite limits, since we only have one Earth. William Rees (1996) introduced the notion of humanity’s Ecological Footprint, the total land and water area needed to support the global population. Currently, our collective footprint is calculated as nearly 25 per cent greater than the capacity of the biosphere to support us (Heinberg, 2007).

Environmental economist Herman Daly has suggested three conditions for sustainability, focusing on the resource base (Meadows, Meadows and Randers. 2004):

- the rate of use of renewable resources must be less than or equal to their rate of regeneration;
- the rate of use of non-renewable resources must be less than or equal to the rate at which they can be replaced by sustainable renewable resources;
- the rate of pollution emissions must be less than or equal to the rate at which they can be absorbed and processed by the environment.

In terms of the above definition, housing will stand in a sustainable relationship to the natural systems within which they are embedded if their rate of usage of both renewable and non-renewable resources, as well as their rate of waste output, is as expressed above. There are concrete implications arising from this point for:

- the source of energy supplied to households
- the management of household energy demand
- the source of water supplied to households
- the management of water consumption by households
- the disposal and recycling of waste generated by households

The economic and social dimensions of sustainable housing practice have been further articulated by Irurah (Syn-Consult Africa. 2006), who argues that sustainable housing practice also embraces socio-economic empowerment and affirms cultural identity, while recognizing the need for institutional facilitation and resource efficiency. In this view sustainable housing practice:

- balances the technical aspects of constructing housing with the critical need for appropriate, decent and affordable shelter within broader communities and metropolitan areas
- balances the technical aspects of constructing housing with the requisite institutional frameworks for housing delivery
- is delivered in a co-evolutionary process between empowered participants engaging with government, understanding and utilizing appropriate technologies and moving away from the conventional one-size-fits-all approach to housing delivery.
Economic and social Indicators of sustainable, affordable and social housing are necessary to measure the performance of housing delivery agents against the objectives referred to above. To enable the definition of performance indicators it is useful to view housing as an asset that needs to be valorized, in both its perceived and its economic value; likewise, it is also useful to measure the extent of informed participation by the users of housing in its provision. Defining the indicators for measuring these variables is a process for which there should be a clear starting point. It is argued that the following four conditions of economic and social sustainability of housing should form the point of departure for defining performance indicators:

- The long-term economic value of the asset should be more than the total financial, environmental and social liabilities secured by the asset
- The ongoing economic, environmental and social costs of physically maintaining the asset and the necessary services that support its residential function must be affordable to the primary stakeholders, namely the state and the household
- The location, design and live-in security of the asset should reflect perceived value by its market
- Households should demonstrate an understanding of the above three items

Many of the principles discussed above resonate with the innovative housing policy, Breaking New Ground, which will be discussed below.
Traditionally, delivery of housing to middle and upper income housing classes has been left almost entirely to for-profit developers operating via traditional market mechanisms and mortgage-secured financing, while housing for the urban poor has been regarded as a welfare function, directly facilitated by the state. This dualism in housing policy and delivery systems underlies the fact that the housing delivery processes aimed at the needs of the urban poor suffer from severe capacity problems and cannot draw on the resources located in the traditional housing and property markets. This is not sustainable.

In contradistinction to the dualism referred to above, a holistic housing strategy should channel substantial allocations of subsidies via mechanisms that enable access for the poor to established housing and property markets. Following the 1994 White Paper on housing, state policy under Joe Slovo (then national minister of housing) and Billy Cobbett (then director-general in the national department of housing) attempted to achieve the above objective through providing subsidies for developers to deliver houses for the poor, but this was only partially successful.

The root cause of the problem was – and still is - land policy; the poor were settled in economically dead, peripheral zones, where land was cheapest, hence justifying housing that could be affordably covered by the state’s capital subsidy. This resulted in mass subsidised housing estates emerging on the urban peripheries, effectively segregated from the middle and upper income housing which was better located in relation to urban facilities. This was in direct contradiction to the central principle of sustainable housing for the poor, namely that they should be located within urban spaces where land values are driven by active market forces.

In contrast, the National Department of Housing’s Breaking New Ground (BNG) policy emphasises the need to create integrated human settlements. BNG intends for geographical spatial integration of all residential communities and the accompanying necessary social facilities, places of work, etc, through the state intervening in property markets, by making land available at affordable prices and through providing subsidies to affect the structure and outputs of the housing markets. In line with BNG the Cape Town IDP (CCT. 2007), for example, has identified seven strategic areas of focus, one of which is integrated human settlements. The core objectives for integrated human settlements include:

2 The reason for the peripheralisation of subsidised housing is that land reform after 1994 was defined purely in terms of “rural land”, i.e. the agrarian question, and then allocated to the Department of Agriculture and Land Affairs. Land reform was not applied to the urban context, resulting in the marginalisation of the urban poor to the urban peripheries, despite the obvious dysfunctionalities of locating housing on the urban peripheries relatively far away from work opportunities and social facilities, subsidised as a welfare function with the private sector as implementer. This was the context that prevented the creation of integrated communities (in race and class terms).
• Improve and develop integrated human settlements through:
  • transforming dormitory suburbs into areas which support a greater mix of land uses, offer a range of amenities and have socially mixed facilities
  • putting in place policy and spatial planning frameworks that will facilitate the development of integrated human settlements
  • developing and implementing an incremental housing programme

• Deliver housing opportunities through:
  • developing new housing opportunities
  • increasing rental stock via social housing partnerships
  • redressing land ownership inequities by providing housing based on restitution claim settlements
  • facilitating gap housing programmes through partnerships with banks and private sector developers
  • developing and maintaining zoned public open spaces, cemeteries, resorts, etc...

While the BNG discourse includes reference to sustainable, integrated human settlements, there is still no specific reference to natural resource usage in relation to the ecosystem goods and services on which settlements depend. The challenge is to interpret the meaning of sustainable resource usage in relation to the sustainability of the natural environment and ecosystems within which housing delivery and human settlement are symbiotically located. Therefore this chapter gives substance and meaning to the “sustainable” part of BNG, by describing the housing-related technologies that enable sustainable resource usage per residential household.

From a sustainable resource use perspective, the historically past and recent housing developments in South Africa’s cities were generally undertaken in an extremely unsustainable way - massive urban sprawl and the destruction of potentially productive land, low numbers of housing units per kilometre of infrastructure line (energy, water, sanitation, storm water drainage, roads, rail, etc), rising levels of waste output, increasing levels of energy and material use, etc. Indeed, as the urban poor were located further and further outside of the city, so too did transport subsidies increase (Behrens & Wilkinson. 2003) thus increasing the dependence of the poor on rapidly increasing oil prices. Similarly, no provision was made for the fact that water and energy resources in our cities are facing depletion and infrastructural systems are overloaded.
Many South African metros and municipalities are facing the twin challenge of massively expanding the size of their formal housing stock to meet the needs of the poor, and a simultaneous increase in demand of middle class markets. However, cities must begin to recognise and remain within accepted ecological limits with respect to energy, water, landfill space, sewage disposal, food supplies and biodiversity.

The challenge is to imagine a massive housing programme in South Africa which:

- provides safe, quality, well-located housing for the poor
- complies with densification policies (which may be too moderate)
- utilises a range of new technologies and design features (enforced through bylaws) that massively reduce the average amount of energy, water, materials and use of sinks (landfill space, air space for pollution, emissions, etc) that each house needs over its life cycle
- boldly intervenes in the agricultural food chain to localise food supplies and thus create markets for urban agriculturalists and peri-urban small-scale farmers.

It is critical that sustainable design criterion are followed, and appropriate technologies are used in sustainable settlement roll-outs. Sustainable design criterion should include the following:

- Thermally efficient design
- Sustainable building materials
- Energy efficiency
- Renewable energy options
- Sustainable water and sanitation systems
- Waste minimisation and recycling

These sustainable resource use interventions should be aligned with the pro-poor approach in BNG, through creating a benchmark that excess consumers must aim to achieve via reduction, and under-consumers (due to poverty/inequality) aim to achieve via access to public goods, subsidies and markets. For example, household consumption of energy could be pegged at 350 KWh per square metre per year and in the commercial sector the average KWh per square metre per year can be pegged at 282 KWh (De Villiers Leach. 2008).

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3 Some of these sustainable resource use interventions are discussed in more depth in other chapters and are included here purely to provide a more complete overview.
In “A Sourcebook of Integrated Ecological Solution,” Janis Birkeland explains that present built environment configurations are the result of modern, industrial modes of development, rooted in fossil fuel and non-renewable resource use (Birkeland. 2002). This is inherently unsustainable. With technological interventions that are already available today, Janis states that resources and energy consumed by the built environment can be reduced dramatically through ecological design. The following technologies, many of which are no and low-cost, illustrate the creation of housing that is based on sustainable resource usage.

**Thermally Efficient Design**

**Orientation and Placement of Windows**

Windows allow solar energy to enter a building (see images below). This is unwanted in summer and desirable in winter. In the southern hemisphere, houses should be orientated to face North (see image below). In general, windows facing the north should be larger (for heat gain during winter) but not too large (increased heat losses in winter and heat gains in summer) while windows facing south should be smaller (to prevent heat losses during winter). The images below illustrate a method of allowing solar rays into the northern side of a house.

The sun changes position in the sky during the year as shown in the image below. By designing an appropriate overhang above the window, the summer sun will be blocked while the winter sun can enter. This is a very cost effective and sustainable way of regulating temperatures within a house or building. An overhang or awning can also be fitted to an existing window.
Appropriate Use of Thermal Mass
Thermal mass is the ability of a material to absorb heat energy. A great portion of heat energy is required to change the temperature of high density materials e.g. concrete, stone, brick and tiles. These materials are therefore considered to have high thermal mass. Lightweight materials such as timber have low thermal mass.

Through the correct application of thermal mass internal temperatures are moderated by averaging the day/night extremes. This increases comfort and reduces energy costs. The ignorant use of thermal mass can exacerbate the worst extremes of the climate and can be a huge energy and comfort liability. To be effective, thermal mass must be integrated with sound passive design techniques. This means having appropriate areas of glazing facing appropriate directions with appropriate levels of shading, insulation and thermal mass.

Effect of thermal mass on building inner air temperatures

**Winter**
Thermal mass absorbs heat during the day from direct sunlight or other radiant sources. The thermal mass will re-radiate this heat into the home throughout the night.

**Summer**
During the night, the thermal mass cools down due to low night temperatures. This could be enhanced through cool night breezes and/or convection currents to pass over the thermal mass. During the day the low temperature thermal mass keeps the inside of the building cool by absorbing energy from the room.
The appropriate use of thermal mass can delay heat flow through the building envelope by as much as 10 to 12 hours producing a warmer house at night in winter and a cooler house during the day in summer. Building materials with high thermal mass include adobe brick, stone, brick, etc. Please see the sustainable building materials chapter for further information.

**Sustainable Building Materials**

According to the Western Cape Human Settlement Strategy, building construction and operation results in 50% of all CO$_2$ emissions worldwide (Department of Local Government and Housing, 2007). The average middle income house uses five to ten tons of cement in the building process, and for every ton of cement manufactured, a ton of CO$_2$ is released.

Thermally efficient, low carbon emission, structurally sound and inexpensive building materials exist that have been used for centuries in household design. Hemp has huge potential in the building market, as do adobe, sand bag construction, cob, thatch, brick, stone and recycled materials. Other ‘low cement’ options, including SABS approved compressed earth blocks (CEBs) using 6% soil stabilisers, are currently being investigated and proposed in sustainable neighbourhood designs.

**Energy Efficiency Applications**

A recent study out of the Energy Research Centre (University of Cape Town) states that energy efficiency in social housing is an area where a policy of direct state financial support to promote energy efficiency seems warranted. In practice, municipal government would need to play an important role in administering a subsidy scheme and providing bridging finance. (Winkler et al. 2002). Some of the most common, cost effective energy efficiency applications are listed below.

**Ceilings**

The benefits associated with ceiling installations include a reduction in expenditure on indoor heating, improved health as a result of improved air quality and more stable internal air temperatures (particularly in households which use paraffin, coal and other heating systems which damage respiratory health), increased productivity resulting from improved health and increased quality of life.

Heat loss through the roof is often greater than heat loss in other areas of the house, thus one of the most effective ways to insulate a house is to put in a ceiling. In cold climactic regions, or regions with cold winters, a ceiling can reduce space heating costs by up to 50 per cent. The department of housing’s Draft Framework on Environmentally Efficient Housing has identified ceilings as an important intervention within the social housing frameworks.

Ekurhuleni has a target goal of 100 per cent installed ceilings installed in households by 2020 (SEA, 2007). According to Sustainable Energy Africa, “if Ekurhuleni achieves its targets by 2024, 550 thousand MWh of

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*4 Sustainable building materials are discussed further in Chapter 3*
electricity will have been saved. In power station capacity terms, in 2024, it will negate the need for an 8MW facility (including transmission line losses and a reserve capacity of 30 per cent), which is slightly more than the Darling Wind Farm produces.” SEA also suggests that over 380 thousand tonnes of CO₂ will be saved by 2024 if this strategy is implemented.

**Insulation**
One of the best ways to make a house more energy efficient is to reduce the flow of heat into and out of the house. Ceiling and roof insulation serve to conserve heat in winter, and maintain cooler temperatures in summer. Climactic regions can make a difference in the level of insulation necessary for a comfortable living environment within a home. In mild climates like the Western Cape, comfort can be achieved without much heating or cooling, if appropriate thermal designs are implemented.

**Sky Lights**
A skylight is a window placed in the roof of a building or in the ceiling of a room to admit light into the room. Designs include transparent roof plates, glass windows and plastic domes with a circular ducts connected to the room. Skylights should ideally be incorporated in the building design to keep the costs down, but can be retrofitted to existing buildings with significant contributions to increased light levels and accompanied energy savings.

**Solar Blinds**
When an existing building does not have an appropriate overhang, a solar blind can be fitted (see image below). These blinds block all the summer sun and let the majority of winter sun through. These fixed blinds let sun light through and does not block the view since they are placed horizontally and are never closed or adjusted. They can be manufactured locally and are cost effective.

![Solar blinds](image)

**CFL Bulbs**
The use of energy efficient lighting is one of the best and most cost effective ways of reducing energy consumption. Efficient lighting will reduce energy consumption and in particular peak demand, which will improve energy security, Eskom also recognizes that efficient lighting will play a major role in its demand side management (DSM) process.
CFL statistics (SEA, 2007: 31):
- CFLs use five times less energy than an equivalent incandescent bulb
- CFLs are expected to last 10 times longer than incandescent bulbs
- Life cycle analysis reveals that the capital cost of a CFL (approximately R18) is nearly half that of 10 incandescent bulbs (approximately R30).
- A CFL is 80% more efficient than an incandescent bulb, which means that 1/5th the power is used over the lifetime of one 18W CFL (the equivalent of a 100W incandescent).
- Approximately 10 000 hours can be saved (a saving of 800kWhrs of electricity that amounts to R300 of electricity saved per CFL using today’s rates).
- Approximately 800kg of CO₂ will be saved over the lifetime of one CFL compared to the equivalent incandescent.
- Improved quality of life can be achieved through a reduction in electricity costs for a low income household where the proportion of energy costs to income is very high.

Renewable energy applications

Solar Water Heaters (SWH) 5
Lack of access to hot water can have negative safety and health impacts on low income households. SWHs can replace the use of “dirtier” fuels, such as paraffin, for water heating. Also, the time lost in heating water by using more “traditional” fuels, such as wood, could be saved by using solar water heaters. SWHs in the low income sector should become a stronger focus. It should be noted that good quality, small (55litre) solar water heaters are available for under R3000 fully installed. These systems can be financially viable, even without being subsidized. Solar water heating technologies are dealt with in detail in the Energy chapter.

Sustainable water and sanitation systems 6
Water efficiency measures can include low flow fixtures in sinks and shower, dual flush systems in toilets, rain water harvesting and water recycling. Dry or urine diversion (UD) toilets can also reduce water consumption in households by approximately 40 per cent. UD toilets also produce compost, which can be used in agricultural production. Grey water recycling in settlements can be inexpensive and can provide nutrients for agricultural production and greening. On-site sewage systems such as vertically integrated wetlands, membrane filtration systems, biolytix systems and biogas digestors can provide nutrients for agriculture, recycled water for toilet flushing and energy for household use.

Waste Minimisation and Recycling
Waste separation and recycling can generate jobs as well as removing recyclable resources from landfill. Individuals and recycling cooperatives can collect and separate wastes and sell recyclable materials. Buy-back centres can be established in neighbourhoods, where recyclers can buy recyclable materials for re-processing. Organic materials can also be separated and made into compost, adding nutrients to soil for agricultural production and greening.
There are at least six housing delivery mechanisms that have emerged in South Africa since the early 1990s, and which are more or less aligned with, or can be used within the context of national and provincial housing policies. This section examines how these mechanisms might address the prevalent housing shortage. Linked to and underpinning the sustainability of housing delivery mechanisms is the crucial factor of housing finance. This necessitates a short overview of the funds and finance available for various forms of housing delivery, as well as the public private relationships involved in implementing housing projects.

The foregoing lays the basis for thinking about new ways to deliver subsidized and affordable housing. The current flexible and open-ended public housing framework should be exploited to maximize the provision of the most appropriate housing to the poor, and housing which is affordable for them. Too often, however, housing authorities think strictly in terms of the penalties if they should fall foul of the Municipal Finance Management Act (MFMA) and its regulations, and this leads to a bureaucratic approach to housing delivery where officials strive to avoid risk rather than explore opportunities opened up by the MFMA.

**Incremental Formal Housing**

There are many poor people in South Africa who have constructed their own informal dwellings. These structures are typically referred to as shacks, and the response of the authorities has often been to engage in shack clearance. However a different, incremental approach to informal structures should be adopted which acknowledges that the poor currently settled illegally, have invested in housing and this housing represents a locator that can be built on. Incremental building facilitates the transformation of informal structures into acceptable formal houses over time. The location of the shacks is critical in determining the success of this mechanism, for if these structures are erected in flood plains, for example, they would not be sustainable. Likewise, the extent of community coherence is also critical in determining the active involvement of the shack dwellers in improving their housing – in this regard older, more established settlements could be expected to provide a more facilitative environment.

A critical starting point is the provision of handing title of stands over to individuals – usually heads of households. Providing proper infrastructure is also critical. Notwithstanding the legal and regularization process required, in-situ upgrading is possible through public financed and procured infrastructure, and this is already happening at scale in certain cities.
Infrastructure provides a developmental platform on the basis of which individual households can be assisted with credit, building materials and technical assistance, to improve and formalise their structures. Local governments are positioned to play a key-facilitating role to enable the provision of these services to the residents of informal structures.

During the process some of the existing home owners might move to other housing projects that better suited their needs, e.g. green fields, social housing, etc. Over time with ownership, neighbourhood improvement should result in the houses becoming tradable assets. This will be the point at which a functioning housing market will have been established in what were previously regarded as “shack settlements”.

In implementing incremental formal housing care should be taken to establish the rules of engagement by the dwellers of informal settlements in the formalisation process. The risk is that such projects could attract more informal settlers and result in urban sprawl rather than the goal of contained, densified housing, which is increasingly being recognized as not only a building block of a compact city but also a precondition for sustainable urban life under conditions of rising transportation, fuel and other costs, which create a general inflationary spiral. In this regard the coherence of existing community structures will be a key factor in stabilising existing informal settlements through a process of incremental formal housing. Incremental implementation is part and parcel of the BNG approach to housing policy.

\[\text{From 2009 the Treasury will provide municipalities with funding from the central fuel fund specifically for investing in infrastructure, the amounts of which will be in proportion to fuel sales in areas of municipal jurisdiction; in addition, for municipalities that have a demonstrable pro-poor infrastructure strategy, the Treasury will also provide additional funding, matched Rand for Rand with the proportionate funding from the fuel fund (Hendler, 2008a).}\]
Subsidised Housing

Over one million subsidised units were delivered between 1994 and 2004 across South Africa, which is probably a world record for quantitative outputs. According to Haskins (2008) some 34 720 affordable housing units were delivered in the City of Cape Town between 2001 and 2007, and most of the units delivered were likely to have been subsidised units. However, the backlog expanded from 240 000 to 350 000. Criticised for being an unsustainable form of housing, the subsidy mechanism is not the major purveyor of affordable housing that it was some years ago. Nevertheless there are probably still many subsidies in the pipeline for housing units still to be built, and given the time that it takes to create alternative programmes it might be prudent to use the subsidy mechanism but in a modified form to address some of its critical weaknesses from a sustainability perspective.

A modified version of subsidised design could be incorporated as a delivery mechanism within a sustainable settlement delivery strategy. Through the investment of public funds from the Municipal Infrastructure Grant (MIG) and other programmes of the Treasury infrastructure could be installed. Through the current capital subsidy programme a defined number of units can be developed that must be integrated with existing settlements and council owned land. These subsidised units can be laid out in denser formats, e.g. as cluster housing, to minimise sprawl and enable more effective use of available land. In a cluster arrangement houses are not laid out within planned grids, but rather clustered closer to each other.

However, subsidised units are not altogether popular with many of the beneficiaries for whom they are targeted. They are small, shell houses that offer very little privacy to individuals, and it has been argued that they are inadequate. Many social ills experienced in low income communities can be linked to inadequate housing units. In houses without room partitions, children are often exposed to sexual activity at a young age. The placement of subsidy houses in peripheral locations forces parents to spend excessive amounts of time and unavailable money on commuting rather than actively looking after their children. Lack of proper ventilation and overcrowding in these units creates an environment where disease can easily spread, and inefficient design increases family expenditure on space and water heating. The high costs of transport, paraffin and increasing food prices prevent many low income families from being able to afford payments for water and electricity, creating debt cycles within city finance streams. Community members without an income add backyard shacks in order to generate an income and this perpetuates the vicious cycle.

In the next section, social, communal, gap, rental and employer housing will be discussed, as they form part of a broad range of housing options for mixed income neighbourhoods settings.

Social Housing

Government policy facilitated the emergence of social housing as a delivery mechanism that enables a choice for alternative forms of tenure in addition to outright ownership – like rental, rent-to-buy, co-operative housing and installment sale. Government provides subsidies to accredited social housing institutions (SHIs) that also raise loans to purchase and refurbish existing buildings, or to start new developments. These institutional subsidies are available for medium to high density social housing units. Recently the social

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This point of view emerged strongly during workshops, facilitated by the author, with housing NGOs, farmers and farm workers from the Stellenbosch municipal area. This view is however more pervasive, and is not confined to these groups from this municipal area.
housing restructuring grant became available for SHIs operating in so-called restructuring zones – this has significantly increased the quantum of public capital available for social housing units, to about R170 000 per unit.

The SHI’s task is to effectively manage the properties to ensure decent and affordable housing for the sector of the population earning between R2 000 and R7 500 per month. Both public and private institutions (including non-profit companies) can manage and maintain such stock. Since 1994 a social housing sector has emerged in the South African housing market, that to date manages approximately 75 000 accommodation units.

Arguably the first SHI in South Africa, the Citizens Housing League – now Communicare – is located in Cape Town and run as a non-profit company. The City has entered into partnerships with Communicare and also with the Social Housing Company (Sohco) (another non-profit company) and the Cape Town Community Housing Company, in which the City is a 50 per cent shareholder with the National Housing Finance Corporation (NHFC). The terms of these partnerships are that the City will give these three companies preferential access to municipal land and institutional subsidies in return for their providing social housing units at scale. To date Communicare has delivered the most rental units, but only recently entered the market for black working class lessees; Sohco recently entered the Cape Town market and their performance there is unknown to the author – they have a track record in Durban and East London; and, CTCHC have been dogged by problems relating to rent defaulting.

The most popular form of tenure in social housing is rental. In addition to the institutional subsidies and restructuring grants, the Community Rental Units (CRU) subsidy\(^\text{10}\), which provides more value per square meter than the conventional institutional housing subsidy. This subsidy is aimed at state-owned properties housing people earning below R3 000 per month, and could facilitate the accommodation of people exiting from the communal/transitional housing programme (see below).

**Communal/Transitional Housing**

Communal and transitional housing is a form of social housing targeted at households earning less than R2 000 per month, including the unemployed. A very high number of these households lack meaningful income-generating work. Accordingly, this mechanism should be highly relevant to contributing to a sustainable housing process.

“Communal” refers to the fact that the cooking and cleaning (ablution) facilities are all shared within a single building or project, and “transitional” refers to the fact that accommodation is only provided for a limited period (say one year) after which an individual or household is expected to assume responsibility for seeking their own accommodation on the housing market, either through private market or social housing delivery mechanisms. Communal/transitional housing has been implemented in larger cities where transformed inner city buildings have provided accommodation for the poor or destitute. A particular housing institution in the Johannesburg inner city\(^\text{11}\) has developed a unique service that includes occupational training and/or

\(^{10}\) CRU subsidies provide the best value of public funding per square meter of residential property. The conditions for this subsidy are: (1) the property is state-owned and may not be alienated; (2) the occupants earn less than R3 000 per month; and, (3) the tenure is rental in perpetuity. Property management can be outsourced to a SHI (SHF, 2006; Hendler, 2008b).

\(^{11}\) Madulomoho Housing, which together with MES Aksie, a faith-based social service group, provides a package of services including occupational training job placement and monitoring.
counseling, assisting residents to find employment and monitoring their employment history to facilitate sustainable income generation.

**Formalised Home Ownership (Mortgaged Property) (Gap housing)**

This is the established delivery mechanism for private, outright ownership. Commercial banks can fund this effectively, and private developers manage the process of acquiring and servicing the land, constructing the houses and transferring of title to new owners. It is assumed that this delivery mechanism would address the needs of many households in overcrowded formal housing units, and probably some who reside in informal structures due to a shortage of formal units available in the housing market rather than financial constraints.

Nevertheless, given the rapid increase in the value of all housing properties in recent years, including those in previously segregated black townships (which also experienced the housing “boom”); the challenge is to make land available at an affordable price to enable entry to the ownership market for those currently excluded through high prices. In some instances this might necessitate the land being made available at no charge.

**Private Rental Market**

Private high, medium and low-density units can be brought onto the market for rental under normal market conditions. However, the rental market in low income areas of can often be anything but “normal”. There are many cases of inadequately maintained stock, rent defaulting and the hijacking of units and entire blocks by gangs of criminals. Tenant management and rent collection can be a big problem. The precise role of the municipality and the partnered SHIs would have to be examined and thought through carefully if outsourcing of these critical property management functions is to succeed.

The providers of private rented accommodation are often private landowners who rent their units to tenants. In many cases in existing townships these landlords live on the same properties and rent out structures in their backyards. What is required here is a flexible application of municipal by-laws so that health and safety can be ensured without negatively impacting on the affordable private rental market through increasing the costs of compliance.

**Employer Housing**

In line with international trends by businesses to focus on core functions and outsource peripheral functions, businesses in South African have tended to avoid getting involved in securing housing for their employees. At best businesses tend to provide financial support in the form of guarantees and sometimes even loans; but the trend is to provide a “clean wage” that assumes the employee can look after the financing of housing themselves.

In the past, large employers of labour, such as mines and parastatals, provided accommodation directly to their employees because it secured a stable, constant supply of labour. Currently, with the high potential
for civil unrest (like the recent outbreaks of xenophobia) prompted partly by completely inadequate living conditions suffered by many people, employers should have an interest in getting more directly involved in their employees’ housing to ensure greater social stability within which to do their business. This would require a champion, probably the mayor, to articulate the need for a “coalition of the willing”, led by the municipality but should also include critical components of the business community, to pursue a developmental agenda in sustainable housing. The delivery mechanisms are depicted graphically below.

Funding Interventions

The Municipality will need to attract the following role players to projects:

- Institutional Investors (e.g. Sanlam or Old Mutual)
- Banks
- International donor and aid organizations
- Development finance institutions
- Local industry players
- Municipal guarantee instruments
- Packaged and prioritised infrastructure financing from organisations like the National Treasury, the Development Bank of Southern Africa (DBSA) and the municipal infrastructure grant (MIG)
- National subsidy funds specifically targeted at housing

**Funding Mechanisms**

Funding mechanisms for housing should include public-private-partnerships (PPPs) which are relatively novel in South Africa, where municipalities have traditionally regulated residential (and non-residential) development by the private sector in terms of planning by-laws and building regulations. They did not, however, take any initiative in shaping the type of developments that would be appropriate and sustainable for the majority of the population living in their jurisdictions.

The conventional approach is for each municipal department to vet a development application, linearly, which can take up to 24 months. Conventionally departments operate in silos, in isolation from, and at times competing with one another. These are serious obstacles, undermining sustainable development.

Municipalities should be driving development through a dedicated structure that includes officials from all key departments, relevant councillors as well as outside specialists, all of whom should write the broad development criteria that would be advertised through Requests for Proposals (RfPs) to the private sector. The details of the development would form part of the private sector bids that they would submit in order to compete for participation in the development. Indicator systems like the CSIRs Sustainable Building Assessment Tool (SBAT) would be useful in providing an overarching set of planning, design and assessment criterion for settlements.

The following are the funding and/or contracting mechanisms that municipalities can employ where appropriate to attract and enlist the services of the successful private sector bidders, and to fast track delivery of housing. A special contract could make provision for community-based organizations (CBOs) to participate in PPPs – this would be a unique contribution to the PPP practice as it has been carried out until now in South Africa, by creating a stake in development for authentic, grassroots-based organizations that can demonstrate that they represent a significant constituency.

**Service contract**

A service contract is an agreement in terms of which the private sector contributes towards specific services, either by undertaking upstream services that flow into the municipality’s or SHIs service, or by providing these services directly to the customers themselves. In its simplest form the service contract would entail the outsourcing of a defined service within the housing value chain to the private sector.

**Management contract**

A management contract would be an agreement in terms of property management whereby the private contractor will manage the public residential property portfolio, including (but not necessarily limited to)
property maintenance, rent collection, accounts management, invoicing, payments and security. The management contract is applied to a more complex set of services and functions that can be contracted to a private party with specific performance requirements attached to a fee. An example could be the management of all rental stock to a private institution for a fee.

**Leasing contract**
A leasing contract is an agreement in terms of which the private contractor will lease and manage the entire residential property portfolio/property assets of the municipality or another public authority. Under this arrangement the municipality could use a longer-term lease over 10 to 50 years to procure public goods such as block of rental flats. The municipality will lease the land and the private sector will raise the capital to build and manage stock until the lease expires. Upon termination of the lease the state has options it could exercise.

**Investment linked contract (Concession)**
A concession is an agreement in terms of which the private contractor will invest in the public residential facility (which could either be new-build or existing structures) by adding value through refurbishment, additions and alterations and/or conversions, manage and/or undertake the construction, operate the facility over the medium to long term and then transfer the facility back to the state's control. Under this agreement a public-private partnership arrangement is necessary. In this case the state continues to hold the fundamental right to provide the service; however, the state contracts the right to operate service and make improvements, to the private sector. The private sector operator will have contracted to provide a service and collect revenues for a defined period of years. The risk of funding is exclusively in the hands of the private sector. The role of the state is to monitor and regulate. At the end of the term the services and the assets created revert to the state.
Corporatization / Joint Venture
This is a contract in terms of which the state gives up limited equity to a private contractor in return for one (or a combination) of practical involvements (i.e. from servicing to direct investment). The municipality is able to structure a unique entity by itself or with the private sector. Under this approach defined roles and contributions are agreed and the institution implements under a specific mandate. This vehicle could fast track delivery through its narrow and focused mandate. Examples of this could include the establishment of an investment promotion agency, a housing development fund or a development agency that can implement this strategy for a defined period on a partnership basis.

Private ownership and operation
In this scenario there is a contract in terms of which the state sells all the equity to the private contractor subject to specified usage and trading conditions for the residential facility. The sale of equity can be phased. In this option the municipality can opt to alienate land to the private sector for development of residential property in the rental and ownership segments of the market.

Community-based non-profit/cooperative institutions
A “community ownership” option, which will form a critical component of a development coalition, rests on collective savings to generate individual and collective equity that could leverage further public and private funds. A pertinent example of this is the savings clubs approach of the Federation of the Urban Poor (FEDUP). This option does not stand alone: it can interface with most of the other public and private relationships referred to above. “Community ownership” means that participants contribute equity which means they also take risk and therefore contribute to the protection of the asset and its continuous improvement. Furthermore, “community ownership” builds bonds of solidarity and reciprocity in the community resulting in a greater sense of community which, in turn, often translates into more reliable repayments, higher levels of ongoing investment in individual and collective assets, and reduced levels of conflict, violence and crime. The institutional arrangements can range from simply savings groups to mobilise community equity and investment, through to housing associations and even housing cooperatives.
It is imperative that councilors, municipal officials and their contractual agents adopt a new way of recognizing opportunities for residential development, in partnership with the private sector and community-based organizations. To enable a new approach to be put into practice may require the establishment of municipal-wide structures, with Mayoral authority, the task of which will be to expedite development by writing the terms of reference and clearing bureaucratic blockages as and when these arise. Council and municipal executives will also need to adopt clear policies on development facilitation, and educate municipal officials in the vision and goals of these policies in order to expedite and facilitate sustainable residential development.
“In terms of green building, we need to reframe the question to: how much does it cost your city not to have a green building policy.”

Barbra Batshalom, Executive Director of The Green Roundtable, speaking at the U.S. Green Building Council in Chicago (November 8, 2007)

Sustainable building materials can be defined as materials with overall superior performance in terms of specified criteria. The following criteria are commonly used:

- Locally produced and sourced materials
- Transport costs and environmental impact
- Thermal efficiency
- Occupant needs and health considerations
- Financial viability
- Recyclability of building materials and the demolished building
This chapter introduces the concept of sustainable building materials and technologies, and suggests the following as good examples:

- recycled materials and bricks made from building rubble
- earthbag construction
- adobe bricks
- stabilized earth blocks
- compressed sand bricks
- Neolite bricks

In our current global setting, building construction and operation results in 50% of all CO₂ emissions worldwide. Five to ten tons of cement are used to build the average middle class house, and for every ton of cement manufactured, a ton of CO₂ is released. (Department of Local Government and Housing, 2007). Thermally efficient, low carbon emission, structurally sound and inexpensive materials and technologies exist, some of which have been used for centuries. Materials that have great potential for building include adobe, sandbag construction, cob, thatch, brick, stone, hemp and the use of recycled materials. Other low-cement options, including SABS approved compressed earth blocks (CEBs) are currently being investigated and proposed for sustainable neighbourhood designs.

The innovative Western Cape Sustainable Human Settlement Strategy (WCSHSS), objective 8, includes eco-design principles in an official policy document (for the first time). It requires that all new buildings, infrastructure and open spaces be planned according to ecological design principles, and that existing buildings, especially in the public sector, be retrofitted. Eco-design principles emphasized include orientation, insulation, roof overhangs, sustainable building materials minimizing embodied energy, thermal mass in wall material and energy saving devices like PV and solar water heaters.
Background: Embodied Energy

The key indicator of the environmental impact of building materials is provided by the concept of ‘embodied energy’. This is the amount of energy consumed to mine, manufacture and transport a particular product. The embodied energy of glass, steel, concrete blocks, bricks etc., or an entire house are measurable. The Victoria University of Wellington, New Zealand provides the following list of embodied energy figures\(^1\).

### EMBODIED ENERGY COEFFICIENTS – MJ/Kg

<table>
<thead>
<tr>
<th>Material</th>
<th>MJ/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adobe block</td>
<td>0.47</td>
</tr>
<tr>
<td>Concrete block/bricks</td>
<td>0.94</td>
</tr>
<tr>
<td>Ceramic brick</td>
<td>2.5</td>
</tr>
<tr>
<td>Glazed brick</td>
<td>7.2</td>
</tr>
<tr>
<td>Cement</td>
<td>7.8</td>
</tr>
<tr>
<td>Glass</td>
<td>15.9</td>
</tr>
<tr>
<td>Steel (structural)</td>
<td>35.0</td>
</tr>
</tbody>
</table>

GJ = giga joule, a unit of energy, 1GJ = 278 kWh

Bricks are fired with either coal or oil in clamp kilns at high temperatures over long periods of up to 3 days, and account for the bulk of a buildings’ embodied energy, and yet remain the material of choice for developers and homeowners. Low-cost housing is mostly built using concrete blocks with relatively low-embodied energy and emissions, compared with brick and concrete middle- and high-income residential and commercial buildings.

It is important to use local and unprocessed building materials that minimize transport and manufacturing energy and air pollution. This also creates local employment and the more localized the project, the more money stays within the community. The next section explores building options that use local and recyclable materials which are thermally efficient and cost effective.

\(^1\) Victoria University of Wellington, New Zealand. 2007
Recycled Building Materials

Recycling is an essential ingredient of green building that reduces non-renewable inputs, especially mining activities, energy use or the heavy-duty transportation of bricks. This includes the use waste products and used building materials. It is especially important to reuse environmentally unfriendly materials that leach toxic materials into the soil and ground water, or release methane into the atmosphere when dumped in landfills.

CASE STUDY

A low-cost home built from rubble, Mbekweni, Paarl

A ‘rubble house’ known as the ‘Stonehouse’ was built in December 2005 by Cape Town architects Vernon Collis and Associates, to demonstrate the construction of a low-cost aesthetically pleasing and energy-efficient eco-home using recycled building materials. It was a People’s Housing Process (PHP) project of the Western Cape Housing Department.

The inner walls were built with dumped bricks recovered from a local landfill and the outer north and south elongated walls were built with a natural stone found on site. The side walls were recycled concrete plaster bricks from Cape Brick.

Building rubble was used in the foundation trenches to enhance thermal mass. An insulated ceiling was installed using recycled carpet underfelt as insulation material, and the ceiling consists of industrial wood pallets. The window frames were constructed from local wood off-cuts, with recycled glazing.

The ‘Stonehouse’ in Mbekweni under construction, with Cape Brick masonry in the foreground
Photo: Pierre Roux
Recycled concrete bricks

It makes environmental sense to recover rubble from demolished buildings and reuse it in recycled concrete bricks. Not only are substantial energy savings made in the brick-making process, but building rubble, otherwise dumped in landfills, can be recycled.

Cape Brick in Salt River manufactures recycled reinforced concrete bricks and a range of SABS-approved concrete products from building material recovered at demolition sites in and around the city centre. After separating materials such as wood, paper, plastic and metals, the demolition waste consisting mainly of reinforced concrete aggregate (RCA) is crushed and reused in their masonry products. The brick making process using building rubble is described by Cobus Kotze in One man’s waste – is another man’s treasure (Kotze, C. January 2008).

Quarried material is become increasingly scarce and expensive, as it has to be mined and transported from quarries to cities and building sites, which taxes the road system and increases greenhouse gas emissions. Cape Brick sources most of its demolition waste within 5 km of its plant, resulting in significant transport energy saving. Their ‘green brick’ has the lowest embodied energy of any concrete product in the Western Cape (Cape Business News on line. 2008).

To further reduce embodied energy, Cape Brick use 50% recycled cement slag in their mix, making the embodied energy value of their ‘green brick’ less than half that of a standard concrete block, and a sixth that of a clay fired brick. Cape Brick recycles some 70 000 tons of reinforced concrete and manufactures about 30 million concrete bricks and blocks per year. Its high compressive strength bricks are approved by the SABS and the Concrete Manufactures Association (Kotze, C. January 2008).
Earthbag construction

Earthbag construction has recently become a popular natural building technique. Sandbags have long been used by the military to create bunkers and other structures. It is literally dirt cheap, as it uses local sand and low-cost polypropylene or geo-fabric bags. The technique is ideal in sandy areas such as the Cape Flats. No bricks or concrete blocks have to be moved, which means there is no energy embodied in transport.

Eco Beam Technologies in Epping developed a sandbag home building kit and a process consisting of three steps. A structure is erected using eco-beams/lattice beams made of two wooden struts connected with zig-zagged aluminium strips to provide rigidity and strength. The frame is then filled in with sand bags to form the walls. The bags rest on each other and are not cemented together like concrete blocks. Plumbing and wiring are routed through the timber uprights. The sandbag walls are then covered with chicken mesh wire, dampened and plastered. Sandbag walls cannot crack, are fireproof, good insulators of temperatures and sound, and resist water penetration.

Construction is much cheaper than with brick or concrete blocks, and sandbag houses are ‘eco-friendly’. Sandbag building is adaptable to a wide range of site conditions and available fill materials. It demands few skills, is easy to learn and can go extremely quickly, much faster than conventional brick and mortar building. The eco beam system is suited for housing delivery on scale and provides job opportunities in local communities, filling thousands of earth bags. This building method has great potential in the low-cost housing sector in SA.
Sandbag houses, Mitchell’s Plain

A sandbag house was erected in Freedom Park, Mitchell’s Plain using eco-beam technology, and 10 more units are planned. They were designed by MMA Architects, Cape Town, as a Design Indaba project which won an international innovative design award from the University of Kentucky, College of Design. The eye-catching 52m² double-storey houses have a living area and kitchen on the ground floor, two bedrooms upstairs, and a balcony that can be turned into another room. They cost less than the government full housing subsidy of R43000.00 for construction of the top structure.

Adobe brick building

Adobe bricks are made of earth and water and dried in the sun. They can be made in various ways, depending on the local climate, site and available materials, tools and labour.

Mc Hendry, a Mexican architect (Kennedy, 2002) provides the following guidance:

“The simplest way is with a single mould. Mud is mixed and placed in the moulds by hand on a smooth surface. The mould is removed and the bricks allowed to dry sufficiently to stand on edge, after which they are trimmed and allowed to dry completely before stacking or use.

The whole process takes about one week in most favourable dry climates. The brick making process can be expanded with the use of shovels, wheelbarrows, multiple forms, front-end loaders and concrete or plaster mixers. The use of a hydraulic pressing machine that can create a large number of bricks (compressed earth blocks) – up to 4,000 a day – is another option.

Once they are dry, adobe bricks are stacked to make walls. The bricks are cemented together with a mud mortar made up of water and screened soil taken from the same sources as the soil used to make the bricks.

…. Adobe walls should be built on a foundation of concrete or stone to protect them from moisture damage. Frames for windows and doors are set in place as the wall goes up.”
Lynedoch Ecovillage, near Stellenbosch

A number of adobe brick homes have been erected for staff members of the Sustainability Institute and the Lynedoch community. Adobe bricks were made on site using a single hand hold form and then cured for a few weeks on the premises. The soil is suitable for adobe brick making as it has a high clay content. Adobe soils contain a mixture of clay, silt, sand and aggregate. Clay provides the glue which holds the bricks together. It is important that they should be dry, hard and crack-free.

Adobe bricks have the capacity to absorb, store and release solar heat, i.e. thermal mass, though their thermal capacity is much lower than that of clay-fired bricks or concrete. The walls were built on a concrete foundation and set on a two-brick pre-wall to protect the adobe bricks from moisture damage (damp). The external walls were also protected by a lime and clay mix plaster. Insulated wooden ceiling were installed, and corrugated roof cladding. Vines and trees can be grown to protect them from driving rains. Vine overhangs also provide shading from the sun on north-facing windows during the summer months.

Insulation involves building cavity walls filled in with an insulation material such as mineral wools, strawboard, wood, glass fibre, and cellulose fibre or recycled carpet under felt as used in the Stonehouse project.

However, insulation is only really necessary in the colder climate regions of Northern Europe and America. (Roaf, S et al. 2003). In South Africa’s low cost housing sector the only issue is to provide ceilings with proper insulation in order to reduce the thermal comfort of tin-roofed matchbox RDP houses (The envelope effect).
Adobe is a truly natural building material, and because the bricks are often made by hand on site, energy use is minimal, except for the builders’ sweat.

The Tiholego Development Project near Rustenburg in the North West Province is a sustainable ecovillage described in Building without Borders by Joseph Kennedy (2004). The building system used is locally manufactured mud-brick walls built on concrete block and stone foundations. The walls were rubbed down with water to reduce cracks and then coated with linseed oil and turpentine for weather resistance. Insulated timber ceilings were installed, with corrugated iron roofs. Passive solar techniques were used like solar orientation, thermal mass and overhangs.

Stabilized earth blocks

Earthen buildings have been built for thousands of years, and there is a strong tradition of earthen structures on the African Continent. Traditional mud huts were the most common form of building, before the advent of modern architecture and planning. Earth buildings still shelter more than a third of the world’s population.

Recently there has been a resurgence of interest worldwide in earth building, especially in developing countries, where local earth is the most accessible source of building material for millions of people. However, most soils do not contain the mix of clay, silt and sand required for good brick making.

Modern stabilization technology (such as AnyWay Soil Block - a non-toxic chemical stabilizer) has broadened the range of natural soils suitable for making compressed stabilized earth blocks (CSEBs), and increased their strength and durability. The photos below explain this process.

Compressed stabilized earth blocks have the following advantages:

- An earth block walling system is much cheaper than bricks. The use of local soil and on-site manufacture saves on transport costs and fuel consumption, especially in remote areas with poor road infrastructure.
- Pressed earth blocks have a low embodied energy value of around 0.42 MJ/kg and a negligible carbon footprint.
- Earth structures have good thermal properties which save on heating and cooling costs. A study by the Institute of Technology, University of Fort Hare found that traditional mud huts offer better thermal comfort than low-cost RDP houses, while ash brick houses had a better thermal performance than RDP houses (Makaka, G & Meyer, E. 2006)
- AnyWay stabilized block making is a non-toxic and environmentally safe process.
- Earth blocks are fire, noise and bug resistant.
- It is a labour-intensive brick-making process that can be easily taught, and the stabilizer can be used in remote areas to create earth building material.
Pilot Project in Simunye Township, Westonaria (Gauteng)

A stabilized earth-block house was constructed in December 2006 by AnyWay Solutions together with the Sinqobile Community Youth Development Trust in the Simunye township of Westonaria (Gauteng). Unemployed people were trained to manufacture compressed stabilized earth blocks (CSEBs) on site with local soil, using a manually-operated press. A low-cost home was built and plastered with earth mortar. The structure was tested by the SABS and found to comply with the requirements of the National Building Regulations.

For CEB’s to bind, 6% stabilizer is required. It is sold in 25kg bags @ R58 per bag. Students at the Sustainability Institute manufactured 51 blocks using 418 kg of soil and one 25 kg bag of stabilizer, i.e. at a cost of R1.13 per block - far less than the cement equivalent, not to mention the CO2 reduction gained by using local soil.

The Simunye Project won the Canadian Award for International Cooperation Prix d’ Excellence Africa 2007 Award for demonstrating a more socially transformative and environmentally sensitive approach to community development that furthered entrepreneurial opportunities for women in Africa. It was also one of 15 finalists for the International Institute for Sustainable Development and UNDP 2008 SEED Award (www.seedinit.org ).
Compressed sand bricks

Where suitable soil is not available, river sand can be mixed with cement to manufacture compressed bricks on site. The picture below shows a four room 50 m² house built from compressed bricks in Limpopo Province by the Tzaneen Municipality, as part of a People’s Housing Process project. The brick-making process has already been described.

A local brickyard for a rural housing project in Limpopo. River sand, stone and cement are mixed and concrete bricks manufactured on site. Two wheelbarrows of sand and stone are mixed with 25 kg of cement and a bucket of water in a Pan Mixer. This is then poured into a hydraulic press that produces compressed sand bricks. The facility is 5 km from a rural village where 115 low-cost houses were constructed. The brickyard employed 32 local people. The sand was sourced and carried by donkey carts and tractor-drawn trailers from a river bed 2 km away. The brick were solar dried in the hot bushveld sun.

50 m² compressed sand-and-cement brick house.

Photo: Pierre Roux
Neolite bricks

Neolite bricks are manufactured by hydraulically compressing a soil-cement mixture in block-making machine. Hydraform in Gauteng sells a range of machines, from a hand-held form to sophisticated hydraulic machines for block yards. Neolite bricks can be manufactured on site and dry-stacked, reducing the embodied transport and curing energy significantly to around 0.635 MJ/kg. The product contains a small percentage of cement which largely accounts for its embodied energy component. Hydraform also has a block yard producing over 2 million bricks per year that comply with SA national building regulation requirements for strength, durability and stability.

Fly Ash Bricks

Fly ash bricks are sometimes used in the construction of toilets and other structures in the low-cost sector. This cement-based brick making process has a typical embodied energy value of 0.632MJ/kg. Fly ash is a waste product from coal power stations, and is an environmental pollutant. Generally these bricks are of poor quality and uniformity, and cannot be plastered as they contain magnesium, which reacts with water, making the bricks ‘pop out’.

Ash bricks are very abrasive and brittle and a nail cannot be driven into them. Other unsolved problems with fly ash bricks are that they tend to have a high water absorption rate and porosity, but low fire resistance. There are only a few projects worldwide using fly ash in building bricks, and more research is required on the health impact of these bricks, as they can contain hazardous substances.

Other applications

While rammed earth, straw bale and hemp construction and cobbing are widely recognised natural building methods, especially in the Northern Hemisphere, they are not practical or commonly used for the South African low-cost housing sector. As these applications are labour-intensive and require highly skilled and qualified artisan expertise ideally more suited to the timeless dedicated green building owner-builder.
This little gum, wattle and daga house was built at Ouden Molen, in Pinelands, Cape Town. It has a gum pole frame with an interlocking wattle basket weave (both invasive aliens), filled in and plastered with locally sourced clay and painted with lime.

Photo: Pierre Roux

Not only new building projects, but also existing neighbourhoods inevitably require new infrastructure, or the upgrading of existing infrastructure. Similar to the emergence of sustainable alternatives to conventional building methods, road building has also engaged with the constraints imposed by scarcity of resources. Landfills are struggling to meet the demands for the disposal of building rubble, and our top soils are also being depleted. The next section will speak to sustainable materials use in road construction at a neighbourhood level.

Soil stabilisation applications can be used to improve the mechanical and physical properties of sub-standard soils so that they can be incorporated into or form the basis for road, rail and building infrastructure. The improvement of in situ soils to required engineering specifications has a far smaller environmental impact than the alternative of rejecting local soils as unsuitable, and importing other selected materials. The benefit of in-situ soil stabilisation technologies includes the possible decrease in transport and building material costs, the conservation of natural resources and the reduction of harmful emissions. The following are examples of successful applications of soil stabilization in construction projects.

The levels of unemployment and poverty in SA, the existing skills-base of many unemployed people and the need for social infrastructure make a persuasive case for far greater use of labour-intensive construction and effective skills transfer. This is recognized by Government and forms part of stated policy.

Soil stabilization empowers local people to fix local problems with local soil, a few simple tools, and their own labour. Suitably trained small teams/SMMEs can undertake many aspects of infrastructure development that directly improves their lives.
Roads and Parking, Residential Complex, Pretoria North

Internal roads and parking areas were required in a residential development in Wolmer Ext. 1 totaling 35,000 m². The in situ material, a problematic clayey, silty, sandy soil with a high swell potential (commonly known as ‘black cotton soil’), presented a difficult engineering challenge. The original design proposed cutting and spoiling the upper 350mm of in situ soil, followed by construction of 500mm of pavement layers, with 350mm of selected imported aggregates.

A cheaper, faster, more efficient and environmentally-friendly solution was proposed, using AnyWay Natural Soil Stabilizer (ANSS) in the following manner:
- the top 120mm in situ soil was stripped and spoiled
- 120mm of selected G6 material was imported and placed on in situ soil
- ANSS was applied at a rate of 3% on top of the G6 material
- the in situ soil, G6 material and ANSS were mixed using a recycler and water cart, to create a 250mm stabilized layer compacted to 95% MOD AASHTO, over a 2 week period.

This design had the additional benefit of providing sound roads for use by construction vehicles in all weather conditions during the house-building phase which eliminated rain-induced delays on the project. Once construction is completed, the roads and parking areas will be surfaced with 60mm concrete pavers.

**Savings using stabilization**
- overall cost saving of 40% on the roads and parking areas
- a time saving of 3 ½ months on the construction of the road/parking area
- further time saving on project by all-weather road use
- pavement thickness is reduced from 50 to 25cm.

**Environmental savings**
- 8,050 m³ less soil spoiled to landfill site
- 8,050 m³ less selected aggregate imported from quarries
- avoidance of 1,208 X 20-ton truck journeys through existing residential area saving road wear and traffic congestion
- a saving of 14 tons CO₂ emissions (global environmental impact).
Township Roads, Dihlabeng District Municipality

Dihlabeng District Municipality has a programme upgrading township roads in its 5 local municipalities. Previously, the in situ clayey soil had to be cut to a depth of 200mm and spoiled, and a 200mm layer of selected aggregate was then imported from a distant and expensive source. As the Municipality wanted to use its own limited road-building equipment and manpower, and reduce costs, it decided to stabilize the in situ soil instead, with great success.

The Municipal Roads Dept. is now able to construct a 1 km stabilized un-surfaced road in 2 days, which previously took 15 days with the “spoil and import” method and limited equipment. The un-surfaced road instantly provides a safe, less dusty, non-slippery wearing surface in all weather. At a later stage the roads are provided with a side-drain and surfaced with 60mm concrete pavers produced by a local community-operated brickyard.

**Savings using stabilization per 1 km road**
- completed in 2 days, instead of previous 15 days
- a cost saving of 50%+ on road layers (surfacing identical in both designs)
- Stabilized road immediately usable, surfacing done when convenient.

**Environmental savings per 1 km road**
- 1,000m³ clayey soil not spolit to landfill site
- 1,000m³ selected aggregate not imported from quarries
- avoidance of 200 X 20-ton truck journeys, saving diesel, reducing road wear and traffic congestion
- a saving of 2 tons CO₂ emissions (global environmental impact).

![Original township road](image1)
![The road after stabilization and compaction, providing a safe, all-weather driving](image2)
![Constructing the side-drain next to the stabilized road](image3)
![The finished road, surfaced with 60mm pavers made by a community-operated brickyard.](image4)
Gundo Lashu Project, Limpopo, 2005

This was a joint project by the International Labour Organisation and Road Agency of Limpopo, with Council for Scientific Industrial Research participation, to develop effective and appropriate labour-based road construction methods. Various soil stabilizers and application methods were used to upgrade the existing un-surfaced gravel Makopane Road.

The AnyWay trial section used in situ soil next to the roadway, which provided soil for road layers as well as creating a drain to remove rainwater from the road. Only manual labour, hand tools, steel shutters and a walk-behind compacting roller were used. Following stabilization, the road was left un-surfaced for 1 year and then surfaced with an Otta seal.
Sustainable building materials should be utilised appropriately and contextually in each neighbourhood development. The use of sustainable building materials not only reduces transport costs, carbon emissions, and in most cases materials costs, it also provides employment and skills development opportunities for community members.
CASE STUDY

Solar Roof Tiles

Solar PV panels are also available in the form of roof tiles. The picture below shows a solar roof tile installation at the Drie Geuwels Guest House, located at the Sustainability Institute outside of Stellenbosch. The PV roof tiles are of a similar shape and size as normal tiles and only make up a portion of the total roof area, as can be seen from the picture below. The peak output from the PV installation is 1.7kW. The daily energy generated from this installation is monitored and can be seen at www.sieckmann.biz/content/ProjectsSustainabilityInstituteReports.htm. The electricity generated by this installation is fed directly into the guest house through a grid-tied inverter and is used to supplement the electricity currently provided by Eskom. No batteries are installed.

Solar roof tile installation at the Sustainability Institute near Stellenbosch.

Photo: Riaan Meyer

CONCLUSION
“The earth is a closed system for matter – nothing disappears. In nature, the cycle of life operates in a circular system and waste generated by one organism becomes food for another. Fallen leaves decay and the nutrients are returned to the earth, to become again food for the tree. An exciting challenge facing city communities is to begin to imagine life without waste, where everything that is thrown away at the end of one life becomes the technical or organic nutrient for another life.”

City of Cape Town Smart Living Handbook

There are many definitions of waste in South African legislation. The most recent definition can be found in the National Environmental Management Waste Bill (DEAT, 2007). This definition states that waste is “…any substance, whether or not that substance can be reduced, reused, recycled and recovered—
(a) that is surplus, unwanted, rejected, discarded, abandoned or disposed of;
(b) where the generator has no further use of for the purposes of production, reprocessing or consumption;
(c) that must be treated or disposed of; or
(d) that is identified as a waste by the Minister, but—
   (i) a by-product is not considered waste; and
   (ii) any portion of waste, once re-used, recycled and recovered, ceases to be waste.”

Section 1 of the South African Environmental Conservation Act also provides for the formulation of a definition of waste by regulation. This definition is:

“An undesirable or superfluous by-product, emission, residue or remainder of any process or activity, any matter, gaseous, liquid or solid or any combination thereof originating from any residential, commercial or industrial area, which is discarded by any person, is accumulated and stored by any person with the purpose of eventually discarding it with or without prior treatment connected with the discarding thereof, or which is stored by any person with the purpose of recycling, reusing or extracting a useable product from such matter,” (Environment Conservation Act. 1989).

Solid waste can be classified in two main categories. General waste and hazardous waste. General waste does not pose an immediate threat to the environment and includes household waste, garden refuse, builder’s rubble, some commercial and dry industrial wastes. Over time, however, these waste streams can pose a threat and must be managed carefully. Pressure, decomposition and infiltration by water produces leachate (liquids which form during the decomposition process) which may be hazardous to the environment.

Hazardous waste is any waste that may (or may not) be likely to cause danger to human health or to the environment. This includes many chemicals, heavy metals, flammable wastes like petrol, diesel, thinners, nail polish, aerosols and alcohol. Other types of hazardous waste include batteries, most paints, corrosives like acid, drain and oven cleaners, bleach and rust removers, and pesticides.

Medical and infectious waste which generally comes from hospitals, clinics and biological research facilities are also classified as hazardous, and include infectious, pathological and chemical waste streams, heavy metals, pharmaceuticals, genotoxic, radioactive and any other waste that is classified as hazardous in terms of the Minimum Requirements (Department of Water Affairs and Forestry. 1998).

In terms of the National Waste Management Strategy all local authorities are required to develop an integrated waste management plan and promote the prevention, minimization and recycling of waste in terms of the revised waste hierarchy. The following table from the National Waste Management Strategies and Action Plans for South Africa (DEAT. 1999), provides an overview of SA’s waste hierarchy.
# WASTE HIERARCHY

<table>
<thead>
<tr>
<th>1. Cleaner Production</th>
<th>Prevention</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimisation</td>
</tr>
<tr>
<td>2. Recycling</td>
<td>Re-Use</td>
</tr>
<tr>
<td></td>
<td>Recovery</td>
</tr>
<tr>
<td></td>
<td>Composting</td>
</tr>
<tr>
<td>3. Treatment</td>
<td>Physical</td>
</tr>
<tr>
<td></td>
<td>Chemical</td>
</tr>
<tr>
<td></td>
<td>Destruction</td>
</tr>
<tr>
<td>4. Disposal</td>
<td>Sanitary Landfill</td>
</tr>
</tbody>
</table>

(Source: DEAT. 1999)
An abundance of legislation governing various aspects of waste and waste related issues exists in South Africa. The National Environmental Management: Waste Management Act (NEMWA. 2008) has recently been promulgated. This Act will form the over arching waste management act governing all spheres of waste management.

The following table provides a summary of the main legislative changes which have taken place since the first democratic elections in South Africa in terms of waste management.

<table>
<thead>
<tr>
<th>Year</th>
<th>Legislation</th>
<th>Main emphasis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973</td>
<td>Hazardous Substances Act, 15 of 1973</td>
<td>Regulates transportation and disposal of defined hazardous substances</td>
</tr>
</tbody>
</table>
| 1996 | Constitution 108 of 1996 – Bill of Rights | • Refuse removal, disposal sites  
• Local government function – governed by Provincial government |
• Framework for the overall protection of the environment |
• Shift from end-of-pipe solutions to prevention of waste |
<table>
<thead>
<tr>
<th>Year</th>
<th>Legislation</th>
<th>Main emphasis</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>National Health Act, 61 of 2003</td>
<td>Designates Municipal services to include waste management and attributes power to the Minister to make regulations regarding health care risk waste.</td>
</tr>
<tr>
<td>2003</td>
<td>National Treasury – Municipal Finance Management Act, 56 of 2003</td>
<td>Roles and responsibilities of municipalities in terms of financial management systems.</td>
</tr>
<tr>
<td>2007</td>
<td>DEAT – Waste Tyre Regulations</td>
<td>Regulations regarding the safe handling, storage and disposal of used tyres</td>
</tr>
</tbody>
</table>

Summary of the legislative framework of waste management in South Africa (Engledow. 2005)

Landfill disposal

In South Africa, landfill disposal is the predominant method of managing general waste streams. Landfills are sites which are chosen, designed and engineered according to specific regulations which take into account human and environmental health. Ideally landfills should be close enough to the serviced population to prevent high costs of transport in disposal.

Landfills are classified according to the type of waste received, the amount of waste received and the water balance of the area, i.e. in terms of potential leachate generation (Engledow & Eichestadt. 2007). Older landfill sites often relied on clay soil barriers to prevent toxic leachate from seeping into the water table. Newer landfills are specifically engineered depending on the type of waste that it will receive. Engineering includes the design of liners with numerous layers consisting of gravel, sand, clay and plastic sheeting (high density Polyethylene-HDPE) to ensure that any leachate generated can be captured within the cell and not to contaminate surface or ground water. The leachate is then either drained to a leachate treatment facility on the site or transferred offsite to a waste water treatment facility.
Waste is dumped into landfill “cells” in layers of about 2m thick, where it is spread, compacted and covered with soil, sand, bark chips, and building rubble. Once the landfill cell has reached its capacity (i.e. a pre-determined height) the cells then need to be properly closed or capped. Thereafter, the waste continues to decompose generating methane and other CO$_2$ equivalent emissions which can be utilized for energy.

**Hazardous waste disposal**

Hazardous materials can only be disposed of at licensed hazardous waste disposal sites, and the management of high level hazardous waste falls within the boundaries of the private sector. Depending on the characteristics of hazardous waste, various treatment methods are applied before disposal. Medical waste must be treated prior to disposal either by incineration, or other accepted methods of treatment like Electro-thermal deactivation or autoclave technology, which uses pressure and heat to sterilise waste.

**Refuse transfer stations and material recovery facilities**

Refuse transfer stations (RTS) receive waste from municipal and private contractors. The waste is offloaded onto an apron area and then pushed by a front end loader onto conveyor belts which then feed the waste in containers where it is compacted. The containers are then transported either by rail or road to a landfill site. These stations act as short term holding and handling facilities for waste that will be transported to landfills.

There are many opportunities to explore at RTS, including the recovery of recyclables. A Material Recovery Facility (MRF) is a facility where there is sorting of the waste prior to compaction for transport to the landfill site. This type of MRF is referred to as a ‘dirty’ MRF. However, a ‘clean’ MRF is the ideal as the waste is source separated at the household / business level prior to further sorting at the MRF.

As the lifespan of many landfill sites in South Africa are coming to an end; new regional landfill sites are being planned and built further from the point of waste generation, i.e. outside of the City / Town boundaries. Therefore the reliance on RTS and especially MRFs will become more and more important in the near future. Recovery of recyclables at the MRF reduces the volume of waste that requires landfill thereby reducing transport costs to landfill sites.

**Drop Off and Buy-Back Facilities**

Drop off facilities provide a useful service to communities. They are often run by Municipalities, NGOs or community organizations. Community members and small garden services often utilize drop off facilities to offload garden waste, Plastics (e.g. polyethylene terephthlate – PET etc, paper, cardboard, glass, used motor oil, e-waste and other recyclable household waste materials. Drop off facilities also help to minimise the amount of green waste going to landfill and to make better use of green waste as a resource material for the production of mulch and compost.
Some community ‘drop off facilities’ referred to as buy-back facilities pay collectors for recyclable materials. Some materials, like scrap metals, mercury and zinc from appliances, reusable plumbing and building materials, wiring, light fixtures have a higher market value than others.

Composting

Composting can be an effective way to reduce green waste from being sent to landfills. Household, garden and other green and organic wastes, as well as primary and secondary sludge from sewage treatment plants may be successfully composted using a variety of methods. There are a number of biological or compost related technologies. These are open windrow, vermi-composting, enclosed composting, anaerobic digestion and fermentation (Engledow & Eichestadt. 2007).

### VARIOUS COMPOSTING METHODS

<table>
<thead>
<tr>
<th>Method</th>
<th>Potential input wastetype</th>
<th>Output product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Windrow –Forced Aeration Composting *</td>
<td>Garden waste, wood waste, sewage sludge, manure, fruit waste</td>
<td>Compost, soil conditioner</td>
</tr>
<tr>
<td>Vermi-composting</td>
<td>Sewage sludge, food &amp; garden waste</td>
<td>Compost, soil conditioner</td>
</tr>
<tr>
<td>Enclosed composting</td>
<td>Mixed organics (food &amp; garden)</td>
<td>Compost, soil conditioner, high calorific value</td>
</tr>
<tr>
<td>Anaerobic digestion</td>
<td>Mixed organics (food &amp; garden)</td>
<td>Biogas, green energy</td>
</tr>
<tr>
<td>Fermentation</td>
<td>Agricultural waste, mixed organics</td>
<td>Liquid fuel</td>
</tr>
</tbody>
</table>

(Source: Engledow & Eichestadt. 2007)
Many of the products we use require large amounts of energy to produce. When disposed of, many waste streams do not decompose (i.e. hard plastics and tyres) and they can be harmful to natural habitats. Collecting, transporting and disposing of waste are costly exercises. We live on a planet that has a finite carrying capacity for waste. Resources and nutrients that can be reused and recycled are lost when sent to landfill. Waste pollutes our water and air, and can create human health risks. By reducing, reusing and recycling waste we reduce our consumption of non-renewable resources, we reduce the amount of energy and water required to produce and dispose of these resources, we prevent waste streams from being sent to landfill, we provide useful products for consumption, we create jobs, and we increase the earth’s carrying capacity.

Reduce

One of the most fundamental needs in effective waste management is behavioral change, which requires a paradigm shift from the ‘end-of-pipe’ treatment ideology of waste to the reduction of consumption of products that end up in landfill. On a local government level, green procurement of environmentally friendly products can substantially reduce waste to landfill. Buying in bulk, buying and consuming environmentally friendly products, purchasing products that do not need or require excessive amounts of packaging, buying recycled goods and refills, avoiding disposable items like nappies, cameras, razors and aerosols and avoiding toxic or hazardous products can go a long way in reducing waste to landfill.

Reuse/Repair

One person’s waste is another person’s treasure. Rather than disposing of useful resources, find an individual or organization that can reuse these materials. Schools, libraries, NGOs, crèches, drop-off facilities and many charities can make use of household goods one may no longer find useful. Many items can be repaired rather than sent to landfill.

Post-consumer waste materials can be used to develop alternative functions through the innovative nature of design.

Photos: Haveena Jhundoo
Materials Recovery and Local Economic Development.

by Haveena Jhundoo

A case study was conducted at Mondipak Kuils River during 2008, in order to assess the feasibility of recovering reusable waste materials in Mondi’s factory. The goal was to train disadvantaged women from the local community to develop handmade crafts.

Mondi sponsored the pilot project and provided the necessary materials and equipment for the project. The training programme started in April 2008 and ended in August 2008. The entire programme was conducted on the factory premises and consisted of the following stages:

1. Identification of reusable waste materials (RWMs) in factory processes;
2. Recovery of identified RWMs as secondary waste materials for crafting purposes through an integrated waste management strategy;
3. Development of prototypes from the RWMs focusing on handmade packaging for craft products;
4. Deconstruction of the design process into easy step-by-step replicable tasks for crafters in training;
5. Market testing on local and international levels;

The type of waste streams classified as reusable were: residual Kraft liners, off-cuts of paper cores, strapping cores post-use, empty starch bags, certain type of rejects of corrugated boards. Certain waste items such as empty coffee tins generated through the canteen were also explored. For training purposes, an office was made available and for prototyping experiments a workshop area was designated on Mondi’s premises.

The research dealt mainly with paper-based waste materials. However, substances such as residual water-based ink, varnish and glue were successfully experimented with in order to develop surface graphics. Other packaging accessories such as eyelets and fabric strapping (overruns) were purchased from suppliers in Cape Town to complete the product range. In some instances waste samples such as waste fabric from other suppliers were collected free of charge.

Overall, the handmade items were made from a minimum of 90% waste materials. The conversion process is termed waste crafting (Billet et al. 1996). In the context of the pilot project, this consisted of tracing the prototype over the waste materials, scoring, cutting, gluing, painting and finally assembly all other necessary components.
The case study was deemed an environmental initiative, as well as a skills development programme in line with the Skills Development Act (1998) and the Broad Base Black Economic Empowerment Act (BBBEE. 2003). The ladies selected in this project had no previous exposure to arts and crafts, yet they learned the basics of paper crafting techniques very quickly. They also attended the CCDI Winter School course in July 2008 where they qualified for an NQF4 level.

The women who successfully completed the programme are now trainers themselves, who can train others and make a difference in their community. They can start their own businesses, or work in a craft environment where their qualification can be recognised. The next phase of the pilot may be explored in 2009 through another community projects.

The Mondi strategy proved successful and helped identify a category of waste that was already being recycled or discarded for eventual landfilling, but had a greater socio-economic value through the reuse principle. This approach is highly recommended in section 16 (b) of chapter 4 of the National Environmental Management: Waste Bill (NEMWB. 2007). By channeling this stream of reusable waste materials to survivalist waste crafters this flow of waste could support several disadvantaged families. In this case, a sheet of Kraft paper of about square meter if hand-painted could generate revenue of R3 for a survivalist crafter and a day’s work could bring R60 as a daily wage.

The following items give an idea of items that have been prototyped from the reusable waste materials:
1. Kraft paper: Gift wrap, carry bags, envelopes, cards
2. Cores: rigid containers for ceramic craft products and bottle holders
3. Paper sacks: heavy duty carry bags

![Starch bag before and after conversion](image)
Recycle

Technically, recycling occurs after waste is separated in the neighbourhood or home. Recycling is the process of making new materials from reclaimed resources or waste materials. Waste separation is only the beginning of the recycling process. Bins can be purchased and used separately for organics, recyclable materials like plastics (PET – polyethylene terephthalate; HDPE – high density polyethylene and LDPE: low-density polyethylene), tin cans, paper and glass (which can be placed in the same bin), and non-recyclable materials.

Separated wastes can be sent to drop-off facilities, recycling depots or alternatively they can be collected by ‘middle-men’ who sell or re-distribute the products. Organic waste can be used in the home and neighbourhood gardens for compost and recycled goods can be purchased in most supermarkets. Without
municipal systems in place, recycling on an individual level can be difficult to do. Without access to nearby drop-off facilities and recycling depots, people tend to put their waste out for the general municipal waste collection service to remove. Neighbourhood or community level waste recycling should be encouraged and can be much more effective.

Recycling can bring needed income for individuals, schools, NGOs and small businesses. It can provide jobs, reduce pressure on natural ecosystems and waste to landfill, and can provide a sense of satisfaction in doing the right thing. Education and awareness also plays a part in the reduce/reuse/recycle process.

Lynedoch Solid Waste Recycling Programme

During May 2008, the Sustainability Institute and the Lynedoch Home Owners Association introduced a new recycling programme throughout the Lynedoch Eco-Village. It comprises a 3-bin system: white bins (for all recyclables like plastics, glass, and tin) green (for organic wastes), and black (for non-recyclable waste). Appropriate, visually strong signage that could engage with the 450 on-site primary school children was developed and placed next to each unit.

A4 fridge magnets were also adapted for household and office use. For the school and for the rest of the site, laminated posters were provided for placement in close proximity to the bin units. This allowed all residents, tenants, children and visitors to easily and efficiently sort their waste from the outset. The programme was launched for the staff, home owners and school children with an interactive presentation explaining the importance of recycling and a question and answer session.

The programme is based on a simple process: the first sort of the different types of waste is managed by residents and visitors on site by choosing an appropriate bin, depending on the waste they wish to throw away. The separate bins’ contents are then collected by the garden and grounds team on a regular basis; organic waste is collected daily; recyclable and non-recyclable waste weekly. A partnership was entered into with a local recycling business (Mr Recycle) who collects the recyclable materials from Lynedoch on a weekly basis, and undertakes a second sort before passing back the respective materials to various organisations as a resource.

The cost of collection is covered by home owner’s monthly levies. Although the implementation took a few weeks (changing habits), the programme has proven to be tremendously successful. Waste has been reduced as indicated below:
Prior to recycling programme:
An average 50 black bin bags were collected per week. This contained a mixture of waste types.

Post implementation of the recycling programme:
The non-recyclable waste has been reduced to an average of 15 black bin bags per week (reduction of 70%). In addition, the site now delivers 20 bags of recyclable materials weekly, with the balance of material consisting of cardboard / paper and glass which are separated. Mr Recycle collects all the recyclables with the exception of the glass, which the Lynedoch garden and grounds team recycle as a separate business opportunity.

Examples of the 3-bin units and signage
(Photo: Pieter Meiring)
City of Cape Town

Municipalities are constitutionally required to provide for waste removal and disposal in their area. The City’s waste-wise programme, established in 2002, and its recently introduced Integrated Waste Management Policy promote the minimisation of waste to landfill and the reduction of negative impacts of solid waste on the environment. Recycling initiatives and activities have included clean-up initiatives in 18 informal settlements (household litter was exchanged for compost and 108 temporary jobs were created); river cleaning projects and an education program training teachers in integrated waste management solutions. The City of Cape Town has also established 20 recycling and waste drop-off sites, promotes partnerships and enabling legislation (including the new integrated waste management bylaw – soon to be promulgated).

The City of Cape Town has also piloted 2 dual collection services (the “think twice” campaign) (a) Pinelands, Parklands, Blaauberg and Somerset West, Strand and Gordon’s Bay. In each pilot area the initiative involves approximately 10,000 households which separate dry and wet waste. Dry waste is sent to the material recovery facility (MRF) in Maitland and Strand for further separation.

Another initiative, the “blue bag” project in Stellenbosch, has been successfully running since 2004. Nearly 1,500 households separate tin, glass and newspaper which are placed in blue bags supplied by Stellenbosch Municipality. These bags are then collected by local buy-back centres. Public private partnerships are important for the success of recycling initiatives. An example of an effective public private partnership is the arrangement between the City of Cape Town and PETCO, who have sponsored bags for the collection of PET, HDPE and LDPE for recycling in the CCT.
Athlone Refuse Transfer Station (ARTS) recycling initiative

At the Athlone refuse transfer station (ARTS), the company Unicell has installed a sorting conveyer, where 20 waste sorters have been hired to separate cardboard, white paper, mixed paper, cans, clear PET, and other plastics. Each waste stream is then bailed for collection. The facility is currently still increasing to full capacity and ultimately should be able to process about 650 t/d and removing up to 20% from the waste stream. A recycle-stream operator, a machine operator and a plant manager have also been hired for this initiative. The bulk of income for this initiative comes from selling-on recyclable materials (Engledow & Eichestadt. 2007).

In 2007, ARTS processed about 200 tonnes of raw refuse per day, and removed about 40 tonnes per day of recyclable materials. A second conveyer line is being installed, with planned 18-hour shifts during the week and a 12-hour shift on Saturday. It is expected that 650 t/d will be processed on weekdays and 433 t/d on Saturdays. Unicell has a contract with CCT to remove a minimum of 15% of the weight processed, but the company is expecting to achieve 20%. Therefore at capacity between 100 and 130 t/d will be diverted from Vissershok landfill site, (Agama Energy & The Sustainability Institute. 2007).

Municipal solid waste (MSW) is offloaded in the receiving apron, compacted into sealed containers (each containing 20 tonnes of refuse) and transported by rail at a rate of about 52 containers a day to Visserhok landfill (Agama Energy & The Sustainability Institute. 2007). The facility is designed to handle 850 tonnes per day but is accepting over 1,000 t/d. The characterisation of this refuse is expected to contain an organic fraction of 47%, 45% of recyclables and 8% of ‘other’ waste (Agama Energy & The Sustainability Institute. 2007).
Corporate interventions

PETCO recycled nearly 15,000 tons of PET in 2006. According to their calculations, “If one person collects 200 bottles for 240 days of the year, it amounts to 1,600 kilograms per year. This means that approximately 15,000 tons of PET collected translates into the creation of an estimated 10,000 jobs.” In 2006, PETCO achieved an annual PET recycling rate of 21% of beverage PET and 15% of total PET produced in South Africa, (PETCO. 2007). Approximately 40,000 collectors sell cans to Nampak’s Collect-a-Can. About 80% of these collectors would otherwise be unemployed (Nampak Recycling. 2009) Collect-a-Can recovered 64.2% of used beverage cans in 2002 (Engledow & Eichestadt. 2007).

Mondi collects 40% of all recycled paper and board in South Africa, and supplies 340,000 tons per year to mills for recycling. In 2001, Mondi recycling employed 300 people. Mondi currently invests in buy-back centres where collectors can bring recyclable paper for Mondi to buy-back. 117 centers are currently in operation, employing approximately 3,000 people (including collectors and sorters). (WBCSD. 2005).

Waste to Energy addresses both the challenge of waste disposal and that of energy needs in fast depleting landfill sites. There are many examples world-wide where waste undergoes treatment to reduce the volume of landfilled materials and to generate energy in the form of electricity, heat or fuel for transport. One of the best examples is here in South Africa.

Durban’s Mariannhill Electricity from Landfill Gas Project

In December 2006, Durban’s registered Clean Development Mechanism (CDM) electricity from landfill gas project went live. Mariannhill is a 4.4 million cubic hectare site, receives about 850 tonnes of solid waste per day and is expected to be operational until 2024 (Moodley, S. 2007). It is widely known that...
Landfills during decomposition phases generate large volumes of landfill gas (LFG) typically containing some 40-60% methane (Weinand. 2007). With climate change looming on all horizons, reduction of these LFGs can make a large impact on municipal and even national greenhouse gas emission reductions.

At the Mariannhill landfill site, landfill gas is extracted through a network of pipe work systems, which allow the gas to be fed into purpose-built spark-ignition engines. A 1000 kW engine has been installed on site, with space allocated for a second engine in further stages when new cells come online. This project currently generates 1 MW of electricity per day and will reduce Durban’s electricity demand from Eskom by up to 10 MW when all three sites are fully operational. According to R Wienand, Mariannhill’s project executive, “This project will reduce approximately 450,000 tons of carbon dioxide which would have been emitted by Eskom’s power stations over the project life span of the sites,” (Weinand. 2007).

Landfill electricity-from-gas generation projects are not competitive with local electricity prices in South Africa. However, Durban’s Mariannhill project was made possible through “carbon finance”, which was channelled through the World Bank’s prototype carbon fund (PCF), a public private partnership with participants from several countries worldwide (Weinand. 2007).

Not only is Mariannhill notable for its electricity generation, peak load and emissions reduction, but it is also Africa’s (and arguably the world’s) first landfill site conservancy. Innovative measures have been put in place to protect natural biodiversity and to reduce negative environmental impacts at the site.

“Naturalistic engineering” techniques have been adopted, which include the promotion of vegetation growth in capped areas, the provision of an on-site, indigenous nursery, and the use of wetlands for storm water management and tertiary water treatment. The conservancy hosts a bird hide where a 118 bird species have been recorded on the site (Moodley, S. 2007), and a community education centre. Mariannhill won the most prestigious prize at the public sector Impumelelo Awards in 2007.
An abundance of legislation governing various aspects of waste and waste related issues exists in South Africa, but to date there is no over arching legislation to guide solid waste delivery and processes. The National Environmental Management: Waste Management Act (NEMWA, 2008) has recently been finalised. This Act will form the over arching waste management act governing all spheres of waste management. South Africa’s standard method of waste disposal is disposal to landfill. More holistic approaches can be rolled out through municipal integrated waste management plans, once the national bill has been promulgated. In some cities, waste minimization strategies are already being implemented (by local government, NGO’s, corporate, schools, etc..) and bylaws are being written in anticipation of this, however, much more can be achieved in terms of reduction, reuse, recycling and alternate methods of solid waste disposal.
“We forget that the water cycle and the life cycle are one.”

Jacques Cousteau

Within the water cycle, water from seas and rivers evaporates to form clouds. Rain falls into rivers, dams, lakes and oceans, or it percolates into the ground (known as groundwater). People and animals use water to drink, clean, cook, for recreation and to carry away waste. Treated and untreated waste water re-enters the rivers and seas, and the cycle begins anew. Pollution at any stage in the cycle could prevent the water from being used elsewhere in the cycle.
Prior to 1994, little was done to address water scarcity in South Africa. Water allocation and sanitation provision were driven by racial bias and the previous National Water Act 54 of 1956 placed industrial and agricultural water needs above any social and/or environmental water concerns. Although a mismatched distribution of water between various user groups is still evident today, national water policy in South Africa is at the forefront of international thinking and is soundly underpinned by the principles of sustainability, equity, and efficiency. The gap between policy and practice however remains one of the key challenges to water managers in all tiers of government.
South Africa is a water poor country – one of the 30 driest countries in the world. South Africa depends mostly on inter-basin transfers (national and local), catchment run-off, dams, rivers, and groundwater extraction from springs, wells and boreholes for its water supply. Typically surface water is stored in dams, rivers and storage tanks (reservoirs). Groundwater is found in aquifers and is extracted by means of boreholes or wells. There are very few natural lakes in South Africa. Rainfall replenishes dams, is absorbed into the ground or evaporates. In a country like South Africa that suffers from water scarcity, groundwater is an important water source for many communities, and will remain so in the future. As surface water resources are used up, groundwater is increasingly likely to be used to supply urban areas as well. It is therefore highly important that we protect the quality of our groundwater.

In the South African context, feasible alternative sources of water can include:

- **Rainwater Harvesting:** Harvested rainwater can be used in gardens, to flush toilets and in other applications particularly in low-income areas. The choice of roof material (galvanized steel) must, however, be examined since zinc and other metals leached off galvanised surfaces can lead to heavy metal toxicity.
- **Aquifer Re-Charge:** Aquifer recharge puts water back into the ground in order to re-charge the levels of water stored underground.
- **Treated Effluent Reuse:** Treated effluent from sewage treatment plants can be used for irrigation of sports fields, golf courses and non-food agricultural crops instead of using potable water (water treated for drinking purposes).
- **Desalination of sea water:** It is currently estimated that the cost of water from a desalination plant could be in the order of R5/m, excluding the cost of transporting the water from sea level (CCT, 2007). The process is however still heavily dependent on large amounts of electricity being available.

There are numerous potential sources of contamination of groundwater. It can be contaminated by sewage from leaking sewage pipes or shoddily built pit latrines, landfill leachate seepage, burial sites, and unregulated animal husbandry sites or from the dumping of pollutants on the ground. These pollutants include
substances that occur in liquid form (like oil), substances that dissolve in water (like nitrate) or substances that are small enough to pass through porous soils (like bacteria). Nitrates and nitrites which come from fertilizers and factory pollution can also contaminate groundwater. Ground water that is close to the surface (high water table) or where the soil is very sandy is more vulnerable to contamination.

Surface waters (rivers and dams) are also polluted because of inadequate sanitation or sewage treatment. In many instances communities do not have adequate sanitation or the sewage treatment plants are too small to cope with the amount of sewage. This results in pollution of rivers with organic materials that can include ammonia, viruses and bacteria. Since many communities rely on untreated surface water for their daily needs, it exposes them to a significant health risk.

The South African Constitution states that all South Africans have the right to an environment that is not harmful to their health or well-being. This includes access to a constant supply of clean, safe drinking water. In South Africa, water is supplied through a network of pipelines, tunnels and canals via gravitational flow and/or pumping stations.

In urban areas the water supply is usually piped to reservoirs, but water may also be drawn from wells, boreholes, springs, dams or rivers. In some areas where water is not accessible or is unavailable, it may be delivered in mobile water tanks or drums.

Water in its natural state is seldom suitable for domestic purposes and has to be purified before being piped to homes. Water that is not treated properly can cause disease. Drinking water should contain no harmful concentrations of chemicals, heavy metals, or micro-organisms, and should ideally have a pleasant appearance, taste and odour. Water that is not stored and distributed properly can form algae and other bacteria that can be harmful to health and to the environment. The purification process carries a financial cost and depends on the nature of the water. Standard purification processes are listed in the box.
• Aeration:
  Water is aerated by pumping in air to address an unpleasant taste and smell due to a lack of oxygen in the water.

• Coagulation/flocculation:
  Water that is cloudy or brown in colour because of tiny suspended particles that are negatively charged and repel each other can be stirred and treated with a positive charge, causing the particles to stick together and form flakes which can then be dropped out of the water by means of sedimentation.

• Water Softening:
  Water that is too “hard”, as a result of the presence of high levels of calcium carbonate. Water softening involves reducing the levels of Calcium carbonate. Correcting the pH serves to mitigate the aggressive (and sometimes corrosive) impact on pipes.

• Sedimentation:
  In this application, which is used in conjunction with coagulation/flocculation, suspended particles or flakes settle to the bottom of settling tanks, are then removed to sludge ponds or landfilled.

• Sand filtering:
  This application is similar to running swimming pool water through sand filters and entails the filtering of water through sand which assists in the purification process.

• Chlorination:
  A small amount of chlorine kills most pathogens (disease-causing organisms) in water sources. Some chlorine remains behind in the water to kill any pathogens that may enter the system between treatment works and taps and can sometimes be smelt in tap water.

• Ultra-violet light:
  Ultra-violet (UV) light is an alternative to chlorination and can destroy micro-organisms that cause disease. UV light is applied to water by means of high pressure UV lamps. In contrast to chlorination, UV does not leave a bad smell or taste behind, but does not provide a residual component in the water system, so contamination of the water can occur before arriving at your tap. Ultra-violet lamps also require electricity, whereas chlorination does not.

• Desalination:
  Desalination is an expensive process that requires quite a lot of electricity, but it effectively removes salts and other particulate matter from brackish groundwater, saline wells, river water and sea water in areas that do not have access to fresh water. Desalination is used in South Africa mainly for treatment of groundwater for drinking purposes.

• Boiling:
  Boiling water for 10-12 minutes can remove many pathogens that can cause gastrointestinal diseases, but boiling will not remove colour, odours, suspended or dissolved particles.

• Special processes are needed to treat water containing algae.
It is important for households to have sufficient water and sanitation to lead healthy lives and to prevent ill-health and disease. Households and neighbourhoods generally use water for drinking, cooking, washing, agriculture, gardens, removal of sewage, and commercial activities.

An increase in household water consumption tends increase when household income increases. Mid to high income households use water more freely as it is piped, easy to use and more affordable. Higher income households also use high water consumption appliances like washing machines and dishwashers; they have a greater tendency to irrigate gardens and to fill swimming pools. On the other hand, lower consumption by low income households can be explained by limited financial resources to pay for appliances, lack of gardens and the sheer additional cost of the water. The 6 kilolitres of free water only applies to households on the piped water supply. So, as provision of basic services improves, and more people are given access to piped water, one can expect the demand on the water supply to increase significantly. The average amount of water used per person can range from 300 liters per person for a high income household to as little as 30 liters per person for a low income household, (Jacobs & Harhoff. 2004).

Guidelines for More Efficient Household Water Use

Studies reveal that an average suburban house can reduce their water consumption by 30-40% without sacrificing any comforts (Jacobs & Harhoff. 2004). In addition, if ‘grey’ water is recycled for garden use, household water use can be reduced by 60% or more, (Jacobs & Harhoff. 2004).
Reduce

Water is often wasted unnecessarily. The largest domestic water consumer (for mid to high income households) is usually the garden followed by the bath/shower and toilet. These are the areas where significant water savings can be achieved by means of very simple interventions. Water used for toilets, washing, laundry and irrigation can be reduced, but this usually applies to households with piped water. Specially designed water-efficient appliances and fittings can also contribute to the conservation of water.

Examples of water saving measures include the following:

Reduce Toilet Flush Volume
Older toilets have cisterns of around 11 to 15 litres, when only half of this water volume is necessary. Modern toilets have more sensible cisterns of around 6 litres, and even this is unnecessarily wasteful for flushing liquids. One can save 100 litres per day (assuming 3 persons per household) by installing a ‘dual-flush’ or ‘multi-flush’ device into the toilet. Dual flush devices have two fixed settings, a light setting (3 litres) for urine and a heavier one (6 litres) for solids.

Multi-flush (or hold flush) devices allow households to flush any amount by holding down the handle for as long as is needed to flush the contents. It is important to remember that best results are achieved for a dual flush system when the bowl is also changed to one that uses the lower volumes of water more efficiently that reduces the need to double flush. To reduce the flush volume without any new installations, households can put a displacement container in the cistern – a brick, large stone or a bottle filled with sand and water will do the trick. An inexpensive commercial product such as a “Hippo Bag” can also be used.

Low-Flow Fixtures
Low flow showerheads reduce shower water use by 50 - 75%. Comfort is maintained by adding air to the water to make it feel like it is flowing harder, providing the feeling of a comfortable shower while using 1/3 of the water. Showering in turn is more water-efficient than bathing, even without the use of low-flow showerheads. Reducing hot water usage through more efficient showering also saves on electricity required to heat the water (water heating is the main electricity consumer in most households).

Installation of Tap Aerators
Tap aerators are small screens that are screwed onto the tap, mixing air with the water so it feels as if more water is coming out of the tap while the pressure is maintained. Flow is reduced by around 50-75%. Without aeration, water from normal taps flows down the drain ineffectively.

Drip Irrigation
In middle income households, the single biggest user of water in the home is typically the garden, so this is where the biggest water savings can be achieved. Drip irrigation systems involve installing thin pipes directly to the base of plant, with drippers on the end of the pipes. These drippers slowly supply water to
the plant directly where it is needed, so less water is required. Also, since the water is not sprayed in the air, there is no water lost by evaporation. The amount of water used for irrigation can be reduced by 50% or more using such a system. PET bottles (Coke bottles) can also provide a low cost drip irrigation system, as demonstrated below. These are very effective for smaller gardens where filling the coke bottles is feasible and the home owner has the diligence to do so.

Reducing Lawn Size
Lawns consume twice as much water to stay healthy than shrubs and flowers. Also, indigenous grasses need much less water. If the lawn area is reduced by 50%, the total amount of water used for the garden can be reduced by 30% (Jacobs & Harhoff. 2004).

Repairing Leaks
Leaking pipes, taps, and toilets waste on average of 80 litres per household per day (Jacobs & Harhoff. 2004). It is important to fix leaks quickly. The most common leak is a leaking cistern due to a worn out washer in the flushing mechanism. This can be easily identified by looking for ripples in the bowl of the toilet as well as the cistern not every filling up (i.e. it makes a noise long after flushing). Dripping taps often just require a new washer.

Re-Use
Water recycling is a viable option in any neighbourhood application. Water used for washing (grey water) can be re-used in toilets and gardens. On-site sewage treatment can also provide a water supply for toilet flushing and non-food garden irrigation. Examples of the re-use of water include:

Grey Water Recycling Systems
By installing a system to collect ‘grey’ water (i.e. from the washing machine, basins, shower and bath) and pump it onto the garden, most households will eliminate the need for any additional garden watering. This
can reduce your consumption by 35% (Jacobs & Harhoff. 2004). These systems need not be expensive, and cost recovery from water saving is ensured.

The treatment of grey water would depend on how it is going to be used. If it is to be used in a drip irrigation system, then only basic filtering is required to remove solids that can block the irrigation system. If it is going to be used for toilet flushing, a certain amount of disinfection (removal of pathogens) and organic reduction would be required. This can be done by means of any aerobic treatment system followed by a disinfection step. A system such as trickling filters can also achieve fairly high removal rates and require less maintenance. If grey water is going to be stored it should be treated with UV radiation or chlorine to kill pathogens.

Grey water should always be filtered before being pumped in order to prevent the pump from being damaged. Water from the kitchen sink and dishwasher is not suitable for grey water reuse because of all the solid particles. Also, shrubs and flowers generally do not like the soaps and oils in grey water, but lawns thrive on the nutrients.

One of the disadvantages of grey water systems is that they use electricity to pump the water onto the lawn (usually because the shower and bath are low down and the tank therefore has to be buried to collect the
water). However, if it is possible to run the grey water directly onto the lawn this should be encouraged. Grey water systems also require some maintenance, for example, screens must be kept clean and tanks should be flushed on a monthly basis.

**Rainwater harvesting:**
The collection of rainwater for reuse can be implemented by individual households. This water can provide an important, additional source of water for the home. Rainwater is collected from the roof and stored in plastic tanks via the gutters and down pipes. If the water is going to be used for drinking purposes then fiber cement or tile roofs are most suitable. Galvanized steel (zinc coated) and other metal roofs may increase the likelihood of health and environmental damage from heavy metal toxins. Water may also be contaminated with dust, leaves, insects and birds, so it should be filtered and purified before being used for drinking water. Rainwater easily be used for irrigation. It is important to remember that tank size has much less impact on the amount of water that can be reused for irrigation than the roof collection area.

Rainwater can also be successfully used for toilet flushing. A pump would be installed in the rainwater tank to pump the water up to a separate header tank that feeds only the toilet cisterns. A much smaller tank is required than for irrigation purposes. A typical home (mid income with 4 persons) using a dual flush toilet would only need 50m² of roof and a 4000 liter tank to supply all their toilet flush water in a winter rainfall area (SA Weather Service and Jacobs & Harhoff. 2004).

**Treated effluent reuse:**
The use of potable water for the irrigation of sports fields and golf courses is not sustainable. A viable alternative is to use treated effluent from sewage treatment plants for this type of irrigation. The treated effluent can be pumped for the sports fields or golf courses after being filtered via a pipe network. Orange pipes are used to distinguish them from normal potable water pipes. Also strict use of special coupling at the irrigation points must be enforced to prevent cross contamination back into the potable water system. There are many examples of this being done in South Africa.
The total amount of water savings that can be achieved using a combination of methods is demonstrated in the following table (Jacobs & Harhoff. 2004). Some conclusions: low flow shower heads reduce shower water usage by 67%, and they reduce overall household water usage by 15%, (Jacobs & Harhoff. 2004). Installing a grey water system can save an average 212 litres per day, reducing a household’s water consumption by 18%. By combining several methods together, total household water usage can be reduced by nearly 60%.

### Income group: High  
### Household size: 3

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Average Daily usage (before)</th>
<th>Average Daily usage (after)</th>
<th>Average savings</th>
<th>% reduction in unit usage</th>
<th>Overall water saving*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bath (Child bathing)</td>
<td>61 Litres/day</td>
<td>61 Litres/day</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bathroom Basin</td>
<td>41 Litres/day</td>
<td>41 Litres/day</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dishwasher</td>
<td>19 Litres/day</td>
<td>19 Litres/day</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kitchen Sink</td>
<td>40 Litres/day</td>
<td>40 Litres/day</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaks</td>
<td>82 Repair leaking cistern</td>
<td>25 Litres/day</td>
<td>57 Litres/day</td>
<td>70%</td>
<td>5%</td>
</tr>
<tr>
<td>Shower</td>
<td>252 Install low flow shower head</td>
<td>84 Litres/day</td>
<td>168 Litres/day</td>
<td>67%</td>
<td>15%</td>
</tr>
<tr>
<td>Toilet</td>
<td>147 Retrofit dual flush toilet</td>
<td>44 Litres/day</td>
<td>103 Litres/day</td>
<td>70%</td>
<td>9%</td>
</tr>
<tr>
<td>Washing Machine</td>
<td>102 Litres/day</td>
<td>102 Litres/day</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pool Filter</td>
<td>26 Litres/day</td>
<td>26 Litres/day</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pool Evaporation</td>
<td>54 Install pool cover</td>
<td>11 Litres/day</td>
<td>43 Litres/day</td>
<td>80%</td>
<td>4%</td>
</tr>
<tr>
<td>Garden – Lawn</td>
<td>212 Install grey water system</td>
<td>0 Litres/day</td>
<td>212 Litres/day</td>
<td>100%</td>
<td>18%</td>
</tr>
<tr>
<td>Garden Beds</td>
<td>113 Retrofit drip irrigation</td>
<td>57 Litres/day</td>
<td>57 Litres/day</td>
<td>50%</td>
<td>5%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1149 Litres/day/day</td>
<td>509 Litres/day</td>
<td>640 Litres/day</td>
<td>56%</td>
<td></td>
</tr>
</tbody>
</table>

Income Group: High  
Household size: 3
Household effluent in urban areas, which is usually treated at a central sewage works, can still release bacteria and pathogens into rivers and ground water due to poor management or failure at the sewage works. In addition, discharges from wastewater works are often not treated according to national standards due to overloading of the works. Poorly treated effluent can cause human disease and eco-system damage as excessive nutrient and pathogen levels reach households, rivers, streams, beaches and recreational areas.

All wastewater in South Africa has to by law be treated to certain set standards laid down by the Department of Water Affairs and Forestry (National Water Act. 1998). This is important in order to prevent pollution of rivers and groundwater which may make downstream water users sick. Water borne diseases are the primary cause death in infants in Africa and accounts for some 70%-80% of all illnesses in developing countries (Chabalala & Mamo. 2001). These impacts can be significantly reduced by properly treating our sewage.

Wastewater in urban areas is usually treated using the following steps:

- **Screening:**
  Screens or sieves are used to block large objects such as rags and sanitary pads out of the sewage.

- **Degritting:**
  Sand and other heavy non-organic material are removed by means of grit channels or vortex degritters. The grit is settled out by either reducing the speed of the water (grit channels) or by stirring it which result in a concentration of the grit in centre (vortex degritters).

- **Primary settling:**
  Water passes through a tank at a certain speed. Most of the solid matter sinks and is removed. This is called primary (or raw) sewage sludge. Fats and oils float to the surface and are also removed and added to the sludge.

- **Biological treatment:**
  The organic matter (e.g. food remains, faeces) in water is broken down by bacteria in a biological reactor. Other bacteria in the tank convert ammonia to nitrate. Both these bacteria require oxygen to be effective and so water is aerated to provided them with enough oxygen. Other compounds such as nitrate and phosphate can be removed through more complex biological processes. Nitrate is removed by bacteria that convert it to nitrogen gas and phosphate is removed by special bacteria that absorb it onto their cell structure.

- **Secondary settling:**
  The bacteria are separated from the treated water by placing the mixture in a tank and allowing
Most of the conventional systems set out below have a degree of sustainability in that they use biological processes to undertake the treatment, but some of these systems can be considered to be more sustainable than others, primarily by virtue of the amount of electricity they use as well as their effectiveness in preventing pollution of water. For example, trickling filters require hardly any power and are simpler to operate and maintain, but they cannot remove nitrate, phosphates and sometimes ammonia and therefore can cause more pollution than say an activated sludge plant which uses more power. Also, aerobic treatment of domestic sewage produces carbon dioxide as a by-product of the biological process.

Conventional waste treatment methods include:

- **Anaerobic Treatment:**
  Sewage can be treated by anaerobic bacteria that grow in environments that are devoid of oxygen. They digest the sewage and produce methane and hydrogen sulphide (rotten egg smell). These can be used on a large scale at a sewage treatment works or on a household level (biodigestors). Bacteria also build up in these digesters and sludge needs to be removed occasionally.

- **Pumping to sea:**
  Raw effluent can be screened and then pumped out to sea (well beyond the point where raw sewage can be washed back inshore. The sewage is broken down anaerobically and the sludge build-up is diluted.

- **Sludge treatment:**
  As a result of consumption of organic material in sewage, bacteria continually increase in number. Therefore, a certain amount of the bacteria, or waste sludge, needs to be removed on a daily basis in order to prevent reactors from getting clogged with bacteria. This sludge needs to be dried before it can be handled easily. This is done by either laying it on beds for it to dry in the sun or through mechanical processes that consume electricity. After this it can be used as a fertiliser or, if it is treated correctly, to make compost. If it is not treated correctly and contains heavy metals, it has to be landfilled.

- **Disinfection:**
  The filtered water is then disinfected with chlorine gas to kill the pathogens before it is pumped into the distribution system.
On site (e.g. VIP, septic tank):
On-site treatment typically uses anaerobic processes that can pollute groundwater if installed in areas where the ground conditions are not suitable. A certain amount of bacteriological treatment can take place in the soil, but this is limited and if a VIP toilet or septic tank is used for too lengthy a time in one location, pollution can occur.

Trickling Filters:
Similar to activated sludge. In this process, biological reactors are replaced by tanks holding stones. Bacteria grow on the stones and are aerated by wind blowing through holes in the tank.

Pond Systems:
Ponds were the first forms of formal sewage treatment. Raw sewage is first screened and then flows into a series of large ponds. The first few ponds are anaerobic where a large amount of organic material is consumed. The algae release oxygen together with wave action over the ponds to allow other bacteria to remove ammonia and other compounds. Ponds are very low maintenance and require no electricity but they do however require very large areas and if not properly lined will pollute groundwater.

Membrane technology:
Water from conventional aerobic sewage treatment plants can be further purified using membranes. Water is pumped through these very fine membranes which are usually made from cellulose acetate. These replace the conventional settling tanks and are used to separate the bacteria from the treated water. They also remove some pathogens.

Another impact on sustainability is the destruction or loss of nutrients for beneficial reuse. Nutrients are usually bound up in the bacterial sludge that is wasted from central treatment plants, but because this sludge is not treated properly it contains pathogens (viruses and bacteria) and therefore cannot be used as a fertiliser. Sludge can also contain heavy metals that come from industries which also discharge into the same sewers. The sustainability of conventional systems can accordingly be improved by using innovative thinking that optimises the uses of the waste products generated by sewage treatments. Some examples are given below.

Sludge composting:
Wastewater sludge is often landfilled thereby taking up valuable airspace or simply dumped which causes pollution of groundwater. If there is sufficient space available, this sludge can be mixed with chipped garden refuse and composted using the turned winrow method. This method requires no electricity but takes 14 to 28 days to produce good compost. In this way the inherent energy as well as nutrients (nitrate and phosphate), which is bound up in the sewage sludge can be beneficially used for agriculture.

Power generation:
Wastewater sludge, particularly raw sludge from the primary settling tanks can be placed in an anaerobic digester. The anaerobic bacteria that digest the sludge produce methane which is a greenhouse gas and which can be used to generate electricity. It is estimated that one person’s sewage will produce 12g of
methane per day (Metcalf & Eddy, 2003). The process is not a simple one and requires skilled operation, apart from the foregoing the process produces a sludge that needs to be disposed of. This sludge is not suitable for composting as most of the energy in the cells has been used up.

**Sludge drying:**
Wasted sludge needs to be dried (to reduce the water content from about 99% about 85%) before it can be handled efficiently. This can be done by placing 300mm of the sludge on open lined beds (drying beds) to allow it to be dried by means of the sun and wind action. This is often considered the most sustainable method to dry the sludge, but drying beds result in odours and do not work well in wet climates (such as the Western Cape in winter). Many wastewater treatment works are also running out of space for such systems which necessitates the use of mechanical dewatering systems, which use electricity.

**Brick making:**
It may be possible to make bricks out of the dried primary sludge. There is a business in Port Elizabeth that is successfully running such an operation where the sludge (with a high energy value) is mixed with the clay before the brick is baked. There is however certain constraints with regard to combination of the type of clay and the nature of the sludge that needs to be carefully considered.

As can be seen there are methods to make urban/communal sewage treatment systems more sustainable. However, other methods can be used to improve sustainability by reducing the load of the wastewater treatment plants.

Ways to reduce the load of the wastewater treatment plants include:
- **Saving water** (see previous section): This reduces the hydraulic load on the plant;
- **Reuse grey water** (see previous section): which reduces both the organic and hydraulic load; and
- **Using alternative sanitation systems** that treat the wastewater closer to the source.

**ALTERNATIVE SANITATION SYSTEMS**

It is imperative that these alternative sanitation systems, the technology of which is discussed below, should do the following:
• not discharge polluted water into the environment;
• use less or no water;
• use biological processes to undertake the treatment;
• not require input of chemicals;
• be affordable (low operating costs);
• beneficially use the inherent energy and nutrients in sewage (e.g. for agriculture);
• preferable not require electricity; and
• be locally managed and maintained (eliminate problem of poor service delivery; and resulting problems of non-payment. Create employment opportunities).

Wetlands
Wetlands are natural filters, helping to purify water by trapping pollutants (such as sediments, excess nutrients, heavy metals, disease-causing bacteria and viruses and synthesised organic pollutants like pesticides). Wetlands are also among the world’s most productive environments because they are home to many different plants and animals.

Engineered or constructed wetlands copy the processes that occur in natural wetlands. Decomposer organisms such as bacteria and fungi live on the surface of the roots of aquatic (water) plants and soil particles. They break down organic material into carbon dioxide and water.

All aquatic plants pump oxygen into their stems and roots under the water. This oxygen is used by the decomposers attached to the plants. The plants also can take up the nitrogen and phosphorous from the wastewater. Wetlands have their own special vegetation types, such as reeds and underwater plants (e.g. papyrus and bulrushes).

Natural and engineered wetlands can perform many vital functions such as:
• natural water filtering by trapping excess nutrients and clean water through reeds;
• water storage;
• storm protection and flood control;
• shoreline stabilisation and erosion control;
• groundwater recharge (replenishment of underground aquifers);
• groundwater discharge (the movement of water upward to become surface water in a wetland); and
• stabilisation of local climate conditions, particularly rainfall and temperature.

There are many examples of where wetlands have been used to effectively treat sewage. Certain aspects should however be considered when designing such a system. Firstly, they require large areas, approximately 3 to 6 m² per person (EPA. 1988), secondly, there are also no clear design equations and as a result they are usually designed using empirical data or by trial and error, and finally, they take a while to get running and up to two years to reach maximum treatment efficiency. Thus, it is advisable to under load them in the beginning.
There is also no reason why wetlands cannot be used as a pre-treatment before discharge into a sewage system which would significantly reduce the organic and hydraulic load on the sewage treatment plants and therefore reduce the amount of energy need to treat the wastewater. It will also reduce the amount of organic carbon that is sent to the wastewater treatment works which will in turn reduce the carbon dioxide emissions.

The effluent from constructed wetlands usually does not meet the required standards for discharge into a natural watercourse. The water thus cannot be discharged directly into a river, but it often meets irrigation standards and can be used to irrigate certain areas such as gardens, pasture lands and orchards.

**Biological Aerobic Systems**

Aerobic systems use oxygen to degrade organic material in the sewage. A good example of an alternative aerobic system is the Biolytix®, an Australia design with international patent. In this system, the sewage is degraded by means of aerobic bacteria, earthworms and other microorganisms that sit on a humus filter in a PVC tank. The advantages are that it does not require electricity and the nutrients are retained in the effluent and can be used for agricultural purposes. It also takes up a make smaller area than a wetland. A single tank can treat 2.2 m³/day (communications with Biolytix®), which is the equivalent to the sewage generated by two average high income houses consisting of 4 persons.

Although the system does not remove pathogens and does not meet the required standards to discharge to a river; it does meet the required standards for irrigation. It is not recommended that above ground irrigation be used since this can lead to pathogens being spread to humans by wind action. In order to address this problem the effluent must be used in a drip irrigation system or disinfected.
Biolytix filter at Lynedoch Ecovillage

Biolytix filtration is a biologically complex ecosystem. In essence it is an aerobic, self-sustaining process that uses the organic nutrients in the wastewater to feed a balance of larger decomposer organisms, earthworms and other microorganisms. The filter contains layers of gravel, peat material (from palm leaves), netting and plastic pipes. The wastewater is piped in and sprinkled over the filter material and earthworms. The earthworms take in the solid wastewater material and convert it to a compost material. The effluent outflow is collected in a sump and then filtered via a sand filter to remove further particulate matter. Water that comes out of the system can be used to drip irrigate shrubs and trees. Further treatment can include passing water through ultra violet lit piping to get rid of any pathogens, but this required significant amounts of electricity.

Vertically integrated wetland at Lynedoch Ecovillage

A halophyte filter or constructed wetland has been built at the Lynedoch ecovillage. This system consists of a water column, substrates with different rates of hydraulic conductivity, swamp water plants and communities of aerobic and anaerobic microbes. The purification process occurs as plants uptake effluent nutrients via physical-chemical and plant-physiological processes. Wastewater is fed intermittently through pipes near to the ground’s surface. The effluent gradually drains freely through
the wetland to its base, allowing oxygen to assist in the cleansing processes. Arum lilies, ‘bloedriet’ reeds and other nitrogen absorbing plants are selected for this application. A layer of iron filings below the surface also serves to absorb phosphorus. The filtered water is pumped through a carbon membrane filtration system (Trunz) which is powered by wind and solar PV panels. The Trunz system can purify 20 000 litres per day of brackish, borehole, pond and other undrinkable water to potable water quality. After having gone through this membrane filtration system, the purified water is fed into the houses for toilet flushing.

Biological Anaerobic Systems

Biogas or anaerobic digestors utilize sewage, grey water, organic matter such as kitchen waste, animal manure and garden waste and convert them into energy. This is done by anaerobic bacteria that digest the waste and produce methane gas as a byproduct. This gas can be used for cooking (on a gas stove) or, it can generate electricity. It is estimated that around 12g of methane gas can be produced by one person’s daily sewage.

If garden refuse is added to the digester, it can produce ethanol which can be used as a biodiesel. Biogas digestors which are safe and effective have been used for centuries in villages in China and India. They can be used on a household level (i.e. one per house) or on a communal level (one per block of houses).

There is a natural public resistance to cook with the gas produced from sewage and these perceptions need to be overcome in order to implement such a system on a communal level. A possible strategy could be to provide communal cook houses where the gas from a communal digester (collecting sewage from 10 to 20 houses) is free for anyone to use for cooking.
Biogas digester Lynedoch Ecovillage

At the Lynedoch Ecovillage, gas stoves have been fitted in all the houses. Though most households currently use LP gas, a biogas digester has been built for several houses on-site. Black water, grey water, kitchen waste, garden waste, and animal manure feed the digester which produces methane gas. This gas is piped into the house and is used for cooking.

Other Applications: Composting (Urine Diversion) Toilets

Composting or urine diversion (UD) toilets that separate urine from solids were first implemented in South Africa in 1997 and there are over 50,000 UD toilets in South Africa. Heat, fans, solar PV panels and various design options allow the solids to be decomposed and used as fertilizers. Chimney and other forms of ventilation systems draw odours away, and these systems can be effectively used in households.

Nearly 30,000 units have been installed in eThekweni and these systems form an effective part of Durban’s ecological sanitation and water resource management programs. Education and training are essential for UD toilet systems to be accepted and effectively used in communities, as this unfamiliar technology may seem less civilised to communities that aspire to waterborne sanitation systems.

Service delivery mechanisms in South Africa have created a mindset that waterborne sanitation is considered to be the top of the sanitation ladder. Therefore, until urine diversion toilets are used by higher income groups as well, waterborne sanitation will remain the sanitation system of choice for low income groups.
Modern urban drainage systems raise two significant sustainability issues, the quantity and the quality of the run-off water. There are many instances in South Africa where the impact of stormwater has been reduced as far back as 15 year ago and certain municipalities are well advanced in implementing these measures mentioned below.

**Quantity of run-off water**

The traditional way to manage rainwater run-off in the past was to remove it from the area as quickly as possible to prevent flooding. This however results in the loading of downstream rivers with unnaturally large volumes of water which not only disturbs the ecosystems and causes erosion, but also the loss of topsoil and potential flooding downstream.

The new approach is to remove rainwater runoff as slowly as possible to simulate the natural (or pre-development) runoff volumes. Still, even with such “storm water calming mechanisms”, the main aim of urban drainage is to prevent flooding. While houses should be protected in all but the worst storms, the degree to which certain non critical areas should be allowed to flood is debatable. The following methods can be used to improve the sustainability of urban stormwater systems.

**Permeable pavements:**
Permeable pavement systems, which are standard engineering practice in Europe, are hardened surfaces with holes in them to allow rainwater to seep through the pavement into the ground, much like it would do naturally. Below the hardened surface are various layers of stone and sand to act as a drain to encourage the water to seep into the ground. A variety concrete paving products, designed specifically as permeable pavers, are available from commercial suppliers. They are particularly effective in parking areas for reducing the amount of surface runoff and simulating natural infiltration. The water seeping through the permeable pavement can also be collected and reused. The advantage to this is that during the filtration process through the drainage layers, a certain amount of treatment can take place.

![Examples of permeable paving](https://via.placeholder.com/150)

*Courtesy INCA paving*
Water harvesting in domestic driveway, Bristol, UK

In this case study, a domestic driveway was surfaced with permeable interlocking paving stones to harvest water. It consisted of 60m² of paving with a geotextile layer beneath which acted as a filter. The filtered water collected in a sump at the centre of the driveway and although the water was used mainly for car washing, could also have been used for irrigation for toilet flushing.

Bristol domestic driveway – water harvesting
Courtesy INCA paving

Natural swales and surface channels:
Another way to simulate natural runoff process and to encourage infiltration is to transport stormwater along unlined surface channels, called swales, instead of sending it through traditional underground stormwater pipes. These unlined channels are planted with grass or other plants to stabilise the soil and retain the shape. Where sediment build-up is a problem, the bottom of the swale can be lined with permeable concrete paver to make it easier to remove sediment with a spade (it should have a smooth surface so that the spade can slide easily). To facilitate the mowing the side of the swales, side slopes of 1:4 or flatter are recommended. Swales allow some of the stormwater to seep into the ground and improve the quality of the stormwater.

Environmental design of canal systems:
Large stormwater systems traditional involve concrete lined canals (built to straight lines) that are designed to take the water away as fast as possible. These large canals can be designed considerably differently entailing attractive curves with a varying width to make slower moving and faster moving areas, thereby simulating a natural river. These can be lined with open concrete blocks (such as Terrafix® blocks or Armorflex®) and planted with various reeds and indigenous wetland vegetation. Important to note is that the design should be done in consultation with a freshwater ecologist. Two local examples are the Langevlei and Little Lotus canals in Cape Town. They were both retrofitted on existing concrete canals and therefore are not the ideal, but do give idea of what is possible.

The Little Lotus was a complete redesign of the existing canal. The design has a concrete lined low flow channel to accommodate the summer flow while the remainder of the canal will use very porous lining (> 60%
openings) which is planted with local wetland plants. The design is intended to make the canal an integral part of the surrounding communities and not to become a waste area to be avoided. Additional canal width is required in order to allow the design storm to pass through as the vegetation slows the water down.

The Langevlei canal was also designed to bring the community back to the water and not isolate it. However, in this instance the existing canal was not replaced and therefore the traditional concrete lined portion remained. However, the area in the photographs show that it was possible to make is look attractive and to create a natural ecosystem in the context of a typical urban area.

Quality of run-off water

Stormwater can pick up any number of pollutants in an urban environment which will be carried into rivers. In some instances, the quality of stormwater can be worse than poorly treated wastewater. The treatment of stormwater is therefore becoming a more common practice in South Africa and certain cities (e.g. City of Cape Town) have written comprehensive guideline documents to ensure proper treatment of stormwater for all new developments. There is a whole host of technologies that can be used to improve the quality of stormwater. Some examples of the technologies that don’t require power are given below.

Bioretention:
These systems capture and retain stormwater from small areas in offline vegetated area where it is filtered through a drainage layer. The filtration can improve the quality of the stormwater and also encourages infiltration. Evaporation and transportation also removes some of the water. These can be well landscaped to
look attractive and the footprint required for the facility is about 10% of the area being drained. However, it does require a fair amount of fall from the drainage area to the stormwater discharge point for the filtration.

**Austin Filter**

These are concrete structures that comprise of a sedimentation tank, litter trap and sand filter that remove sediment and improve microbiological quality. The maintenance required includes regular cleaning of the litter trap and replacement of the filter sand every year.

Other interventions that can improve the quality of stormwater include:

- In channel litter traps (preferable with declined screens, such as SCS or Baramy)
- Kerb side litter traps
- Wetlands
- Kerbside sand filters
- Kerbside oil/water separators
- Breakaway bags
- Passive skimmers (to remove oils)
- Inline UV filtration
- Vegetated swales

Next to air, water is our most precious and valuable resource. South African water policy is considered best practice around the world, however, there is still much that can be done with water efficiency and water conservation in the South Africa context. Reduction in water usage through low flow and other water efficiency applications, water harvesting through rainwater collection, water recycling through grey water systems, local sewage processing for nutrient capture and re-use in agriculture are some of the ways we can make better use of the water cycle, reduce our ecological footprint and release more resources for all.
“I think that the suburban destiny is a pretty hopeless situation… I think it’s going to be a political, economic and social shitstorm and we’re not prepared for it… we’re literally stuck up a cul-de-sac in a cement SUV without a fill-up ”

Author James Howard Kunstler (in The End of Suburbia: Oil Depletion and the Collapse of the American Dream, a film directed by Gregory Greene, 2004)

One possible measure of the overall (un)sustainability of an urban transport system is the vehicle-kilometres travelled (VKT) within the functional area of the relevant city to support its routine daily activities. Given the high degree of reliance of dominant transport technologies on fossil fuels – including electric vehicles drawing on electricity grids in which coal-fired powered stations are an important component – aggregate motorised travel correlates closely with levels of non-renewable resource consumption (oil, coal), on the one hand, and the emission of greenhouse gases, on the other. On a broader canvas, the VKT
measure could be extended to include the movement of people and goods into and out of the city, but this goes beyond the conventional understanding of what constitutes an urban transport system to incorporate elements of inter-urban and international transport systems.

Addressing the more restricted measure – and accepting that emergence of non-fossil fuel based (and non-greenhouse gas emitting) transport technologies available on a mass basis is unlikely in the foreseeable future – efforts to improve the overall sustainability of an urban transport system by reducing aggregate VKT would involve two primary strategies. The first would be directed towards reducing the number of vehicles in the urban passenger transport system by bringing about a shift from the use of low-occupancy private motorised vehicles (cars, motorcycles) to non-motorised transport modes (walking, cycling), where feasible, and to shared ride or public transport modes (both road and rail-based), where not.

The second strategy would be directed towards reducing the overall length of trips within the city by initiating and sustaining changes toward a more compact urban form, in particular by seeking to bring employment activities into closer proximity to residential activities which, in principle, would have the effect of decreasing the contribution of a major component of aggregate VKT in the form of daily commutes. Realistically, given the inertia literally built into current highly ‘automobile-dependent’ urban structures, the timeframe for any such strategy to take effect would have to be measured in decades or generations rather than the five or ten year periods commonly associated with planning cycles.

This suggests that the attainment of fully sustainable transport systems is certainly not a short term prospect and that the most that seems practically feasible right now is to begin to redirect urban form and the operation of associated transport services towards the more sustainable patterns suggested above. This, however, should in no way be treated as a reason to delay such intervention, whose urgency must be clearly apparent to those who are not in denial about the seriousness of the resource depletion and global climate change crises which confront us at both the local and the global levels.

A major shift in the orientation of South African urban passenger transport policy occurred during the 1990s, in part as a response to changing ideas about the appropriate framing of such policy internationally, but also – and more importantly perhaps – to address certain unacceptable conditions in passenger transport
systems as the country entered the post-apartheid era. Three key documents were central to the process: the White Paper on National Transport Policy (1996), Moving South Africa: The Action Agenda. A 20-Year Strategic Framework for Transport in South Africa (1999), and the National Land Transport Transition Act (22 of 2000) – the latter shortly to be replaced by the National Land Transport Act which, however, does not significantly revise the basic parameters of the policy shift.

Very schematically, three axes or vectors of this shift can be identified (Behrens & Wilkinson 2003; Wilkinson 2008):

- from a ‘supply side’ orientation, involving the expansion of road networks to meet anticipated traffic volumes, together with the limited subsidisation of certain rail and bus commuter services, to a focus on serving the travel needs of differentiated ‘customer base’ – a ‘demand side’ orientation – as far as possible on a full cost recovery basis within a framework of ‘regulated competition’ among public transport operators;
- from a system of modally fragmented planning and management of transport provision, largely isolated from local land use planning, to a framework for integrated, cross-modal transport planning devolved to the local level, and undertaken in close cooperation with land use planning as part of the broader integrated development planning process undertaken by all municipalities;
- from an implicit prioritisation of the needs of private transport users reflected in the expansion of road networks and the gradual degradation of the levels of service offered by established public transport operations to an explicit commitment to putting ‘Public Transport First’ through prioritising investment in rationalised public transport (and non-motorised transport) facilities and services, together with appropriate travel demand management and road space management measures, including congestion charging, parking restrictions and other disincentives to the use of private vehicles.

References to the need to take issues of environmental sustainability into account tend to be muted in the current policy and legislative framework, and there is no overt reference to the global problems of oil depletion and global climate change, to which transport operations are quite evidently a major contributor. Nevertheless, the thrust of the current framework towards supporting and enhancing public and non-motorised transport modes while seeking to restrain the use of private vehicles is clearly an important indicator that movement in the direction of developing more sustainable passenger transport systems in South African cities is both mandated and possible.
This chapter sets out to make a case for urgent intervention to initiate a radical transformation to a more sustainable pattern of resource use in a key component of Cape Town’s transport sector. Attention is focused primarily on the city’s passenger transport system, which certainly accounts for the large majority of aggregate vehicle-kilometres travelled (VKT) within the metropolitan area.

The significance of this is that a decrease in aggregate VKT would be a fundamental indicator of progress towards reduced petroleum-based liquid fuel consumption and reduced greenhouse gas emissions – two critically important preconditions for achieving a more sustainable urban transport system. While the intra-urban movement of freight should not be considered inconsequential in this regard, it presents a set of issues which are different from, and possibly even more intractable than those we wish to explore for passenger transport, and we will refer to it only in passing. A similar proviso applies in the case of supra-local or inter-city passenger and freight movements by ground, air and sea transport.

The paper has been structured as follows: first, we provide a brief and schematic overview of Cape Town’s passenger transport system and outline the major environmental impacts associated with its current pattern of operation. Against the backdrop of rising concern about two key challenges in the contemporary world – the depletion of global oil and natural gas stocks and the prospect of global climate change induced by greenhouse gas emissions – we then draw out the possible implications for the sustainability of passenger transport operations in Cape Town.

Finally, we present some broadly framed ideas about what might constitute the elements of a strategic response to these problems and close with a somewhat blunt reminder of the urgency of the present situation, which – in our view – precludes any suggestion that fundamentally transformative action can be deferred to some later date.

Our explicit intention in the paper is to put forward a position on this particular issue, or cluster of issues, and we have written it accordingly in a style that is generally perhaps more polemical than is academically conventional. We are aware that some of our conclusions regarding the current situation, as well as some of the proposals we have put forward as to what might be done about it, are not substantiated by reference to the results of systematic and reliable empirical research. The relative paucity of such research in this field of enquiry is symptomatic, in our view, of the somewhat marginal status it appears to have been accorded to date.
Metropolitan Cape Town has a diverse and well-established transport infrastructure which has evolved gradually over some three centuries, but developed particularly rapidly during the second half of the twentieth century. Major sea and airport facilities connect the city externally into both national and international maritime and air transport systems, while comparatively extensive national road and rail networks accommodate the movement of people and goods at the regional and national scales.

Within the city, a relatively dense road network serves road-based public transport in the form of scheduled bus services and minibus-taxi operations as well as general traffic flows of private personal and freight transport vehicles. Uniquely in the contemporary South African context, the city’s radially-configured passenger rail network carries the largest proportion of public transport users, specifically in peak periods.

Transport infrastructure

The total length of the city’s road network was estimated in 2002 to be 8,200 kilometres, of which some 2,200 kilometres (27%) could be described as being of metropolitan significance in terms of traffic functions, with the remaining 6,000 kilometres (73%) comprising local distributor and access roads – representing a total asset replacement value then in the region of R16 billion. Regular scheduled maintenance of the road network was effectively suspended for a number of years in the face of budgetary constraints, but has since been resumed.

The total length of passenger rail track in the metropolitan area is currently of the order of 260 kilometres, served by 97 stations. The combined asset replacement value of rail track and rolling stock was estimated at R14 billion in 2002. The integrity of signalling systems has often been compromised by cable theft, leading to delays and cancellation of services, while vandalism of rolling stock remains a serious problem.

Provision for non-motorised transport (NMT) modes – predominantly walking and, very much less significantly, cycling – has been limited to the installation of conventional sidewalk and pedestrian crossing facilities in most areas and the establishment of some limited and disconnected cycleway routes. The very high incidence of accidents involving pedestrians, including a significant proportion of fatalities, suggests that the accommodation of pedestrian movements within the system remains patently inadequate.

1 Unless otherwise attributed, statistics included in this and the following sections are drawn from Behrens & Wilkinson (2003), which incorporates data from various official sources, or the 2004/5 Current Public Transport Record (CoCT, 2005).
Vehicle fleets and rolling stock

The fleet of private vehicles of all types in Cape Town totalled 790,000 in 2000, including some 570,000 registered cars – an estimated ratio of 190 cars/thousand people, which appears to be significantly higher than that found in other South African cities (Venter. 2007). The mean annual growth rate of registered cars in the metropolitan area was 3% between 1995 and 2000, while the number of daily car commuters grew from around 285,000 in 1980 to 680,000 in 2001 at a mean annual rate of around 4.6%.

The rate of growth in car usage exceeds population growth in general as well as growth in vehicle registrations, and has resulted in relatively sharp increases in daily traffic volumes on the major road network with a concomitant intensification of peak period congestion levels.

The primary modes of public transport in the city – passenger rail services operated by the South African Rail Commuter Corporation (SARCC), scheduled bus services operated primarily by Golden Arrow Bus Services (GABS), and unscheduled and only partially regulated minibus-taxi services provided by numerous individual and small-scale operators – together serve a daily market of some 1.13 million passenger trips.

In 2004, the SARCC was operating 66 train sets in peak periods, employing rolling stock comprising 231 motor coaches and 770 passenger coaches, serving a 54% share of this market. Plans to upgrade and replace the aging rolling stock through very substantially higher levels of investment than were previously undertaken were announced recently.

In 2004, GABS was operating a fleet of 852 single deck buses with an average capacity of 90 passengers (60 seated) on 736 scheduled service routes during morning peak periods, using 50 terminals and 80 ranks as well as 2 holding areas, with a 17% share of daily passenger trips in the public transport market. In the same year, some 7,500 licensed and unlicensed 15-seater minibus-taxis operating on 555 routes in morning peak periods from 112 terminals and 61 ranks, as well as 30 holding areas, provided unscheduled services to 29% of this market.

Ongoing replacement and extension of the bus fleet has been negatively affected by uncertainty regarding plans to reform the road-based public transport system, while the much delayed government-funded taxi recapitalisation programme has yet to have any significant impact on replacement the minibus-taxi industry's generally aging vehicle fleet.

Modal split

Broadly indicative data on commuter travel patterns in Cape Town obtained from household surveys conducted in 1991 and 2004 reveal an overall shift during this period from public to private modes of transport and, within the public transport sector, a shift from scheduled bus and rail services to minibus-taxi services (see table below).²

² The substantial discrepancy in the public transport sector modal split for 2004 between this data set and that obtained from the 2004/5 Current Public Transport Record (cited in the previous section with respect to public transport passenger market shares) is not explained but the overall directions of the key trends are likely to remain generally correct.
The first of these trends accords with other evidence which suggests that – at least until the recent sharp escalations in both fuel prices and finance charges substantially altered the parameters of such choices – those public transport users able to acquire private vehicles have done so as soon as their economic circumstances have permitted this, largely due to dissatisfaction with the levels of service offered by the public transport system.

The modal shift within the public transport system towards minibus-taxis has long been evident and has been attributed to their higher levels of convenience relative to the scheduled modes, despite widespread concerns about their higher (unsubsidised) fares, overcrowding and compromised safety due to poor driving behaviour.

Systemic duality and differentiated mobilities

The dualistic structure of the passenger transport system is both derived from and reinforced by the legacy of socio-spatial segregation inherited from apartheid era urban planning practices. On the one hand, when they can afford it, members of lower income households, predominantly situated in what are often geographically peripheralised townships and informal settlements, constitute the majority of ‘captive’ users of public transport – or they otherwise walk.

On the other hand, members of middle and higher income households, situated in wealthier and sometimes more conveniently located suburbs, for the most part have acquired and routinely use private vehicles rather than public transport. The routine travel patterns and experiences of people within these two broadly defined segments within the passenger transport market therefore remain effectively discrete, reflecting significantly different mobilities.

Most immediately, such differentiated mobility is evident in the lack of convenience, comfort and safety routinely endured by ‘captive’ users of the three primary public transport modes, but it is also apparent in lengthy travel times and transport expenditures which tend to be relatively less affordable than those incurred by wealthier households using private transport. Lower income households – those earning less than R500/month – can end up committing as much as 35% of their total income to meeting basic transport costs, while this figure falls to 5% for wealthier households earning more than R3,000/month, which are likely to own and use private transport (DoT. 2005).

### Changing modal split in commuter travel, 1991 - 2004

<table>
<thead>
<tr>
<th></th>
<th>Private transport</th>
<th>Public transport</th>
<th>Walk / other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Rail</td>
<td>Buses</td>
</tr>
<tr>
<td>1991</td>
<td>44%</td>
<td>27%</td>
<td>16%</td>
</tr>
<tr>
<td>2004</td>
<td>48%</td>
<td>13%</td>
<td>7%</td>
</tr>
</tbody>
</table>

Source: CoCT 2006
Aggregate travel patterns

Although not uniformly so, the city’s present spatial structure is dominated by sprawling, low density development patterns. Together with the geographical eccentricity of its historical core area in which a large proportion of economic activities and employment opportunities continue to be concentrated, this imposes long average trip lengths on much of the population, particularly the lower income people living in the metropolitan south-east sector in the more recently developed and heavily populated residential areas and informal settlements.

The overall pattern of significant geographical separation between zones of employment and major residential zones leads to the phenomenon of ‘tidal flow’ in commuter traffic, in which peak period congestion and overcrowding of public transport in one direction is combined with the presence of unused or underused road capacity and public transport passenger capacity in the reverse direction. This reflects what is probably the single most significant inefficiency imposed on the operation of the passenger transport system.

Institutional framework

The institutional framework governing the operation of Cape Town’s passenger transport system is characterised by a high degree of fragmentation, resulting in poorly coordinated, occasionally incoherent, planning and regulation, as well as generally inefficient operational management (Wilkinson. 2008). The fragmentation cuts across the parastatal and private agencies involved in operating the different modes of public transport and across the three spheres of government responsible for different aspects of infrastructural provision, and the planning, regulation and disbursement of public subsidy funding within the system.

The establishment of local level transport authorities to integrate and coordinate the execution of most of these functions – excluding those associated with the provision of passenger rail services – has been legally possible since the passage of the National Land Transport Transition Act (NLTTA) in 2000. For complex reasons, however, to date there has been no effective progress in this regard in Cape Town, although there is some expectation that the recently published National Land Transport Bill, which is intended to replace the NLTTA, may resolve some of the difficulties that have been seen to obstruct the installation of a suitably constituted metropolitan transport authority.
The impacts of transport system operation and associated patterns of travel behaviour described in the preceding section on resource use and the surrounding biophysical environment are considered here in terms of fuel consumption and gaseous emissions.

The significance of the inefficiency and contribution of Cape Town's transport system to energy consumption and greenhouse gas (GHG) emissions discussed needs to be viewed within the context of global concerns about oil depletion (Box 1) and climate change (Box 2). Clearly transport systems have a variety of aural and visual pollution effects, as well as 'barrier' or 'severance' affects, on local communities but these are arguably less significant from the perspective of resource use sustainability, and are therefore excluded from more detailed discussion here.

With regard to fuel consumption, according to a 2008 report by the Sustainability Institute, the transport sector is the largest consumer of energy, accounting for 47% of the city's total energy consumption, followed by commerce and industry (38%) and households (14%) (see table below). Within the transport sector, 60% of liquid fuel consumption is in the form of petrol, and 20% in the form of diesel.

Table 2 illustrates that the energy use profile for the city as a whole is dominated by petrol (28%), electricity (29%) and diesel (18%), with paraffin, liquefied petroleum gas, coal, heavy furnace oil, jet fuel and wood accounting for the remaining 24% of energy.

### Annual energy use by user group and fuel type (1,000 gigajoules)

<table>
<thead>
<tr>
<th>User Group</th>
<th>Electricity</th>
<th>Diesel</th>
<th>Petrol</th>
<th>Paraffin</th>
<th>LPG</th>
<th>Wood</th>
<th>Coal</th>
<th>Heavy furnace oil</th>
<th>Jet fuel</th>
<th>Total</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Households</td>
<td>17,969</td>
<td>-</td>
<td>-</td>
<td>2,587</td>
<td>547</td>
<td>359</td>
<td>43</td>
<td>-</td>
<td>-</td>
<td>21,505</td>
<td>14%</td>
</tr>
<tr>
<td>Industry/commerce</td>
<td>24,755</td>
<td>13,160</td>
<td>-</td>
<td>444</td>
<td>2,718</td>
<td>561</td>
<td>10,788</td>
<td>4,696</td>
<td>-</td>
<td>57,123</td>
<td>38%</td>
</tr>
<tr>
<td>Local authority</td>
<td>1,747</td>
<td>234</td>
<td>119</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2,100</td>
<td>1%</td>
</tr>
<tr>
<td>Transport</td>
<td>-</td>
<td>14,337</td>
<td>42,294</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>13,616</td>
<td>70,246</td>
<td></td>
<td>47%</td>
</tr>
<tr>
<td>Total</td>
<td>44,472</td>
<td>27,731</td>
<td>42,413</td>
<td>3,030</td>
<td>3,265</td>
<td>920</td>
<td>10,831</td>
<td>4,696</td>
<td>13,616</td>
<td>150,975</td>
<td>100%</td>
</tr>
<tr>
<td>Total (%)</td>
<td>29%</td>
<td>18%</td>
<td>28%</td>
<td>2%</td>
<td>2%</td>
<td>1%</td>
<td>7%</td>
<td>3%</td>
<td>9%</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

Source: Sustainability Institute 2008

---

3 An earlier study in 1997 estimated that the transport sector was responsible for 44% of energy consumption (Wicking-Baird et al 1997) – suggesting perhaps that the transport sector’s relative energy consumption has grown.

4 A limitation of these data is their omission of electricity consumption by the city’s extensive rail operations.
Key debates in the area of global oil depletion revolve around when and how the operation of transport systems, and of economic systems more generally, will be impacted. As oil is a finite resource, the rising production of oil that has underpinned economic growth over the last 150 years cannot continue indefinitely. Currently, oil accounts for around 35% of global energy supply. As an energy source it is used for electricity generation, heating and as a liquid fuel for transport systems. The world’s transport systems (including land, air and sea transport modes) depend on oil for around 90% of their energy requirements (Wakeford. 2007).

| Global energy supply by fuel type (2004) (million tons of oil equivalent) |
|-----------------------------|-----------------------------|
| Million tons of oil equivalent | Percentage |
| Oil | 3,947 | 35% |
| Coal | 2,769 | 25% |
| Gas | 2,310 | 21% |
| Combustible renewables and waste | 1,177 | 10% |
| Nuclear | 718 | 6% |
| Hydro | 247 | 2% |
| Geothermal/solar/wind | 56 | 0.5% |

Source: Wakeford 2007 (citing the International Energy Agency)

Hubbert (1956) assessed discovery rates, production rates and cumulative production in the oil industry and predicted that production in any given region would follow a bell-shaped curve (subsequently known as the ‘Hubbert curve’), rising to a peak when approximately half of the total oil had been extracted, and thereafter gradually falling toward zero as extraction becomes progressively more difficult and costly.

The Association for the Study of Peak Oil (ASPO) argues that there is growing evidence that global oil production is nearing, or at, the top of the ‘Hubbert curve’ (a point of production referred to as ‘peak oil’). This evidence includes, amongst other things, a steady decline in new ‘conventional oil’ discoveries since the 1960s, oil consumption rates exceeding discovery rates since 1981, and 33 out of the 48 significant oil-producing nations passing their individual production peaks (Wakeford. 2007).

Predictions about the timing of the world peak vary amongst oil geologists and energy agencies (see Wakeford. 2007). Some predict ‘peak oil’ within the next five to ten years, while others predict a peak in about 25 years. The main sources of contention revolve around the accuracy of reported Middle
Eastern reserves, and potential yields from ‘unconventional’ sources (e.g. tar sand and shale). On the current evidence, it appears unlikely that production will increase substantially beyond its current level (at around 86 millions barrel/day), and that following a ‘bumpy plateau’ of several years it will begin to decline. The impact of stagnant or declining oil production, and the probable unavailability in the short term of alternative fuels distributable on a mass basis will be a growing supply-demand gap, with inevitable consequences for fuel prices. As a heavy user of oil, Cape Town’s transport system is likely to be hard hit.

With regard to gaseous emissions, important quantifiable emissions from the transport sector which either directly or indirectly contribute to the ‘greenhouse effect’ include: carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), mono-nitrogen oxides (NOₓ), carbon monoxide (CO) and sulphur dioxide (SO₂) (ERI 2002).

A study of photochemical smog, or ‘brown haze’, in Cape Town in 1997 estimated that the transport sector was the largest contributor to nitrous oxide, and the largest contributor to photochemical smog (52%) in the city (Wicking-Baird et al 1997). In Cape Town, 2,815,566 kg of CO₂ were estimated to have been emitted from petrol consumption in 2001, and 1,487,441 kg from diesel consumption (CoCT 2003).

An update of GHG emissions data in Cape Town by Kennedy et al (2008) is illustrated in Table 4. These provisional data suggest that ground transport is responsible for some 12.7 megatons of CO₂ equivalent per year, representing around 33% to 45% of total direct GHG emissions.

<table>
<thead>
<tr>
<th>Provisional estimate of direct greenhouse gas emissions in Cape Town</th>
<th>Annual GHG emissions (megaton CO₂ equivalent)</th>
<th>Percentage of total emissions included in estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>8.6</td>
<td>22.6%</td>
</tr>
<tr>
<td>Heating and industrial</td>
<td>3.7</td>
<td>10.6%</td>
</tr>
<tr>
<td>Ground transport</td>
<td>12.7</td>
<td>33.5%</td>
</tr>
<tr>
<td>Air and marine transport</td>
<td>12.6</td>
<td>33.3%</td>
</tr>
<tr>
<td>Direct industrial</td>
<td>not determined</td>
<td></td>
</tr>
<tr>
<td>Waste</td>
<td>not determined</td>
<td></td>
</tr>
<tr>
<td>Vegetation</td>
<td>not determined</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>37.6</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: Hansen and Gasson 2008
Notes:

1. The estimated split between petrol and diesel is 8.9 megaton and 3.8 megaton of CO₂ equivalent respectively.

2. This estimate allocates 100% of emissions generated from the consumption of fuels put on board in Cape Town, to the Cape Town area.

3. If it is assumed that only 25% of marine and air transport emissions are allocated to the Cape Town area, the total is reduced to 28 megaton CO₂ equivalent.

From an energy and emissions perspective, Cape Town’s transport system will therefore be central to any attempt to place the city on a sustainable resource use path.

**TRANSPORT AND GLOBAL CLIMATE CHANGE**

The Intergovernmental Panel on Climate Change (IPCC) has concluded that most of the observed increase in globally averaged temperatures since the mid-1900s is very likely due to observed increases in anthropogenic GHG concentrations via an enhanced ‘greenhouse effect’.

Paleoclimatic studies of ice cores spanning the last 650,000 years indicate that global atmospheric concentrations of CO₂, CH₄ and N₂O have increased markedly as a result of human activities since the mid-1700s and now far exceed pre-industrial values (IPCC. 2007). The recent global increases in CO₂ equivalent concentration are argued to be due primarily to fossil fuel use and land use change.

The following table illustrates the contemporary relative contributions of key sectors to global GHG emission, with the transport sector estimated to be responsible for 14% (Stern. 2006).

<table>
<thead>
<tr>
<th>Global Greenhouse gas emissions by sector (2000) (gigatons of CO₂ equivalent)</th>
<th>Gigatons CO₂ equivalent</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>10.08</td>
<td>24%</td>
</tr>
<tr>
<td>Land use</td>
<td>7.56</td>
<td>18%</td>
</tr>
<tr>
<td>Agriculture</td>
<td>5.88</td>
<td>14%</td>
</tr>
<tr>
<td>Industry</td>
<td>5.88</td>
<td>14%</td>
</tr>
<tr>
<td>Transport</td>
<td>5.88</td>
<td>14%</td>
</tr>
<tr>
<td>Buildings</td>
<td>3.36</td>
<td>8%</td>
</tr>
<tr>
<td>Other energy related</td>
<td>2.10</td>
<td>5%</td>
</tr>
<tr>
<td>Waste</td>
<td>1.26</td>
<td>3%</td>
</tr>
</tbody>
</table>

Source: Stern. 2006

Climate model projections summarised by the IPCC (2007) indicate that average global surface temperature will likely rise a further 1.1°C to 6.4°C over the next century if no significant action is
taken. The Stern Review on the economics of climate change in 2006 argued that such a radical change in the physical geography of the world must lead to major changes in its human geography (Stern. 2006). Even at more moderate levels of warming, climate change will have serious impacts on economic systems and human life. These predicted impacts include, amongst other things, increased flood risk, reduced water supplies, decreased crop yields, rising sea levels, and reduced biodiversity (Stern. 2006).

Imminent international political pressure to substantially decrease GHG emission through the introduction of carbon pricing (and trading) measures or penalties for exceeding emission constraints, as well as sustained increases in the price of petroleum fuels, will have significant implications for Cape Town’s transport system. We believe that the more important of these are likely to include the following:

- The accelerating ‘automobilisation’ – acquisition and use of private cars – experienced in the city’s passenger transport sector over the last 50 years is likely to be gradually halted and then permanently reversed. In the likely event that affordable alternative fuels are not readily available at least in the short term, a substantial number of ‘choice’ passengers will be unable to bear the growing cost of extensive car use. A significant level of private car (and perhaps motorcycle) usage is, nevertheless, likely to remain in the medium term future, unless additional constraints are introduced and the levels of service offered by the public transport system improved significantly.

- Generally within the public transport passenger market, a shift from minibus-taxi services back to the commonly cheaper, publicly subsidised rail and bus services is likely where such services are reasonably accessible. More specifically among the poorest sections of the ‘captive’ public transport passenger market, reliance on non-motorised travel (NMT) modes, particularly walking, is likely to deepen as public transport fares rise to incorporate fuel price increases and any form of motorised travel becomes increasingly unaffordable.

- The likely effects of possible future carbon pricing measures and associated energy price escalations would be felt across both electrified and petroleum fuel-based transport systems. In the inter-city land freight transport sector, such price escalations, in conjunction with those induced by oil depletion, would probably lead to a shift from road to electrified rail services, provided the reliability and competitiveness
of the latter can be improved and the long-term decline in its ‘reach’ or penetration across the national space-economy can be reversed. Within the intra-urban land freight transport sector, however, a similar shift from road back to rail is less likely due to inherent inertia in the current locational patterns of economic activities in the city’s land use system.

- The viability of air transport for both freight and passenger movements – particularly those of a discretionary (e.g. tourism) and short-haul nature – is likely to decline fairly rapidly in the face of aviation fuel price increases. Given the substantial investment currently being made in the expansion of the city’s facilities to service anticipated growth in air transport, there must be some possibility that such new infrastructure could become an underutilised ‘white elephant’.

Ideally, to achieve a more sustainable pattern of resource use in Cape Town’s transport sector, the routine movement of both people and goods would need to become as ‘localised’ and non-dependent on carbon energy sources as possible. The key indicator of progress in this regard would be a reduction in the total amount of vehicle-kilometres travelled (VKT) both within the metropolitan area and in connecting it externally to other cities and regions, specifically in travel using the conventional motorised modes.

Petrol and diesel-powered vehicles obviously fall into this category but, given the current level of reliance of the national electricity grid on coal-based generation, the use of electrically-powered vehicles on either the road or the rail networks would also have to be regarded as problematic, at least for the foreseeable future. In the absence of practical alternatives, the growing economic significance of the city’s external connections – particularly those made by air transport – presents what is probably an even more pressing problem from this perspective.

Focusing most immediately here on the issue of intra-metropolitan passenger movement, however, the feasibility of bringing about a significant reduction of VKT can be seen to be determined primarily by the realistic prospects of reducing the need to travel in the first place and, where that is not possible, by promoting the use of more fuel-efficient and less polluting modes of motorised transport, particularly public transport, as well as the key NMT modes of walking and cycling. The first of these prospects – reducing aggregate travel demand – is shaped directly by the pattern of accessibility of workplaces, of shops, of schools, health care, recreational and other public facilities embodied in the spatial fabric of the city, which has evolved historically over long spans of time and which therefore has a substantial degree of inertia built – literally – into
it. Transforming the current pattern of accessibility into one which is less structured to accommodate, and consequently is dependent on, motorised transport is therefore by no means an option likely to be realised in the short or even medium term.

The second prospect – that of promoting a shift towards the use of more sustainable modes of transport, including NMT – can be realised only through the emergence of a very significant shift in current patterns of travel behaviour. In the context of contemporary Cape Town, as in other South African cities, the key target here would be that relatively more wealthy segment of the dualistically structured passenger transport market which relies largely or exclusively on petrol or diesel-driven private transport (cars and two wheelers) to meet its mobility needs. The absolutely essential preconditions to effect appropriate change in such people’s travel behaviour would be to establish an well-integrated, reliable and safe public transport system – which nevertheless remains affordable to its current mainly lower income users – and to provide much more systematically and comprehensively than at present for the needs of pedestrians and cyclists – not least in terms of enabling them to access public transport facilities safely and conveniently.

Building on this still provisional and undoubtedly incomplete understanding of the issues involved, we would advocate that a strategically framed response to the complex and difficult task of inducing movement towards more sustainable resource use in Cape Town’s passenger transport sector should incorporate, and appropriately elaborate, at least the following set of key policies or actions:

- Introduction of an appropriately structured and phased programme of travel demand and road space management measures, including – but not limited to – the prioritising of available road space for public transport operations over any accommodation of general traffic flows (though the provision of dedicated public transport lanes, intersection signalling priority, etc), instituting direct or proxy road use pricing for private vehicles, encouraging the formation of lift clubs, firm-based travel planning and other ‘mobility management’ measures, and the promotion of compressed working week schedules or telecommuting options, or both in combination, among local employers.

- The establishment of a systematically planned public transport network which operates efficiently and effectively across appropriately and comprehensively integrated road and rail-based modes to facilitate the easy (‘seamless’), reliable, safe and affordable passage of its users throughout the metropolitan area. Very substantial amounts of capital expenditure, as well as public funding for operating subsidies are likely to be involved.

- Initiation of a programme of significant investment in the extension and upgrading of pedestrian and cycling infrastructure, systematically integrated with current and planned public transport facilities but also offering opportunities for safe non-motorised travel within and between local areas.

- As the corollary of prioritising provision for public transport and NMT modes, investment in infrastructure or facilities which primarily or exclusively serve the least sustainable modes of transport – particularly the
use of private cars and air travel – should be discontinued, other than in cases justified on the basis of careful and comprehensive assessment of the full range of social and environmental costs that may be involved to realise any claimed benefits of such investment.

- The planning and regulation of integrated public transport operations should explicitly acknowledge and build upon the significant physical and human capital assets represented by key components of the current public transport system – local passenger rail services, in particular, but also the privately-operated and long-established scheduled bus services, as well as, perhaps more problematically, the minibus-taxi industry. This implies the modification of any proposed tabula rasa or ‘clean sheet’ approaches to the necessary far-reaching reform of the city’s public transport system in such a way that present contextual realities are appropriately accommodated.

- The formulation of robust, well-grounded and widely canvassed plans (‘spatial development frameworks’) which seek to promote, through appropriate land use management measures and careful planning of the installation of urban infrastructure, the evolution over time of less travel-intensive patterns of urban development. These would generally include, but not be limited to, the emergence of polycentric spatial structures at the city scale and the facilitation of ‘transit oriented’ mixed use and higher density development associated with public transport interchange, terminal or station precincts at the local area or neighbourhood scale. This obviously requires the abandonment of any planning or regulatory practices which underpin the extension of current patterns of low density and spatially fragmented ‘urban sprawl’ and ‘automobile dependent development’ at either the city-wide or the local area scales.

- Spatial development plans should, to the degree possible in the face of uncertainties and imponderables in this regard, allow for and support the increased ‘localisation’ of appropriately reconfigured economic activities as transport costs become increasingly burdensome, including, perhaps most importantly, the production and marketing of foodstuffs.
It seems clear that both at the global and at the immediately local scale, we are rapidly approaching what may prove to be a critical ‘tipping point’ in the way that our present transport systems operate, which in turn will have fundamental implications for the manner in which our cities themselves are structured and function. When liquid fuel prices exhibit a sustained rise above some threshold level which we cannot readily predict but may be imminent, the now unaffordable travel behaviour of many people will unavoidably have to change, and with it all or most of their essential ‘lifestyle’ choices – where to live and work, where to send children to school, and where to shop and recreate, among others. The viability, not only of our transport systems in particular, but also of our urban systems more generally, will certainly then be thrown dramatically into question.

In addition, while this remains the object of ongoing controversy, it is possible that another critical tipping point, which will have equally significant – if not even more fundamental – impacts on our behaviour and lifestyles may already have been passed. There is now a weight of informed opinion that anthropogenic climate change as a result of increased GHG emissions, to which transport systems have been a major contributor, is already a reality.

Even if we were to manage to reduce the absolute volume of GHG emissions immediately – requiring a massive and fundamental transformation of the way our social and economic systems work – we may already have set processes of irreversible climate change in motion on a planetary scale. At the very least, then, acceptance of the so-called ‘precautionary principle’ would imply that we need to act now to contain and reduce the level of such emissions in all sectors, but certainly, from the perspective of our concerns here, in the transport sector.

The expectations some may hold that technological ‘fixes’ will inevitably emerge in the form of greatly more fuel efficient and less polluting or non-petroleum-based vehicle propulsion systems which will obviate the need for any radical systemic transformation are, in our view, likely to prove self-deluding. As in other arenas of contemporary existence, the issue is primarily not one of simply substituting one technology for another, but rather of reforming or transforming the social structures and practices in which the use of any technology is embedded.

Efforts to suppress recognition of the urgency of the current situation, and to delay intervention to secure transition towards a more sustainable urban transport system in the interests of continuing ‘business as usual’, we believe can no longer be seen as tenable.
“The world food situation is being rapidly redefined by new driving forces. Changes in food availability, rising commodity prices and new producer-consumer linkages have crucial implications for the livelihoods of poor and food-insecure people.”

Von Braun. 2007

Urban Agriculture (UA) can be defined as an industry located within (intra-urban) or on the fringe (peri-urban) of a town, a city or a metropolis, which grows and raises, processes and distributes, a diversity of food and non-food products, (re)using largely human and material resources, products and services found in and around that urban area, and in turn supplying human and material resources, products and services largely to that urban area (Mougeot. 2005).

Sustainable Urban Agriculture

While there are many critical contributors to the advancement of or decline in sustainability, four key focus areas are where we live and work and the related contributors (shelter); the fuel that “powers” our way of life (energy); how we, and the goods we consume, are moved (transport); and lastly, what we eat and
how the food we eat is produced (agriculture). A sustainable neighbourhood recognises the interrelationship between these contributors that together with many local and site specific needs become critical in the formulation of strategies and approaches pertinent to the functioning of the urban environment. The nexus between development, ecological services preservation, social justice and the economy impacts directly on all strategies and policies of a neighbourhood development.

This chapter attempts to address what is required for a neighbourhood to effectively support its residents to access healthy, nutritious and local food. Specifically, what is necessary for this to be done in a manner that enhances social justice, the supply and maintenance of ecological services and a neighbourhood’s effective functioning? At a time of great insecurity that requires approaches to consider a far deeper and longer term view, strategies must be adopted that actively build capital (not only economic, but also social and ecological capital) instead of degrading it?

The recent review of the current industrialised approach to food production by the United Nations International Assessment of Agricultural Knowledge, Science and Technology for Development report (UN IAASTD. 2008) highlights the significant flaws of this approach. The report argues for fundamental changes in the world’s agricultural systems. It highlights the inequitable distribution of costs and benefits of the present agricultural systems, particularly the pervasive influence of agribusiness and unfair trade policies that have negatively impacted on communities in the developing world. According to Washington-based International Food Policy Research Institute (IFPRI), low growth rates in food production “will be insufficient to meet the expected increase in demand. IFPRI research suggests that prospects for a food secure world in 2020 look bleak if the global community continues with ‘business as usual,’ (Scherr. 1999). In this regard the IAASTD report proposed that smallholder agro-ecological farming will be more effective at meeting today’s food production challenges than the old energy and chemical-intensive paradigm of industrial agriculture, if societal inequalities are to be reversed.

Urban neighbourhoods are becoming the dominant human environment and between now and 2050, the bulk of urbanisation is expected to occur within developing world urban centres. It follows that efforts to address food and nutritional security need to be identified within the urban context. Food production in urban neighbourhoods has a long tradition in many countries and the UNDP (1998) has estimated that urban agriculture produces between 15 and 20% of the world’s food.
Considering the food needs of a city and using the City of Cape Town as an example and by applying the internationally recognised norm of 0.4 hectares of arable land to feed a person, the food needs for the City of Cape Town, using the 2006 population figures of 3,240,000 (PGWC. 2006), would mean that Cape Town requires 1.3 million hectares to sustain its population. This is in fact 9.2 percent of South Africa’s arable land. This means that footprint in terms of food production is significant. Food plays a vital role in broader sustainability issues and food production is seen as a key element within future strategies for an urban area or even region in terms of both footprint reduction but also social justice and ecological sustainability.
Food security is a national issue. The obligation to protect, or at least insulate, the populace, and in particular the poor, from erratically fluctuating food prices is a core responsibility of government. However, it is naive to expect that government alone will be able to address these challenges. Civil society and the private sector must become core partners in any endeavour to address issues of food security. Current price fixing in food production and manufacturing provide evidence of a lack of cooperation and partnerships. What then should the policy frameworks be that will ensure that all the various parties work together towards an environment that ensures food security within the urban context?

As argued in this chapter, one of the core thrusts of any urban agriculture policy is to ensure that planning directorates recognize urban agriculture as a core activity within the urban form. At a national level, Urban Agriculture is recognized within the Land Care Department, as evidenced by Land Care’s involvement in the Green Lungs project which is a large macro projects that seeks, for example, to create over 1000 food gardens within a limited period of time. While this is certainly a critical project, the ability for Land Care officials to implement this without other local policy mechanisms being in place is questioned.

At a more regional level, urban agriculture is a core component of the Gauteng Agriculture, Conservation and Environment Ministry. The foresaid Ministry developed the Gauteng Agricultural Development Strategy or GADS which was implemented to take advantage of the sector’s potential for economic empowerment and growth (Mosunkutu. 2007). It is however questioned how pro-poor the strategy actually is, with its focus on bio-technology, agro-processing and high value and niche market crops.

The recognition of urban agriculture as a key activity within the various centres within South Africa is evidenced in how urban agriculture is articulated within the various strategies and policies. The City of Cape Town is the one metropole that has a specific Urban Agriculture Policy (CoCT. 2008); while other centres such as the City of Tshwane have developed an Urban Agriculture Development Policy; Port Elizabeth has established the Urban Agriculture sub-directorate which aims to provide infrastructure for commercial and emerging agricultural activities to take place, and Durban has an Informal Economy Policy (2001), of which urban agriculture is one component.

The great challenge that emerges with all the various policies and strategies being located within different ministries and directorates is the ability to develop coherent and effective national initiatives that work with existing policies instruments and frameworks, while complimenting one another through shared learning and

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2 The Green Lungs/Urban Agriculture – Project (DOA Presentation May 2007)
3 Only a Draft submission of this document could be located, dated 2007.
5 See: http://www.streetnet.org.za/English/policyurban.htm
experience. While all policies share similar goals, such as the creation of an enabling policy environment, capacity development, infrastructure development, the recognition of cross-cutting issues, market and demand challenges, national and international trade opportunities and synergy, this is often read as jargon with limited implementation demands or requirements.

The need to align urban agriculture policies from the various centres and to link these to existing macro level strategies or mechanisms such as the Expanded Public Works Campaign, Microeconomic Reform Strategy and the Agriculture Sector Plan, is critical.

Regardless of the various needs, wants and political imperatives, Drescher, Nugent and de Zeeuw (2000) argue that the critical focus of any urban agriculture policy should be:

- Food security and nutrition
- Health and the urban environment
- Urban planning

While the economic component is recognized as being important, the dominance of this within the South African policies and strategies is questioned. If planning facilitates the correct urban environment to promote public health, nutritional and food security, it is argued that the economic component with follow. Conversely, focusing on the economic component in order to address the broader issues may prove to be counterproductive and further alienate the vulnerable and insecure.

The Nexus Between Urban Agricultural and Policy

There are critical connections where urban agriculture and urban policies bisect and are intrinsically linked. The following recommendations have been adapted from de Zeeuw (2003):

- **Integration in Urban Land Use Planning:**
  The revision of urban zoning by-laws which can determine the prohibition, allowance or promotion of urban agricultural zoning within specified modalities. Access to land can be enhanced by offering vacant urban open spaces and semi-public spaces (grounds of schools, hospitals, prisons, etc.) with medium-term leases. The promotion of multifunctional land use\(^6\), the promotion of community participation in the management of urban open spaces, the inclusion of space for individual or community gardens in new housing projects and in private building schemes.

- **Inclusion of Agriculture in Urban Food Security Policies:**
  The provision of budget and expertise to boost the preparation of broader urban agriculture programmes. The stimulation of participatory adapted research, oriented towards development of technologies suitable for farming in confined spaces and with low risks for health and the urban environment. The organisation of farmers’ study clubs and the provision of training and technical advice to urban farmers. The improvement of access of urban farmers to credit schemes for investments in production infrastructure and innovation

\(^6\) This refers to land that is used for a variety of functions and would not be exclusively for agriculture. This could include commonage areas where there are a mix of uses or could be areas that are used at specific times of the year only.
of production technologies as well as the facilitation the local marketing of fresh urban produce and finally, the promotion of small-scale enterprises linked with urban agriculture.

- **Integration of Agriculture in Urban Environmental Policies:**
  The establishment of low-cost facilities for sorting of organic wastes and the production of compost and animal feed or biogas; stimulation of practical research to develop adequate composting and digesting technologies. The promotion of investments in systems for rainwater collection and storage and the establishment of localised water-efficient irrigation systems in order to reduce the demand for expensive municipal water. The implementation of projects with decentralised collection and treatment of household wastewater for use in agricultural production and the promotion of the supply of natural fertilisers, bio-pesticides, soil amendments and quality seeds to urban farmers.

- **Integration of agriculture in urban health policies:**
  Farmer education on health risks associated with urban farming and the promotion of ecological farming practices such as integrated pest and disease management, ecological soil fertility management, soil and water conservation. The organisation of joint agriculture/health programmes on prevention of vector born diseases with emphasis on adequate environmental management and the placement of restrictions on production of certain types of crops or animals or certain farming practices in specific parts of the city where such crops, animals, practices may cause unacceptable health risks.

**Creation of an Enabling Environment**

Girardet, et al (1999) argue that the interrelated nature of food, agriculture, health and ecology calls for a more integrated approach to urban agriculture and proposes the formation of municipal working groups that can deal with food issues from a total system perspective allowing for interventions that cross specific functions and needs within the neighbourhood. While cities often articulate these needs within policy, it is generally unclear how this would be achieved. These structures are seen as critical components of urban agriculture policies.
Another key approach to facilitate an enabling environment for urban agriculture could be the creation of cooperatives, organizations or agencies which support urban food issues. Urban food policy councils, for example, have been successfully formed in other countries to help guide government decisions on food. Food policy councils bring public and non governmental agencies into the debate.

These councils are often informal coalitions of local politicians, hunger activists, environmentalists, sustainable agriculture advocates, and community development groups which can allow food policy decisions to reflect a broad range of interests (Pothukuchi & Kaufman. 1999; Hamilton. 2002). In many cases, communities endeavour to address food security without reference to any overall strategy. When existing strategies are in place, mechanisms should be provided to integrate these strategies within communities.

Discussions on urban agriculture often result in a debate on challenges and constraints. Though these challenges can be valid, uninformed and outdated paradigms may generate negative responses. Those responsible for the development of urban agricultural projects should look beyond these challenges and seek out ways in which to turn these challenges into opportunities. When stated challenges are reviewed and alternatives considered, innovative solutions often emerge.

Urban agriculture could include a variety of farming typologies that vary from small scale backyard gardens to larger scale “urban farms”, from fish farming to horticulture. These require management teams that would be able to respond to the wide ranging options and support interventions in a proactive manner. Such an approach calls for a far broader view of the potential benefits and advantages that urban agriculture holds forth urban environment. The integrated nature of urban agriculture requires a holistic approach that should feature much more prominently in future planning of the functioning within the towns and cities.

What is the role of planning and policy in urban areas that will provide a response to the structural and policy challenge of “business as usual” what are the new perspectives required to incorporate these issues into the planning process? Halweil and Nierenberg (2007) argue that planners interested in making room for farming in cities must look beyond farmers’ markets and community gardens to much broader issues in overall city design.
Urban planners commonly consider urban gardening and livestock keeping as a ‘hang-over’ of rural habits, a marginal activity of little economic importance, or alternatively, a health risk and a source of pollution that has to be curtailed. Such biases, sustained by the limited exposure of policy makers and planners to grounded information on urban agriculture, have resulted in far reaching legal restrictions on urban agriculture. Nevertheless, urban agriculture has continued to grow in most cities in the South (de Zeeuw, 2003). However, few authorities recognise urban farming as an urban form of land use, despite its prevalence (Gabel, S. 2005).

The coordination of data sets on land suitability and availability, commonage, parks and green spaces, water courses, flood zones, etc. is also a critical aspect of planning and strategy, and should be coordinated with reviews and audits. A starting point in any approach to an integrated urban agriculture strategy should be a thorough land audit.

It is believed that by adopting a proactive and integrative approach to urban agriculture that is firmly embedded within the planning processes, cities can unlock significant potential. Any strategy would need to incorporate proactive steps to reduce the footprint of the City without which efforts at sustainability will remain tokenistic and inconsequential.

**Types of Urban Agriculture**

Although this chapter starts with a definition of Urban Agriculture, it should be recognised that Urban Agriculture is not easily defined since a large variety of urban farming systems can be encountered, with varying characteristics according to local socio-economic, physiogeographic and political conditions. A selection of other definitions and explanations are detailed below.

**Urban forestry** can be defined as an integrated approach to the planting, care and management of trees in urban and peri-urban areas to secure economic, environmental and social benefits for urban dwellers.

**Urban agriculture** produces and markets foods and fuel largely in response to the daily demand of consumers within a town, city or metropolis, on land and water dispensed throughout the urban and peri-urban area.

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7 Marielle Dubbeling, IPES/Urban Management Programme (UMP-LAC/UNCHS-HABITAT), with contributions from: Andrea Carrión (UMP-LAC, Ecuador), Maria Caridad Cruz (FUNAT, Cuba), Asteria Mlambo (Dar Es Salaam City Council, Tanzania) and Fernando Patiño, (HABITAT Regional Office, Brazil): Discussion paper for the Workshop on “Appropriate Methodologies for Urban Agriculture Research, Policy, Planning, Implementation and Evaluation”, Nairobi, October 02-05, 2001.
**Permaculture** is a sustainable form of agriculture highly appropriate to urban areas, and comprises a system of farming and gardening that combines plants, animals, buildings, water, the landscape and people in a way that produces more energy than it uses.

**Urban agroforestry** is the combination of agriculture and forestry on the same land with livestock or cropping enterprises running underneath a regime of widely spaced trees, either simultaneously or in sequence.

All these components of can be applied to improve the quality of the urban environment, generally in open spaces. Urban open space management is not only confined to parks and roadsides but includes household gardens, factories, business areas, mine dumps, transmission lines, flood plains, taxi ranks, rooftops, schools, clinics and churches.

One has to consider various aspects of urban agriculture in order to arrive at a definition that is meaningful in the local context (Bruinsma & Hertog. 2003)\(^8\):

**Types of products:**
Urban agriculture may include different types of plants or animals, or combinations of these. Often the more perishable and relatively highly valued vegetables and animal products and by-products are favoured. Non-food products include aromatic and medicinal herbs, ornamental plants, tree products, tree seedlings, and so on. Production units in urban agriculture in general tend to be more specialised than rural enterprises, and exchanges take place across production units.

**Types of economic activities:**
Urban agriculture includes production activities as well as related processing and marketing activities, input production, services (e.g. animal health services) by specialised micro-enterprises or NGOs, etc... The interactions between these activities are also important (chains, clusters). In urban agriculture, production and marketing (and also processing) tend to be more interrelated in terms of time and space than is the case for rural agriculture, as a result of greater geographic proximity and quicker resource flow. Economies of agglomeration seem to prevail over those of scale.

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\(^8\) Adapted from Bruinsma, W. & Hertog, W. eds. (2003). Annotated Bibliography on Urban Agriculture. ETC – Urban Agriculture Programme in cooperation with TUAN and other organisations
Types of location:
Urban agriculture may take place in locations inside cities (intra-urban) or in peri-urban areas. The activities may take place on the homestead (on-plot) or on land away from the residence (off-plot), on private land (owned, leased) or on public land (parks, conservation areas, along roads, streams and railways), or semi-public land (schoolyards, grounds of schools and hospitals).

Scales of production and technology used:
In the city, we may encounter individual or family farms, group or cooperative farms and enterprises, micro, small and medium-sized enterprises, as well as large-scale undertakings. The technological level of the majority of urban agriculture enterprises in developing countries is still rather low. However, the tendency is towards more technically advanced and intensive agriculture and various examples of such can be found in most cities.

Product destination / degree of market orientation:
In most cities in developing countries, an important part of urban agricultural production is for domestic consumption, with surpluses being traded. However, the importance of market-oriented urban agriculture, both in volume and economic value, should not be underestimated. Products are sold at the farm gate, from the cart in the same or other neighbourhoods, in local shops, at local (farmers) markets or to intermediaries and supermarkets. Mainly fresh products are sold, but part of these are processed for own use, cooked and sold on the streets, or processed and packaged for sale to one of the outlets mentioned above.

Types of actors involved:
Many of the people involved in urban agriculture belong to the urban poor. However, they are often not the most disadvantaged people, nor are they (contrary to general belief) recent immigrants from rural areas, as urban farmers need time to gain access to urban land, water and other productive resources. In many urban centres, one will often find lower and mid-level government officials, school teachers and others involved in agriculture, as well as wealthier people who are seeking a good investment for their capital. Women constitute an important part of the urban farmer population, since agriculture and related processing and selling activities can often be more easily combined with their other tasks in the household. It is however more difficult to combine these with urban jobs that require travelling to the town centre, industrial areas or to the houses of the rich.

*URBAN FOOD SECURITY IN DEVELOPING COUNTRIES*

In Harare, sixty percent of food consumed by low-income groups was self-produced. In Kampala, children aged five years or less in low-income farming households were found to be significantly better-off nutritionally (less stunted) than counterparts in non-farming households. Urban producers obtained 40 to 60 percent or more of their household food needs from their own urban garden. In Cagayan de Oro, urban farmers generally eat more vegetables than non-urban farmers of the same wealth class, and also more than consumers from a higher wealth class (who consume more meat).
There is a need for interventions that go beyond urban greening, second economy economic interventions and food security. It is essential that urban agriculture becomes a core thrust within the planning and development of the urban environment. In order for this to become a reality, urban agriculture needs to be multi-sectoral, diverse, innovative, and relevant, and at the same time, span economic sectors within the town or city.

**CASE STUDY**

SEED (Schools Environmental Education and Development) works at transforming learning environments through Permaculture. SEED has grown out of the harsh Cape Flats Primary School Environment and is now rolling out a national programme that incorporates this school-based work and also focused on Accredited Permaculture Facilitator Training. Seed has training sites in urban areas of Cape Town, Mamelodi and Bethlehem, among others. Some of the programmes run by SEED include:

- **The Organic Classroom Program** partners schools for three years. The exit strategy ensures a sustainable Permaculture system providing food security, an education tool and a garden-based entrepreneurial project which generates sufficient income to employ one community member.
- **Teachers for Permaculture Education** this five-day course imparts teachers with hands-on Permaculture skills applied Outcomes-based Education. This course is usually the starting point for SEEDs school-based work and helps us identify our champions
- **Accredited Permaculture Training** This month-long course focuses on equipping facilitators with the skills to design and implement basic Permaculture gardens and use these gardens in the delivery of Outcomes-based Education lessons. SEED offers graduates intern positions.
Urban agricultural should be informed by the specific needs of the particular community. This identification of specific needs should evolve as part of a process that maps the food status of the various regions of the town or city. It should identify potential solutions that are specific to the various regions and community structures that could best be activated to support the development process.

The identified structures then need to work collaboratively to map out a path that is agreed upon, supported and sustainable. Only once these needs have been mapped out would a community be in a position to respond to the realities of each situation. Examples from existing groups that have worked to build social capital over time should be drawn on to support this process and to provide much needed insight into the strategies required. Small community based interventions, as evidenced in many cities around the world, such as Havana (Funes, et al. 2002), Addis Ababa and Harare (Mougeot, 2005) are able to address livelihood and nutritional needs while providing communities with the necessary resilience needed to sustain themselves and contribute in a positive manner to the city in question.

The links between urban food production and other urban related aspects are best illustrated if one considers health and nutritional aspects, which are becoming more relevant in developing countries, particularly in the light of the HIV/AIDS pandemic and the essential links between treatment of HIV/AIDS and effective nutrition. Another challenge facing many urban neighbourhoods is malnutrition. The UNICEF framework for understanding malnutrition has now been widely applied in urban areas. The framework notes the importance not only of access to adequate food in achieving adequate nutritional status, but also the importance of health and care practices.

**THE UNICEF FRAMEWORK: Food Security, Dietary Intake and Nutritional Status**

![Diagram of UNICEF Framework]

Source: Adapted from UNICEF (1990)
Abalimi

Abalimi is a Non-Profit Organisation which works to empower the disadvantaged through urban agriculture and environmental programs and projects. It operates in the socially and economically neglected townships of Khayelitsha, Nyanga and the surrounding areas on the Cape Flats near Cape Town. Abalimi means “the Planters” in Xhosa, which is the home language of the community Abalimi assists.

Through Abalimi’s experience, it can be seen that organic group gardening facilitates community building, and helps the personal growth and self esteem of individuals. Once produce has been harvested, approximately 50% gets packaged and sold on consignment through a project called Harvest of Hope, which has been set up in partnership with the South African Institute of Entrepreneurship (SAIE) and the Business Place Philippi, funded by the Pick ‘n Pay Foundation. The other 50% is consumed by the farmers, sold locally or given to sick or poor people in their neighbourhoods. Harvest of Hope was established to find and secure long term external markets for the farmers.

The farmers provide produce such as carrots, lettuce, tomatoes, potatoes and much more. By 2009/2010, there will be between 150-200 farmers in about 20 community gardens producing 600 boxes per week and earning up to R2000 or even R3000/month each. Over the last 25 years since its establishment in 1982, Abalimi has helped the community to initiate and maintain the growing of many thousands of organic vegetable gardens.

Photo: Vanessa Heyman
While urban greening is an important aspect of a sustainable city, it may result in land that is not suitably maintained by communities, which can place a burden on city budgets and management systems. In addition, some urban green spaces are inclined to become places that are unsafe or a security risk. Placing members of the community as “farmers” in these areas is an opportunity that can help resolve these challenges. Access to the land may need to be strictly controlled via allotment systems or other municipal land usage agreements.

International examples of allotments, such as in the town of Ely in Cambridgeshire, and in Kent can serve as examples of governance and leasehold models. Alternative economic models are also required. The establishment of cooperatives have proven effective in the stimulation of urban agriculture in other regions (Mougeot. 2005). The connection between urban agriculture and alternative localised economies, such as seed saving groups and seed banks also provide opportunities that are often not considered as benefits associated with urban agriculture. Seed saving, exchange and sharing is social capital that has been lost, but is central to the growing community of urban farmers (Saruchera. 2008). These alternative economies become a critical component of urban agriculture.

It is incorrect to assume that urban agriculture is carried out for solely economic activities. Urban agriculture is in fact often an indicator of alternative economies taking place within the communities. Urban agriculture is carried out, often directly related to nutritional security needs and for this reason is often not considered within the generalised planning and operational processes within the local governance structures. It is believed that by adopting a proactive and integrative approach to urban agriculture that is firmly embedded within the planning processes, communities can unlock the significant potential.

With urbanisation rates of developing countries (and South Africa in particular) twice that of the world average, the focus of future food demands and consumption will be in the urban centres. International data reveals that the locus of poverty is increasingly urban, and that the most significant food security challenges will be experienced in urban areas. This rising demand in urban centres suggests that poverty in South
Africa is no longer only a rural problem. Urban agriculture should become a core area of development focus in the future. Strategies and plans to implement this in a manner that enhances social justice, ensures ecological sustainability and responds to the needs of all within the urban context will be critical.

**CASE STUDY**

**Lindros Whole Earth Consultants**

Lindros implemented a PAETA 30 day training program with the Kara Heritage Institute. 24 youths were trained at the Wildrocke Eco Centre, Midrand, Gauteng. Each Person had an individual plot and received the appropriate coaching throughout the process from seed to harvest. The initial site was an old horse training facility and the group of youth set about transforming this land into a productive urban agricultural site. Each participant was given a small section to tend and all transformed these areas into productive spaces.

(Photos: Courtesy of Lindros)

**CASE STUDY**

**Skye Farm – Philippi**

Faced with severe space shortages, limiting productivity and potential returns, Skye, an urban farmer in Philippi, Cape Town decided to start farming vertically, significantly increasing production and financial flows – This approach also brought about other benefits such as reduced water use, better pest control and improved product quality.

(Photo: Tarak Kate)
“What hope is there for individual reality or authenticity when the forces of violence and orthodoxy, the earthly powers of guns and bombs and manipulated public opinion make it impossible for us to be authentic and fulfilled human beings?

The only hope is in the creation of alternative values, alternative realities. The only hope is in daring to redream one’s place in the world – a beautiful act of imagination, and a sustained act of self-becoming. Which is to say that in some way or another we breach and confound the accepted frontiers of things.”

Ben Okri, A Way of Being Free, 1989

A socioecological approach to sustainable neighbourhoods embeds all human activity within the eco-system of which it is part, recognising its limits and constraints. It seems the fabric that knits together individuals, communities, nature and sustainable resource use is intangible, uncertain and ambiguous. While
the challenges, contradictions and paradoxes within sustainable development are frequently stark and conflictual, it is also within these tensions that possibilities arise for ‘doing things differently’. This chapter will attempt to provide pointers and various approaches to socio-ecological development within sustainable neighbourhoods. These approaches can serve as forms of scaffolding which can bridge the gap between policy, current practice and the goal of sustainable living and livelihoods. This we intend to do firstly through key aspects of enabling capabilities within multiple participants in neighbourhoods; and, secondly by highlighting South African stories of sustainability in practice.

What is proposed is that learning is determined by context. Deeply embedded practice may demonstrate possibilities in one context that are different in another. A way of being that rests in not-knowing may well be better grounded in listening, learning, making connections and stitching together solutions combining skills, knowledge and wisdom of officials, communities, professionals and technologies. While one-size-fits-all approaches are understandable in their attempt to standardize learning and ‘take it to scale’, these approaches too frequently ignore complexities, provide simplistic and mechanistic solutions which deny possibilities for a local home-brew that creatively works with potentialities of specific contexts.

The importance of the role of the public sector is critical in designing and building sustainable neighbourhood settlements. It is well recognised that the paradigm of development emphasising financial investment or growth per individual has shifted. Indeed, South Africa’s own proclamations of ‘a developmental state’ are moving encouragingly towards a more appropriate paradigm. Amartya Sen and Peter Evans argue for ‘development as freedom.’ Evans (2002) quotes Sen as follows: “Development as Freedom’s basic proposition is that we should evaluate development in terms of “the expansion of the ‘capabilities’ of people to lead the kind of lives they value—and have reason to value” (Evans. 2002) which is Sen’s definition of freedom.

Unlike increases in income, the expansion of people’s “capabilities” depends both on the elimination of oppression and on the provision of facilities like basic education, health care, and social safety nets. Basic education, health care, and women’s rights are themselves constitutive of development. Growth in real output per head is also likely to expand people’s capabilities, especially at lower levels of income, but it cannot be considered, in itself, the ultimate yardstick of development or well-being. (Evans. 2002)

Evans continues by pointing out: “The upshot of Sen’s argument … implies that choices about those allocations and growth strategies must be “democratic,” not just in the “thin” sense of having leadership succession determined by a regular electoral process, but in the “thick” sense of messy and continuous involvement of the citizenry in the setting of economic priorities. And, this democratic imperative does not flow from the fact that “democracy is also a good thing.” It flows from the fact that it is not possible to evaluate economic outputs without such full-fledged discussion and exchange.” (Evans. 2002)

In continuing to grapple with Sen’s proposition, Evans makes the point that Sen’s work is still in the liberal tradition of focusing on individuals and their relationship with a social context. Evans takes this further by making collectives and collective approaches the bridge between the two: “In practice, my ability to choose
the life I have reason to value often hangs on the possibility of my acting together with others who have reason to value similar things. Individual capabilities depend on collective capabilities.” In fact, as Sen’s own formulations about the importance of “public discussion and interchange” imply, the capability of choosing itself may be, in essence, a collective rather than an individual capability.” (Evans. 2002)

Beginning with what is, what exists and, in particular, individuals and small groups already demonstrating the will to take responsibility for change, we have chosen several multi-nodal, often parallel, processes that seem most helpful in building thick networks of socio-ecological capabilities. These are: continuous social conversations, alliance and partnership building; appreciative inquiry; accredited capacity building in community development practice; and the people’s housing process. It is recognised that there are other processes (like micro-credit clubs linked to housing) and definitions of processes that are not explored in this chapter. It is also recognised that many of the case studies listed below could fall within more than one category.

Continuous social conversations, alliance and partnership building

The capacity of officials to build capabilities in continuous social conversations, alliance and partnership building, in formal and informal ways, within enabling policy frameworks appears to be one of the keys to successful implementation of existing policies within sustainable neighbourhood design. Officials who are able to play an active role in participating with communities through providing deep knowledge of the planning laws and processes; active participation in conversations that co-create solutions within legal limits and constraints; making connections between various participants in local spaces that generate new energy; actively seek ways of making possible creative innovations within accountable and ethical terms of engagement between community, private and public sector partnerships contribute in major ways to building spaces of possibility.
Sakhasonke Village
by Pierre Roux

The medium density multi-storey ‘pedestrianised’ Sakhasonke (Xhosa for ‘We built together’) Village some 5km from Nelson Mandela Bay’s Central Business District constitutes an innovative best practice model in delivery of a high-quality environment for poor people. This fully government-subsidised housing project developed by General Motors Foundation in partnership with the Urban Services Group, the Department of Housing and Local Government and Nelson Mandela Bay Municipality won the South African Housing Foundation’s 2006 award for the top national housing project and the prestigious Impumelelo Platinum Award in 2007.

The village design theme successfully fused the concepts of density and community. Lance Del Monte, who planned and designed Sakhasonke explained, “Community issues had to be incorporated with the design, as close living conditions sometimes result in social friction. Great emphasis was therefore placed on the spatial development and the ‘feel’ of the complex to create a safe and ‘open’ atmosphere. Elevated surveillance from the double-story buildings creates a safe atmosphere where people can relax in their own defendable space. The atmosphere was further enhanced by natural symmetry in the layout of the village as well as the overall cubic structure of the buildings” (Kotze. 2007).

Community participation and buy-in by the community was central to the ultimate success of the project. People living in South African townships and residents from informal settlement areas have no experience of medium-density suburban environments and would typically think of multi-story housing in terms of the legacy of the ‘single-quarters’ hostels constructed in the apartheid era to accommodate migrants on the mines in Gauteng or in relation to the infamous gangland tenement blocks on the Cape Flats.

In order to address this resistance, strong emphasis was placed on a continuous participation process and community programmes that where implemented to promote social cohesion and sustainable
livelihoods. The Impumelelo annual magazine, Innovations Award Trust Winners 2006/7 (Impumelelo. 2007) commented that:

“As a project, it successfully combined engineering with social development, creating one of the definitive low density housing areas, where community buy-in became central to the development of the area”

Local residents were consulted throughout the process and were actively involved in the planning and construction. Although initially designed by Metroplan Town and Regional Planners as a pilot to demonstrate the advantages of medium-density housing in the inner city, would-be beneficiaries soon bought into the village concept and became involved at a level of ‘functional participation’ and as such, ownership passed on to the beneficiaries.

The residents of Walmer township were notified of the development by way of flyers and a series of general meetings. A ‘showhouse’ was built in 2002. Following a positive response to the showhouse, the Urban Services Group (USG), a local housing and urban development NGO, facilitated various workshops at which the concept was carefully explained using a ‘dolls house’ and models of the units and overall planned development. Floor plans were discussed and house and plot sizes physically scaled at these workshops.

Various aspects associated with home-ownership were also discussed. Felix explained the importance of institutions to help previous shack dwellers realise the responsibilities of homeownership to the Impumelelo project evaluator:

“The majority of the people have previously lived in shacks for up to forty years where they never had the financial responsibilities of maintenance of a formal house and paying for consumer charges. Attitudes must change and that takes time and is a continuous process which needs to be supported and managed. A holistic approach is necessary and the social element should be recognized and funded by the provincial government as part of the housing process” (Sakhasonke. 2005).
An elected Residents’ Committee co-ordinates different working groups to contribute to the long-term sustainability of the project. House rules have been adopted which prohibit shebeens, erection of backyard shacks and rentals. Rules are rigorously enforced. Some groups manage a garden; others an HIV/Aids home care; another group manages the Women’s Forum; patrols formed a Neighbourhood Watch and from the community centre a pre-school and crèche are operated. A few unemployed residents run a recycling and sewing business.

**Developmental dialogue - Appreciative Inquiry**

Appreciative Inquiry (AI) is a tool of social construction that is used internationally. It provides a framework or an approach for a co-evolutionary search for the best in individuals, organisations and communities within an eco-system, and engages them in its transformation and development. Drawing on stories of success, it is a process that co-evolves possible futures that build on what is doing well, and is thus appreciated in a particular context.

“Appreciative Inquiry is about the co-evolutionary search for the best in people, their organizations, and the relevant world around them. In its broadest focus, it involves systematic discovery of what gives “life” to a living system when it is most alive, most effective, and most constructively capable in economic, ecological, and human terms. AI involves, in a central way, the art and practice of asking questions that strengthen a system’s capacity to apprehend, anticipate, and heighten positive potential. It centrally involves the mobilization of inquiry through the crafting of the “unconditional positive question,” often-involving hundreds or sometimes thousands of people.” (Cooperrider & Whitney. 2005).
AI is a particular way of asking questions collaboratively that focuses on what is working well in a particular context, not on its problems. It is used to generate change in communities, cities, local authorities, NPO’s, CBO’s, education institutions, etc… across many diverse and large groups of people.

It envisages futures that nurture positive relationships and builds on basic decency and goodness in people and communities. It enhances the system’s capacity for co-operation, collaboration and change.

Worth noting is that AI uses a 4-stage process:

1. Discover – what works well?
2. Dream – envisioning processes that may work well in the future
3. Design – planning and prioritising envisioned processes that may work well in the future
4. Delivery – implementation of the design

Deceptively simple, the art is in the questions developed to substantiate these phases, and the entire thrust on what works, what is positive, what can be built upon rather than what needs fixing, what is negative or what the problems are. Exploring and working with what can be appreciated makes possible liberated energy, connections and enhancing relationships of possibility.

The full participation of community membership, officials, CBO’s, NGO’s, professionals, private sector, entrepreneurs, etc… in AI processes focusing on the development of an area into a sustainable neighbourhood has the benefit of building a common approach towards an envisaged future. However, the possibility of inspiring, ‘vision-led’ processes being left high and dry is very likely if there is not ongoing investment in community development practice.

It is common cause that community membership and organisations of civil society play a critically important role, alongside government and the private sector in solving the problems of poverty, social and environmental injustice. Yet despite this, there is no effective system of professional development for people working in the field of development practice with its unique mix of developmental and management capabilities.

At present, training and capacity-building in development practice and management are delivered through a fragmented and largely donor-driven model of short skills workshops that do not build competence in any deep or sustained manner, do not allow for any kind of authentic assessment or validation of competence, and do not enable coherent learning or career pathways in the field. As a result, work in this field is under-valued and unrecognised by individuals and by society at large.

The following case study illustrates how developmental dialogue can be used creatively in the delivery of appropriate housing. This case uses many of the tenets of the appreciative inquiry process.
Freedom Park settlement upgrading in Mitchell’s Plain, Cape Town
by Pierre Roux

On Freedom Day 1998 a group of households, mostly women-headed occupied a vacant school site in Tafelsig, Mitchell’s Plain. The Development Action Group (DAG) and Legal Resources Centre (LRC) assisted the community in a struggle against eviction by the City of Cape Town. The households came from backyard shacks and overcrowded homes in the surrounding areas. The City eventually agreed to develop the area and the Freedom Park housing project commenced in 2006. About 300 families lived in the settlement. It is a phased in situ upgrade which involved an innovative participatory lay-out planning process that gave rise to a medium-density housing development. This process allowed all beneficiaries the opportunity to design the community lay out and to indicate their preferences with regard to housing typology, neighbours and plot location. In order to address this resistance, strong emphasis was placed on the participation process and community programmes implemented to promote social cohesion and sustainable livelihoods.

Urban poverty is complex and multi-dimensional. The poor are not a homogenous group and single sector interventions cannot improve the shelter conditions of urban poor households in a sustainable manner. A one-size-fits-all approach to informal settlement upgrading, which ignores the differences within them, is rarely successful – it is crucial that the complexities of informal settlements need to be understood before developmental interventions are made. An understanding of the livelihood strategies is particularly important as a basis for designing housing and development interventions (Smit. 2006).

Understanding household’s livelihood strategies, using participatory assessment, can be an important methodology towards achieving more integrated housing developments. In Freedom Park, DAG carried out a participatory livelihood assessment together with the community, which was then used...
as the basis for planning a range of developmental initiatives in partnership with other NGO’s: for example a savings club, a recycling project, a home-based crèche, a food garden and multi-purpose community centre.

The participatory social mapping exercise of Freedom Park (reproduced below) graphically illustrates the diversity of social problems in the settlement. Gang turf and where they meet to fight are illustrated. Shebeens are also shown and one of them is considered as being a ‘place of danger’. Freedom Park is spatially divided into “well off” and “vulnerable/poor” sections. “Rastas” (Rastafarians) and “alcoholics” are part of the “vulnerable/poor” section. The prominence of a soup kitchen and places where food is donated highlights the complexity of poverty and vulnerability within the community, (Smit. 2006).

This project resonates with the Breaking New Ground housing policy that calls for “communities and community-based organizations to engage more effectively with the housing programme”. It encourages community involvement in informal settlement upgrading by way of participatory layout planning. In Freedom Park DAG assisted in building the capacity of the community through training courses and workshops. It engaged with the City housing officials through a 13 member Housing Committee, mostly women elected on a yearly basis.

DAG and the Freedom Park Development Association also conducted workshops where the beneficiaries had the opportunity to design the proposed layout as well as select house typologies. Aside from infrastructure and services, which were seen as ‘technical issues’ by the City of Cape Town, the community was involved in the planning process. The level of participation in the layout planning proved to be a real achievement, as evidenced by the even different drafts before a community layout plan was finalized that satisfied the needs of the residents.
The infrastructure (roads, sewerage and water lines) was completed in 2007. A multi-stakeholder partnership was formed with the Naill Mellon Township Trust (NMTT) who agreed to construct the houses. During October 2007, some 1,350 Irish volunteers in the Trust’s annual housing blitz constructed 439 homes (single story freestanding and semi-detached units and double story row houses and semi-detached units) which are larger (42m2) with improved finishes as well as a community centre.

It involved a roll-over development as shacks were moved around by residents themselves when the roads and services were under construction. This approach prevented the removal of the community to a transit camp and the displacement of social networks and vulnerable livelihoods. The Freedom Park project demonstrates the merits of in situ settlement upgrading through community-based methodologies such as participatory poverty assessments, social mapping and community layout planning to achieve integrated development.

Similarly, in the Hangberg informal settlement on Sentinel Hill above Hout Bay harbour, DAG is involved in an innovative socio-economic participatory survey and mapping exercise that is spatially referenced to a Geographic Information Systems (GIS) community register and a digital data base. It contains not only narrow household income figures but also poverty data on issues such as HIV/Aids, child care, security, perceived safe spaces and so on. Since the spatial form and demographics of settlement
communities continuously changes over time this household data base is consequently updated by community-based field workers trained up by DAG. Data on public open spaces, footpaths, trees, no-go areas, shebeens and drug dens as well as all informal businesses are incorporated into the Arc-GIS database known as the Hangberg Land and Services Management Tool.

The purpose is to use this tool to underpin a tenure arrangement and incremental site and service upgrade. The engineering works will have to accommodate the squatters’ home-made infrastructure into the formal plan. This project was recently commended in the Sunday Times (2008) as an ideal sea-facing location for informal settlement upgrading.

Accredited Capacity Building

To support sustainable neighbourhood processes, it seems vital that accredited training programmes in community development practice are offered on a mid-to long term basis. Focusing on the development of capable and competent development practitioners through the meeting of sensible and useful standards, this approach offers the possibility of a shared language being developed through education in core areas such as project management, financial management, leadership, IT, etc..., and the enhancement of skills through actual work within the sustainable neighbourhood design and delivery process.

Over the years, low cost construction was expected to have created hundreds of thousands of formal employment opportunities, though this has rarely materialized. According to Khan and Thring (2003) the emphasis on ‘delivery as quickly as possible’ and the dominance of technocratic delivery approaches rarely permits engagement with the livelihood and coping strategies of the poor.

In this regard Khan and Thring (2003) argue that ‘greater development of local government in the location of housing projects requires linking housing approval processes to integrated development plans coupled to aggressive capacity building programmes and broader organisational development. The nature and content of the capacitation programme will need to go beyond the technical sphere, however, encompassing the building of appropriate capabilities to construct developmental partnerships between local government and communities’.

An example, albeit limited, of the type of cooperation suggested above, is illustrated by the following development in Limpopo.
Mawa Block, Tzaneen, Limpopo
by Pierre Roux

Mawa Block is a rural housing initiative which successfully combines service delivery with local economic development (LED) in a rural district of Limpopo about 90 km northeast of Tzaneen. Unemployment in the area is high and the majority of working people stay on as migrant labourers on the Phalaborwa mines and surrounding citrus estates.

It is another best practice project identified and rewarded by the Cape Town based Impumelelo Innovations Trust with a Silver award as an effective model in public participation, service delivery and rural governance. The innovation of this housing project lies in its methodology. It seeks to use, as well as create, resources within the community, thereby cutting costs on unnecessary external bodies like contractors that build for profit. Hence the community of Mawa was involved at all levels of the process and were paid for services rendered, with 75% of project funds allocated for this purpose (Impumelelo. 2007).

The community was mobilized through a participation process involving politicians and tribal authorities and community members empowered in building construction, paying them from project funds and providing opportunities for further employment. It is an example of how low-cost housing initiatives in conjunction with community involvement and LED can work well in rural areas in order to create sustainable livelihoods.

Four show houses were constructed in the village of Mawa. Mass meetings like the one pictured above initiated the project. Tzaneen Municipality dedicated a facilitator to the project and placed two full-time community workers within the village. A series of workshops took place. A Steering Committee represented the community at municipal level and site meetings. Regular open air meetings were held where project management, the local ward councilor, politicians and the tribal leaders reported back to the community on problems and delays with the project, progress and new developments and so on.
During 2005/6 this project finished 115 homes of 50m² (2/3 larger than standard RDP houses) located on freehold agricultural plots. In 2007 another 200 units were completed in a neighbouring village. The Mawa project created employment for 34 bricklayers and 87 labourers of which 53 were women (Since most households in the community are female-headed) and provided jobs for 30 more people at a local brickyard. Apart from employment, the project provided training to 119 community members in basic building skills such as bricklaying and construction. 50 people were indirectly employed to make bricks, window frames, and to transport materials. Residents who owned tractors as well as donkey carts were paid for transporting materials to and from the site. In the words of the Impumelelo Evaluator, “An outstanding aspect was that the Local Economic Development input was taken full advantage of” (Impumelelo. 2007).

Another spinoff was the Merekome Brickyard that was set up for the project is the only semi-industrial business in the vicinity and employ 30 people. (For a photograph and discussion of the brickyard see the Chapter on Building Materials).

People’s Housing Process

The People’s Housing Partnership Trust defines the People’s Housing Process in this way:

“Our while many people need houses, official housing programmes have not been able to meet the diverse needs of our various communities, and the necessary resources are not always readily available. People have consequently, over the years, been building houses for themselves. This is what is referred to as the “People’s Housing Process.” Typically it is where individuals, families or groups take the initiative to organise the planning, design and the building of, or actually build, their own homes” (PHPT. 1998).

Breaking New Ground, on the other hand, envisages the a participatory housing process in the following way:

“Housing authorities at all levels are moving in the direction of increased use of the People’s Housing Process (PHP). The thinking behind this expansion is however contradictory. On the one hand, PHP is promoted as it provides residents a greater choice over the use of their subsidy. This generates positive housing outcomes, increased beneficiary input, and greatly enhances beneficiary commitment to those outcomes.

Thus, the PHP achieves its two main goals of ‘more for less’ and improved beneficiary commitment to housing outcomes by increased productivity through ‘intellectual equity’ (not primarily cost reduction through ‘sweat equity’), and by increasing beneficiary ‘ownership’ through the exercise of considered choice (not by forcing
beneficiaries to provide free labour). Other participants view PHP as primarily a vehicle for the mobilization of sweat equity as an alternative to existing beneficiary contributions. This ‘sweat equity’ approach to the PHP tends to undermine the key benefits of the approach. The current approach towards PHP is thus inherently contradictory (BNG. 2004).

People’s housing process projects have found multiple applications in South Arica over the years. An example of a modern PHP approach is illustrated below.

**CASE STUDY**

The People’s Housing Process, Ocean View, Cape Town.

Ocean View is on the mountain behind Kommetjie in the South Peninsula of Cape Town. When Simon’s Town was designated as a white area in the 1960’s a forced removal relocated the port’s coloured community in flats and small council houses at Ocean View.

No formal housing had been erected since the 1970’s, despite the growing population. By the 1990’s some 30,000 inhabitants were living in extremely overcrowded conditions in 600 flats, 1800 township houses and in backyard shacks. An informal settlement was also formed in an area known as Atlantic Heights.

The project illustrates how the housing crisis prompted self-mobilisation of the community from the bottom up and through collective action they took control over this resource. In response to these conditions, a number of community-based organisations (CBOs) banded together and founded the Ocean View Development Trust (OVDT) in 1992. OVDT represents 30 CBOs with trustees drawn from community leaders. Its aim was to seek ways of alleviating the accommodation crisis through community action.

Since 2000, the OVDT facilitated the construction of about 700 homes in Ocean View through a self-help scheme for beneficiaries drawn from overcrowded township homes and from the informal settlement. This project was initiated in 1994 and was financed by the original ‘Consolidation Subsidy’ for site-and-service developments. It was a National Housing Board pilot project for the development of a self-help People’s Housing Process programme.
To ensure that residents could make the best use of the small consolidation subsidy (around R7,500.00 in 1994) OVDT implemented a number of support initiatives. A Housing Support Centre where would be owner-builders obtained advice on technical and building trade matters was established. The concept of a housing support centre was subsequently adopted as formal policy in the government’s PHP housing delivery mechanism.

A community block making facility had by 2002 produced over a million blocks for Ocean View residents at affordable prices. OVDT projects a vision that housing and construction should provide an impetus for community development and local economic development through job creation and capital re-circulation. Aside from the building contractors and artisans employed it created various micro enterprises such as plumbers, glazing operations, carpentry shops, backyard welders and so on.

A key feature of the Ocean View initiative was to encourage homeowners to engage in incremental building which allowed them to consolidate and extend their dwellings over time. In 2000, the OVDT, introduced a ‘Roll Over Fund’ that lends money to households that wish to extend or improve their dwellings. Repaying has proved satisfactory.

A decade later, and housing projects should only be audited after a long period, the result is a suburban milieu with its own character of diverse structures (depicted below). The nature of upgrading and extensions, which is an ongoing organic process, suggests that given enough time, households prove resourceful in obtaining the money to invest in their dwelling.

The Ocean View community certainly view their homes as valuable assets. Ocean View’s success has provided a model project for the government’s PHP programme. In 2005 it received recognition as an UN-HABITAT World Award finalist.
Socioecological participation strives to expand the capabilities of people, in order to help them lead the kind of lives they value, via growth strategies that are democratic. These strategies allow continuous involvement of the citizenry in the setting of socioecological priorities. Though by no means exhaustive, this chapter has provided several methodologies that can be used in successful participatory housing and settlement delivery.
"While the environmental and human health benefits of green building have been widely recognized, this comprehensive (US) report confirms that minimal increases in upfront costs of 0-2% to support green design will result in life cycle savings of 20% of total construction costs – more than ten times the initial investment. In other words, an initial upfront investment of up to $100,000 to incorporate green building features into a $5 million project would result in a savings of $1 million in today’s dollars over the life of the building."


There is now an emerging global consensus that unsustainable resource use (global warming, breakdown of eco-system services, depletion of key renewable and non-renewable resources) will threaten the existence of large numbers of human and non-human species. These threats have been well documented in several major international reports, including inter alia the impact of human-induced global warming (Intergovernmental
Panel on Climate Change. 2007), the breakdown of the eco-system services that humans and other living species depend on (United Nations. 2005), the depletion of oil reserves (International Energy Agency. 2008), the ecological threats to food supplies (Watson et al., 2008), the threat of water scarcity (Gleick. 2006; United Nations Development Programme. 2006), and the negative impacts on the poor of the global crisis of unsustainability (United Nations Development Programme. 2007). The result is a global consensus that the continuation of unsustainable modes of development will need to be replaced by what the Johannesburg Plan of Implementation adopted at the World Summit on Sustainable Development (WSSD) in 2002 defined as “sustainable consumption and production”. This broad framework has led to a focus on cities because it is generally assumed that the construction and operation of the built environment is responsible for approximately 50% of all CO₂ emissions. There is a growing consensus that cities have to play a leading role in the transition to a more sustainable socioecological regime (United Nations. 2006).

Significantly, recent empirical research commissioned by the United Nations Environment Programme (UNEP) has identified three priority challenges, namely transport, food supplies and the construction of buildings/urban infrastructure, which together account for more than 60 percent of total energy and materials used by the global economy. This brings into focus the technical aspects of the design and construction of buildings. More sustainable use of resources means reducing CO₂ emissions, using less primary material resources and reducing unproductive waste outputs. Sustainable living is made possible when the built environment is configured to achieve these objectives.

There is, however, a common – and sometimes offensive – opinion that sustainable built environments will remain the preserve of the affluent and/or developed economies, while minimum standard conventional housing provision remains the only affordable option for the poor. This common assumption is based on hard facts about what it costs to construct the physical structure of the house and related infrastructure, but it ignores the cost of operating the house over its entire life-cycle. This is highly problematic in light of the fact that life-cycle operating costs are projected to rise faster than inflation due to declining supply of key input resources.

The objective of this research was to demonstrate that a life-cycle approach rather than the more traditional once-off capital cost approach generates results that demonstrate that sustainable living is more affordable for both the household and the tax base of the city. This has been achieved by collecting data and information on life-cycle costs of both minimum standard conventional housing provision (hereafter referred to as the “current approach”) as well as a package of “sustainable living” applications. Conclusions were reached by measuring and comparing 30-year life-cycle cost effectiveness of the two alternatives. The results are expressed as net present values, using a discount rate of 9%.

According to Wrisberg, there are several “life-cycle” methodologies that are in use in the world today that have emerged in response to the global demand for “tools” to determine the material and energy content of particular production and consumption processes, as well as environmental impacts (Wrisberg et al. 2002).
A “life cycle” approach is necessary because it has become imperative to take into account the full capital and operational costs of a given production or consumption process over the life cycle of the process. Without this kind of analysis it will not be possible at the design stage to determine which process will contribute most towards achieving a more sustainable socioecological regime; or alternative, which one will do the least damage.

However, a wide range of life-cycle methodologies have emerged for different purposes. These included the following: Life Cycle Assessment, Material Input per Unit of Service (MIPS), Environmental Risk Assessment (ERA), Material Flow Accounting (MFA), Cumulative Energy Requirements Analysis (CERA), Environmental Input-Output Analysis (env.IOA), analytical tools for eco-design, Life Cycle Costing (LCC), Total Cost Accounting (TCA), Cost-Benefit Analysis (CBA) and Cost Effectiveness Analysis (CEA). It is not possible to describe and analyse these different methodologies here.

Suffice it to say that a CEA approach has been adopted because this makes it possible to compare the “conventional approach” to housing delivery to a “sustainable living” alternative across the life-cycle. The essence of this approach, according to Wrisberg, et al (2002), is that it does not quantify benefits like CBA, even though they regard it as a derivative of CBA. Citing a report by RPA (1998) entitled Economic Evaluation of Environmental Policies and Legislation, Final Report for DG III of the European Commission, Contract Number: ETD/97/501287, Wrisberg, et al (2002) states that CEA aims at determining the least cost option of attaining a predefined target after the fundamental decision process has been finalised. CBA, by contrast, is used to assess viability of an investment by quantifying the future realisation of costs and benefits, generally through discounted cash-flow analysis. An investment is viable if the present value of all benefits exceeds the present value of all costs. The net present value (NPV) should therefore indicate a positive return.

The following sections will cover; first a definition and description of housing, including the current approach and sustainable living alternatives; second a description of what was included in the measurement and how the measurement was executed; third the actual measurement of data collected on the current approach; fourth the actual measurement of data on the package of sustainable living applications; and fifth an interpretation of the results and formulation of recommendations.
The intention here is not to recoup on housing literature through the ages, but it is of relevance to firstly refer to John Turner’s 1972 benchmark work where housing is defined as both a noun and a verb (quoted in Spence, Wells & Dudley. 1993). When considered as a verb, the focus is not on the physical structure of the house, but on the processes of how people came to be housed and how those people continue to sustain their existence in and from such a house. Bourne (1981) defines housing as a ‘flow of services’ with inputs, a matching process and outputs.

On the outputs side, shelter is only one such output and is supplemented by equity, satisfaction and status, environment, access, services and social relations, all of which have a bearing on sustainable living. This agrees with Turner’s laws of housing, which emphasize that housing is not what it is, but what it does in the lives of people (Spence et al. 1993). Even though such conceptualisations of housing find many practical manifestations in various systems taking care of the livelihoods of the poor in South Africa, they are not taken to the logical conclusion of one integrated cost effectiveness framework for evaluating housing delivery in its entire life-cycle.

When turning to the sustainable living construct – or sustainable development to make it a delivery construct – it is once again not the intention to reflect on the growing volumes of literature, but as with the brief return to seminal housing definitions, the watershed Brundtland Report (World Commission on Environment and Development. 1987) and its definition invoking the needs of future generations counterbalanced by the as yet unmet current needs of a large proportion of the world’s population is of relevance. The three mutually reinforcing and critical aims of sustainable development conceptualised in the Brundtland Report, namely improvement of human well-being, more equitable distribution of resource use benefits across and within societies and development that ensure ecological integrity over intergenerational timescales (see Sneddon, Howarth & Norgaard. 2006) serves as reality check when reflecting on how to improve the livelihoods of literally millions of South Africans.

It is an undeniable fact that South Africa’s total ecological footprint is already between 15 and 20 percent higher than its total biocapacity (World Wildlife Foundation. 2006) and that the many current power outages and water restrictions clearly signal that it is impossible to keep on expanding business as usual as the current approach to housing delivery is doing. The National Framework for Sustainable Development that was adopted by the South African Government in June 2008 (by Cabinet resolution) explicitly stated that South African cities and housing construction must adopt sustainable resource use guidelines.
The National Department of Housing is responsible for housing delivery. Since 1994 it has adopted and implemented two quite different housing policies. The first was articulated in the 1998 White Paper on Housing which essentially provided for a capital subsidy to drive housing delivery for poor households. Because this subsidy included the land cost, the urban poor that received houses landed up on the outskirts of the urban system far from places of work and connected via expensive transport systems. Since 2004 the Department of Housing has implemented a new housing policy known as Breaking New Ground.

This policy recognises the need to provide for a range of interventions aimed at creating integrated human settlements rather than marginalised ghettos. Significantly, the current approach does not ignore sustainable development – at least not in policy and strategy development. Since the promulgation of the Housing Act, 1997 (RSA, Act 107 of 1997), housing policy development has increasingly emphasised the importance of sustainable livelihoods. Such conditions were defined in the Act and subsequently further clarified with policies and strategies and also given content with new funding arrangements.

The Comprehensive Housing Plan for the Development of Integrated Sustainable Human Settlements (otherwise known as Breaking New Ground) as announced by the Minister of Housing, Dr Lindiwe Sisulu, in September 2004 (RSA, National Department of Housing. 2004) provides for not only the development of low-cost housing, medium-density accommodation and rental housing, but also the promotion of the residential property market through stronger partnerships with the private sector; social infrastructure; and amenities to promote the achievement of a non-racial, integrated society. Since late 2008, the Minister and her Department have emphasized the need to include “sustainability”. This current approach entails making available a top structure subsidy of R43 506 (2008/09 amount) that must provide as a minimum a 40m² gross area, 2 bedrooms, separate bathroom with toilet, shower and hand basin, a combined kitchen/living area, “Ready Board” electricity supply and adhere to NHBRC technical specifications (Provincial Government of the Western Cape (PGWC), Department of Local Government and Housing, 2007). These technical specifications are quite comprehensive, but nevertheless distinguish between Level 1 and Level 2 User
Performance parameters, with Level 1 “intended for houses, where for reasons of access to initial capital a user is able to tolerate more frequent maintenance cycles, limited penetration of water to the interiors, discernable deflections, minor levels of cracking etc.” (RSA, National Department of Housing. 2003: 38). Even though the specifications also prescribe a design working life of 30 years for structural systems and non-accessible components and 15 years for repairable or replaceable components, the existence of a Level 1 illustrates that it remains a tendency to shift as many costs as possible later into the life cycle of the asset. This invariably means lightening the financial burden for tax-funded housing providers, but increasing the burden for tax-funded infrastructure operators and self-funded households.

The sustainable living applications package for the sake of this research project moves from the premise that the initial tax funded provision should be substantially increased in order to reduce tax funded and self-funded life-cycle operating costs, but simultaneously achieve better total life-cycle cost effectiveness. Although the emphasis is therefore on cost-effectiveness measurement (as explained in the next section), the sustainable living package selected for this comparison requires a much higher initial investment in order to introduce qualities indispensible for social, socio-economic and ecological sustainability. The sustainable living package as measured in this research is derived from the Kosovo Project design concept and estimates (ARG Design, 2008 and Kahts & Sparks, 2008) as well as research results of a Lynedoch Eco Village project as captured by Dowling (2007).

The package has the following features:
- Medium density development, i.e. 158 units per ha compared to the approximately 70 units per ha of typical “current approach” projects in order to reduce land cost per unit and give more households better access to opportunities and facilities, thereby serving the densification strategies of the City;
- Civil services infrastructure that is already more cost effective due to higher density development;
- A neighbourhood-level sanitation system consisting of neighbourhood sewage treatment plant and re-use of water, nutrients and potentially methane;
- Medium density housing structures of two to three storeys providing design opportunity for better sense of space and security;
- Better quality units, consisting of User Performance Level 2 specifications (RSA, National Department of Housing. 2003) and higher levels of finishes and fittings, ventilation, insulation with specific ecological design features with regards to orientation of units, roof and structural shielding and window sizes to maximise solar penetration in winter and shade in summer, and including thermal mass for passive heating and cooling (R3 449 per m² used in estimates compared to the R1 088 per m² used in the current approach);
- Solar water heating, with higher density allowing sharing of components between units; and
- Landscaping as ecological design feature, i.e. to use plants to provide shade in summer.

It is acknowledged that the specific package as set out here may be supplemented by further elements such as solid waste separation and recycling and rain water harvesting, the above were selected for their relative ease of application and the measurability of their life-cycle operating costs.
In this section, cost effectiveness analysis, the use of a spreadsheet template for measuring cost effectiveness analysis, the types of cost items and various sources contributing to the financing of life-cycle costs are described.

Cost effectiveness analysis

Cost effectiveness analysis is a technique for investment appraisal prescribed in the South African National Treasury directives. The “Medium Term Expenditure Framework Treasury Guidelines: Preparing Budget Proposals for the 2007 MTEF” (RSA, National Treasury. 2006), expresses the following intention: “It is the intention of the National Treasury to progressively require more detailed analyses as funding requests are becoming larger compared to available resources. Under these circumstances it is appropriate to prioritise requests which can demonstrate the largest benefits to our country.”

Since the 2007 MTEF, all new infrastructure projects or programmes require some form of appraisal to demonstrate advanced planning. Such appraisal may include needs analyses, options analyses, cost-benefit analyses, lifecycle costs and affordability analyses. Cost-effectiveness analysis (CEA) was specifically identified by National Treasury as a tool that can help to ensure efficient use of investment resources in sectors where it is difficult to value benefits in monetary terms. They specifically identified CEA as useful for the selection of alternative projects with the same objective (quantified in physical terms), and it is most commonly used in the evaluation of social projects – e.g. in the health or education sectors (RSA, National Treasury. 2006). It is therefore a logical deduction to use CEA for measuring the long term cost of housing sustainability.

A critical factor is the selection of a discount rate to convert future money into present value in order to compare costs and benefits spread unevenly over time. The higher the discount rate, the smaller the weight of future costs in the NPV. Seeing that the majority of costs in a capital investment are incurred early in the life-cycle and benefits are accrued over the longer term, it is advisable to use a higher discount rate in order to rather have a pessimistic view on future benefits. Another factor influencing the choice of a discount rate is the economic situation of the particular source. Winkler, Spalding-Fecher, Tyani and Matibe (2002) for example used the social discount rate (then 8 percent) for tax-funded investment, but a consumer discount rate of 30% for investment by poor households in their cost benefit analysis of energy efficiency in urban low-cost housing. The authors argued that poor households do not have money to invest upfront, forcing them to rely on very punitive sources of capital.
In cost effectiveness analysis, benefits or returns are not quantified. The costs incurred over a period of time for two or more alternatives serving the same purpose are discounted to a NPV and the alternative with the lowest NPV therefore represents the most cost effective investment. It stands to reason that conservatively future costs should be weighed heavier in the NPV, meaning a lower discount rate.

Similarly, future costs for poor households with their lower than inflation increase in revenue should be weighed conservatively more than present costs by means of the use of a lower than social discount rate. However, for the sake of simplicity and because we may be accused of deliberately favouring the sustainable living alternative with its higher capital and lower life-cycle operating costs, we used the 2007 National Treasury prescribed 9% social discount rate for all sources.

The spreadsheet template used

The spreadsheet template designed for measuring the NPVs of different alternatives require as input the identified capital expenditure and operating expenditure cost items, each with its base year (2008) amount, identification of its source, the year in which the expenditure starts, the year in which the expenditure ends and the price escalation expected for that item. Further input required is the discount rate per source and the identity of each source. Different discount rates to different sources could therefore be assigned, should further debate about discount rates be considered necessary in future.

Finally, the life-cycle duration must be entered. The template can therefore test NPVs for different periods of time, up to 40 years. The values depicted at the end of this report represent NPVs for different periods, ranging from five to 40 years. We went beyond 30 years even though the technical specifications for the current approach calls for a design working life of 30 years for structural systems and non-accessible components and 15 years for repairable or replaceable components in order to indicate the widening gap between the current and sustainable living packages. The latter arguably has a design life of much longer than 30 years.

Types of cost items and cost item sources

Cost items for the two alternatives were firstly divided into capital expenditure items incurred in the base year and operating expenditure items incurred from year one. Capital expenditure items had two sources: Source 1, the City or Municipality, providing funding for infrastructure and city-wide bulk services, plant and installations; and Source 2, the Department of Housing Subsidy Quantum funding the current approach to the set minimum standards.

For the sustainable living alternative, the package set out in the previous section would require a bigger allocation per house. Operating cost items had two sources, namely Source 1, operating and maintaining infrastructure and funding indirect service costs and Source 3, the household, paying consumption tariffs and maintaining the house. These costs items are set out in Tables 1 and 2 in the following sections.
The main sources of data and information on the capital and operating cost items relating to the current approach were extracted or derived from the “Neighbourhood Baseline Report” (Lagus. 2007) commissioned by the Sustainability Institute; Circular Minute No. 5 of 2007, “Adjustment of the housing subsidy quantum and the introduction of the new 40 square metre quality house: 01 April 2007” (PGWC, Department of Local Government and Housing. 2007); the 2008/09 subsidy quantum updates (PGWC, Department of Local Government and Housing. 2008); “Design and Construction of Houses. Project Linked Greenfield Subsidy Project Developments. Generic SpecificationGFSH-11” (National Department of Housing. 2003); “Assessment of Housing Products” (NHBRC. 2005) and presentation notes from a September 2008 Social Housing Foundation/ShiFT workshop, “Design for efficient maintenance” (Pienaar. 2008). In addition, actual costing of various recent or planned projects in the Western Cape was used as explained below. All prices are per unit. Table 1 provides a list of cost items for the current approach. 2008 prices are used.

<table>
<thead>
<tr>
<th>Capex Item</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land</td>
<td>10 050</td>
</tr>
<tr>
<td>Civil services infrastructure</td>
<td>25 855</td>
</tr>
<tr>
<td>Electrical infrastructure</td>
<td>9 600</td>
</tr>
<tr>
<td>Top structure 40m²</td>
<td>43 506</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Opex Item</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household water and sanitation</td>
<td>362</td>
</tr>
<tr>
<td>Household electricity</td>
<td>1 020</td>
</tr>
<tr>
<td>Household other energy</td>
<td>850</td>
</tr>
<tr>
<td>Household maintenance</td>
<td>1 305</td>
</tr>
<tr>
<td>City water and sanitation</td>
<td>492</td>
</tr>
<tr>
<td>City electricity</td>
<td>293</td>
</tr>
</tbody>
</table>

The capital cost items measured included land, civil services infrastructure, electrical infrastructure and top structure. The price used for land was the actual price of a recent Mitchells Plain project. The other prices with the exception of top structure were derived from Lagus (2007) and escalated by 20% for base-year amounts. The reason for this high mark-up is to acknowledge the real capital expenditure for infrastructure improvement by the city in the coming years as reported by Lagus. Even the 20% escalation may be too conservative if the required long-term massive city-wide investments in especially water infrastructure (the
Berg River Dam was recently completed at a cost of R1.4bn) and electrical infrastructure are to be realised. As for top structure, the 2008/09 subsidy quantum update amount of R43 506 was used. For this amount, a minimum 40m² gross area, 2 bedrooms, separate bathroom with toilet, shower and hand basin, a combined kitchen/living area, “Ready Board” electricity supply and adherence to NHBRC technical specifications is expected (Department of Local Government and Housing. 2007). The housing subsidy quantum also contains information and a cost breakdown of a serviced stand totalling a 2008 amount of R17 847, which is lower than the amount used as derived from the Lagus Report, but the latter was used, because it is based on prices from actual projects and includes bulk services contributions. All capital cost items were entered in the template as if incurred in Year 0, i.e. a one year capital project taking place during 2008.

Operating cost items included in the analysis were household expenditure on water and sanitation, electricity, other energy and maintenance. With the exception of maintenance, costs were derived from the 2007 Lagus Report and escalated to 2008 prices as with capital costs. Maintenance was priced as 3% of current top structure cost. This however, may be too low, taking into consideration the Level 1 User Performance Parameters, acknowledged to require “more frequent maintenance cycles” and remedial work caused by “limited penetration of water to the interiors, discernable deflections, minor levels of cracking etc.” (National Department of Housing. 2003: 38). Life-cycle price escalations used for operating cost items were 15% for water and sanitation, 16% for electricity and 9% for maintenance, keeping in mind ever increasing resource and space shortages over the next 30 years.

Capex items not included, but arguably indispensable to occur somewhere during the life-cycle, are top structure upgrading, including full electricity distribution in the unit.
Data and information for this section came from the same sources as mentioned in the previous section, but in addition, design and cost estimate information of the Kosovo Project design concept and estimates (ARG Design. 2008; Kahts & Sparks. 2008) as well as research results of a Lynedoch Eco Village project as captured by Dowling (2007) were used to inform costs.

Capital cost items included are land utilised at Kosovo density; civil services infrastructure utilised at Kosovo density and with neighbourhood level water and sanitation system; city-wide water and sewage; electrical infrastructure; city-wide solid waste; top structure Kosovo density, User Performance Level 2, ecological design features; full electrical distribution; solar water heating and landscaping as ecological design feature. Items at 2008 prices were included in the sustainable living alternative and are shown in Table 2. All capital cost items were entered in the template as if incurred in Year 0, i.e. a one year capital project taking place during 2008.

<table>
<thead>
<tr>
<th>Capex Item</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land medium density</td>
<td>4 430</td>
</tr>
<tr>
<td>Civil services infrastructure, including neighbourhood water and sanitation system</td>
<td>17 227</td>
</tr>
<tr>
<td>Electrical infrastructure, reduced capacity and network distances</td>
<td>7 680</td>
</tr>
<tr>
<td>Top structure 46m², medium density, User Performance Level 2, ecological design</td>
<td>158 654</td>
</tr>
<tr>
<td>Solar water heating, components shared between units</td>
<td>5 000</td>
</tr>
<tr>
<td>Solar water heating replacement in Year 20</td>
<td>5 000</td>
</tr>
<tr>
<td>Landscaping as ecological design feature</td>
<td>640</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Opex Item</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household water and sanitation</td>
<td>181</td>
</tr>
<tr>
<td>Household electricity</td>
<td>510</td>
</tr>
<tr>
<td>Household other energy</td>
<td>425</td>
</tr>
<tr>
<td>Household maintenance</td>
<td>1 305</td>
</tr>
<tr>
<td>City water and sanitation</td>
<td>123</td>
</tr>
<tr>
<td>City electricity</td>
<td>147</td>
</tr>
</tbody>
</table>
The assumptions and cost estimates of each of these items require further clarification:

a. **Land, medium density use:**
   A land price per unit of R4 430 compared to the R10 050 of the current approach was derived from the Kosovo Project costing.

b. **Civil services infrastructure, medium density, neighbourhood water and sanitation system:**
   The price of R17 227 was derived by using the current approach amount, and then splitting the amount into two, assigning R13 864 to water and sanitation and R11 715 to roads and storm water, using the Department of Local Government and Housing (2008) figures to guide the split. The R11 715 roads and storm water portion was multiplied by 70 and divided by 258 to adjust it for medium density compared to the current single unit per stand approach. The water and sanitation amount was then replaced by the per unit cost of the neighbourhood water and sanitation system, using adjusted (2008) prices of the Lynedoch Eco Village Project.

c. **Electrical infrastructure reduced capacity due to smaller demand and shorter per unit cable distances due to higher density development:**
   20 percent reduction in neighbourhood electrical infrastructure compared to current approach.

d. **Top structure medium density, 46m², User Performance Level 2, ecological design features:**
   This item provides for the most significant cost increase compared to the current approach. The estimated cost of R158 654 per unit is derived from Kosovo estimates.

e. **Solar water heating:**
   Provided at R5 000 per unit, but because of the high density, units may be able to share components, bringing about savings. Solar water heaters have an estimated life span of 20 years and provision is made for a replacement after 20 years.

f. **Landscaping as ecological design feature:**
   Trees and shrubs serve to provide further thermal control and are included as R640 per unit, based on Kosovo estimates.

Operating items are the same as with the current approach, but the objective of this project was to measure cost effectiveness, with the expectation that the higher initial investment would result in substantive life-cycle savings. Price escalations were kept similar to that of the current approach package.

**Costs were derived as follows:**

- g. Household water and sanitation, 50% saving on current approach;
- h. Household electricity, 50% saving on current approach from solar water heating and ecological design;
- i. Household other energy: According to Lagus (2007), paraffin and gas is used primarily for space heating and to a limited extent, cooking. User Performance Level 2 and ecological design features will reduce the need for space heating substantively, R425 allowed.
- j. Household maintenance: Same amount allowed as for current approach even though the higher quality of structure and finishes will require less maintenance.
- k. City water and sanitation: No sewerage and 50% less water: R123 per unit allowed.
- l. City electricity: 50% saving on current approach, assuming cost allocation based on consumption.
The objective of this research project was to compare life-cycle cost effectiveness of housing as currently provided with a package of sustainable living alternatives by using as far as possible costing of recent, ongoing and planned projects in the Cape Town area. This was done to determine if the common belief that sustainable housing alternatives are too expensive when compared to the current approach is valid. This section concludes on the achievement of the research objective by summarising and interpreting the results of the cost effectiveness analysis using the data as explained in the previous two sections. Table 3 and Graph 1 provide a summary and illustration of the results. They reveal that the common belief is a false perception created by the illusion of not looking beyond start-up costs. By way of interpretation of the results, the amounts in the table are explained in the following subsections.

a. Capital expenditure

The sustainable living package used for the purpose of this analysis requires R104 620 (117 percent) more than what is currently invested. However, in user performance level, finishes and fittings, it is a superior product not only designed to promote ecological and economic sustainability through less resource consumption and life-cycle operating costs, but also to promote social sustainability through living and community space design.

b. Life-cycle cost effectiveness

The sustainable living package has, measured in NPV at a 9 percent discount rate, a R4 666 (1.4 percent) lower life-cycle cost over the prescribed 30 year technical design working life, with the added benefit that structural elements will last far beyond 30 years.
c. Investment by the City:

Investment not including the initial top structure cost is already lower from the first year of the life-cycle and by the end of the design working life; the sustainable living package has life-cycle cost effectiveness 52 percent better than the current approach. Apart from cost effectiveness, scarcity of urban space and the rapidly increasing scarcity of water and raw material for non-renewable energy are making dramatic densification and reduced extraction of water and energy from nature inevitable. It must be emphasised that the sustainable living package does not demand less resource consumption than the current, but cuts down on adding new water and non-renewable energy by means of recycling and use of renewable sources. The capacity of current city-wide installations and plants such as dams, purification plants, reservoirs, sewerage plants and electricity plants is stretched to their maximum already and not even the intended massive investment in new infrastructure will alleviate the problem anymore.

d. Investment by the household:

The most important source pays less right from the start, ending the 30-year design working life period with 37 percent better cost effectiveness than the current approach. This amount does not even include savings due to improved access to opportunities for more people resulting from higher density living or reduced health related costs due to better living conditions.

As was explained in Section 3 of this report, benefits are not quantified when using CEA. However, benefits that may result from a particular alternative, but are of such a nature that they are not directly quantifiable in terms of the unit of analysis, should still be identified and considered.
The benefits from a sustainable living application - apart from cost effectiveness - that deserve some explanation include creation of assets for the poor, improved access to opportunities, improved quality of life and more opportunities for utilising the large potential of renewable energy.

- The establishment of quality neighbourhoods are indispensable for realising the intended economic value of residential property. According to Blakely and Bradshaw (2002) a quality environment and strong community capacity multiply natural advantages for local economic development.

- It is not possible in this exercise and on this level of analysis to quantify and compare costs of travelling and potential lower costs of travelling of higher density developments with better access to opportunities, but it is worthwhile to refer to various research projects in this regard. According to Khan (2009, also quoting Behrens & Wilkinson. 2003; Dewar. 1995; CSIR. 1997), there is no economic justification for locating low income settlements far away from employment opportunities and higher order commercial and social facilities. For households, exorbitant travel costs weigh heavily on time and expenditure that could be deployed towards improving nutrition, health, education, incomes and dwellings. For the state, for example, the annual bus subsidy in Cape Town accumulated over five years, is equivalent to the housing subsidy, and over twenty years, it would be the equivalent of four subsidies. It is argued that if the number of South African subsidised bus commuters travelling longer than an hour were to be relocated closer to work, the yearly saving would be around R118.6 million. If central location enabled a switch to walking or other unsubsidised modes of transport, recouping the capital investment would be considerably less than twenty eight years.

- Even though quality of life indicators are used widely, it is not possible to correlate it directly with quality of living environment. However, better ventilated and insulated space as proposed by the sustainable living package will undoubtedly provide health benefits.

- South Africa’s potential for utilising renewable energy and job creation through renewable energy is far from utilised as is alluded to in the White Paper on Renewable Energy (RSA, Department of Minerals and Energy. 2003). The sustainable living package does not exhaust the potential for further new innovations and technologies. Photovoltaic wind and solar generation is rapidly becoming cost effectiveness, especially with neighbourhood-level systems. This should enable energy self-sufficiency in the near future and further improve life-cycle cost efficiency even though it will further increase initial capital outlay.
CONCLUSION

We have two sets of recommendations, namely more research and short term policy adjustments:

The data captured in this report is Cape Town based. Undoubtedly, data from all urban centres and most rural areas will yield similar results, but for the sake of enhancing the validity of findings, research should be expanded to other areas and specific aspects such as the real cost of maintenance or the loss where maintenance is neglected. Empirical data on health conditions caused by inadequate insulation and either top-structure compromises must also be collected in order to enhance knowledge and further inform policy decisions. In addition, on the housing and urban development policy side, it is recommended that drastic steps to enable sustainable living housing provision should be taken immediately. The technical specifications should include all the sustainable living features and more as compulsory elements to housing provision, just as the current subsidy quantum has certain minimum design criteria. This should apply to all housing provision, even for small projects of limited numbers of housing. The initial increased demands for capital outlay should not even have to lead to a slowdown in housing provision, because of immediate savings in city-wide infrastructure costs.

These steps represent a substantive investment in the future. If there can be consensus in the car industry that massive investment to reducing the carbon footprint is nonnegotiable, then the policy and practice steps proposed here must be considered equally nonnegotiable in the face of the social, economic and ecological challenges in South Africa.
In South Africa we have a plethora of good legislation and policies which govern urban planning, housing, energy, water, sanitation, solid waste, transport and other aspects of settlements. But these complex and sometimes overlapping frameworks are difficult for councillors and officials to comprehend, and a veritable policy gridlock tends to obscure rather than facilitate sustainable solutions.

This manual thus focuses on practical and tangible sustainable development solutions that are in line with existing legislation and policy. In most sectors the challenge is not policy development but implementation and innovation in practice at municipal level.

However, there are serious constraints that need to be acknowledged and addressed. Short-term thinking that neglects longer-term social and environmental impacts, and entrenched traditional approaches to urban design and planning prevent the implementation of progressive policies and sustainable solutions. Many municipalities are also struggling to become financially viable, and only survive with significant national subsidies. In certain instances the Municipal Finance Management Act (MFMA) restricts their ability to innovate and operate optimally.

Then there is the general lack of interdepartmental and intergovernmental communication and collaboration. This leads to decisions being made in isolation, with negative impacts on other departments and development projects. Integrated development planning as required by law is seldom truly integrated, and rarely leads to integrated development and implementation in practice.

The National Department of Housing's Breaking New Ground is a good example of progressive policy based on the key development principles of integration and sustainability. But the challenge is for provincial departments and municipalities to put this policy into practice in the design and construction of sustainable human settlements. This manual is designed to help support the meeting of this challenge.
Learning and Development are Essential

It is imperative that councillors, municipal officials and their contracted agents understand the new policies, and cooperate in developing new approaches to urban planning and upgrading, in partnership with communities and community-based organisations. This will require a clear, shared vision, political will and the commitment and participation of all stakeholders at local level in appropriate processes.

New and innovative approaches will require significant learning, and the development of new ways of working, from writing terms of reference based on integration and sustainability to clearing bureaucratic obstacles and accessing innovative funding options. Municipalities will need clear policies on development facilitation, and they will need to develop and contract the capacities required to facilitate sustainable settlement development.

Principles for Designing Sustainable Settlements

The first principle is to understand settlements as living and evolving human communities, and not just a collection of physical structures that can be erected and forgotten. The built environment should provide a suitable ‘body’ for the life processes, social interaction and development of the soul and spirit of the community and its individual members and families.

Sustainable settlement planning should create a built environment that supports sustainable livelihoods and living in well-designed and integrated social, economic and environmental contexts. The following principles should guide the holistic planning of such settlements. Key components include good urban and housing design, integration of built and natural environments, sustainable technologies, methods and materials, and community participation in development processes.

Appropriate Densification

Though many applicants for subsidised housing want stand-alone units, the cost and scarcity of well-located land and escalating transport costs makes this option increasingly unsustainable in larger towns and cities. Urban sprawl also creates inefficiencies in service provision, and reduces valuable agricultural land and potential green open spaces. Mixed-use development corridors with increased density can provide efficient public transport, local economic opportunities and varied services in residential areas.

Proper and progressive land planning and management are needed to provide land for formal settlements, for properly designed and managed informal settlements, and to curb land invasions and overcrowded settlements on unsuitable, un-serviced and often unserviceable land such as flood plains.

Integration and Mixed-Use Development

Neighbourhoods are enriched by the integration of different social groups and income levels. Physical and functional integration include provision of essential services within walking distance to limit the need for motorized transport, integration of private and public spaces and of the built and green environment. Mixed use allows and encourages multiple activities, including living, working, trading, accessing services, appropriate
structures and recreation in the same areas, as opposed to the old single-use zoning approaches. This is essential to support the informal economy and local economic development.

**Sustainable Technologies**

Sustainable technologies covered in this manual include renewable energy options and particularly solar water heating, which provides long-term energy and cost savings and lessens environmental impacts. In recognition of this, Eskom now provides a 15 to 20% (of cost) subsidy on solar water heating systems. Low and no-cost energy efficient designs can also enhance natural warming and cooling of homes, thereby reducing the homeowner’s electricity costs and the load on Eskom. Other sustainable technologies and design applications that are practical and cost-efficient include: north orientation, roof overhangs, ceilings, insulation, CFL bulbs, water efficiency technologies, rain and stormwater retention and harvesting.

Many of these solutions save on infrastructure costs and support urban agriculture and greening. Local composting and reuse of organic materials reduces waste transportation, landfill airspace and enriches local soils. Sustainable waste management that involves waste reduction, recycling and reuse needs to be supported by appropriate facilities and community education and organization in order to reduce pollution, conserve resources and care for the environment. Sustainable waste management that involves communities also provides significant opportunities for local work and income generation, as demonstrated in Curitiba, a sustainable city in Brazil.

**Sustainable Materials**

Sustainable materials represent an exciting area of innovation involving a mix of traditional methods and new technologies. Examples include the use of local natural materials, recycled building materials and soil stabilization (rather than removal and replacement). These materials and methods all lower transport costs and environmental impacts, reduce waste and often have significant cost advantages.

**Sustainable Economics**

Many sustainable options can be supported by special housing and project subsidies. Such investments save money in the long-term, which becomes evident when life-cycle and full-cost accounting are applied, and include the externalized costs of environmental damage. In the past decade such potential costs have escalated exponentially as global warming drives climate changes that threaten increasing and unprecedented natural disasters. The Clean Development Mechanism as an international carbon credit exchange provides an innovative source of funding for renewable energy and energy efficiency projects such as the Kuyasa Low-income Urban Housing Energy Upgrading Project in Khayelitsha.

**Local Economic Development**

Local economic development is essential to reduce poverty. Many sustainable construction and maintenance methods are labour-intensive and provide local work and income, skills development and
opportunities for local entrepreneurs and emerging contractors. The People’s Housing Process, which allows citizens to participate in building and upgrading their own homes, is a good example. Sustainable construction also allows more money to remain and circulate in the local community. The development and maintenance of sustainable human settlements can constitute a comprehensive local economic development and poverty reduction strategy. Urban agriculture, greening, environmental care and development all provide significant opportunities for enhancing livelihoods, generating income and saving on costs in poor communities. In Cuba for example, a significant proportion of food is grown organically and locally, in and adjacent to urban areas.

Creating an Enabling Environment

Though national policy supports sustainable practices, old thinking and habits, and bureaucratic inertia often prevail at provincial and local levels. Inappropriate restrictions need to be replaced with incentives for developments that include sustainable design criteria, technologies and materials in projects that provide appropriate and affordable accommodation to the urban poor. Various forms of land tenure are another necessary element that promotes flexibility and a variety of options to suit different needs and circumstances. Innovation in settlement design and housing construction also require changes in construction regulations, including those of the National Home Builders Registration Council (NHBRC), so that sustainable methods and materials are allowed and encouraged.

Community Participation and Development

Sustainable settlement design and development cannot be achieved without community participation. Building sustainable settlements is not just a matter of delivering infrastructure and houses. People who inhabit settlements must be part of the process, as their activities and interaction constitute the life of any neighbourhood. Where the principles of participation are transgressed, alienation and soullessness can occur, resulting in a plethora of social ills and challenges. Planners need to recognise the full spectrum of human needs and engage community members by working with them to create neighbourhoods worthy of human beings. Such neighbourhoods can have a rich cultural-spiritual identity and soul life, as was evident in communities such as Sophia Town and District Six, which were destroyed by Apartheid planning.

Communities rarely survive relocation, as the process of uprooting a community usually destroys its social fabric. In-situ upgrading and incremental approaches to designing and building settlements are thus the preferred option for informal settlement upgrades. New innovative and participative approaches make this possible. The poverty and wealth of communities clearly have multiple dimensions that are not determined only by monetary values, individual incomes and material assets.

Sustainable approaches value and encourage variety, individual creativity and innovation, and are thus necessarily decentralised, diverse and bottom-up. Centralized, standardized and top-down approaches with ambitious quantitative targets seldom consider the quality of life recipients will experience in these settings. Municipalities can provide mechanisms which encourage timely delivery of developments. In the GAP housing
market, financial institutions often require potential home-owners to undergo (and pass) personal financial management courses in order to receive a home loan. Municipalities, linked with registered training providers and outcomes-based materials, can also provide appropriate training (and required attendance) for potential housing beneficiaries.

The National Department of Housing states that, “Housing policy and strategy must be structured so that South Africa’s housing process… maximizes the involvement of the community and leads to transformation of skills to and empowerment of the community to ensure higher levels of appropriateness and acceptability of such projects as well as the development of skills and capacities within these communities to pursue other development projects” (Department of Housing, 2000).

Partnerships
Government cannot create sustainable settlements and reduce poverty alone. Partnerships and cooperation with communities, NGOs, donors and private sector stakeholders are essential, and a key principle of Agenda 21 and Sustainable Development. In all good case study examples, the cooperation of multiple stakeholders is a significant success factor. Appropriate and facilitated community participation processes are also necessary to avoid conflicts that arise when different groups compete for access to processes and resources. Many a development project with great potential has been wrecked by community conflicts and/or the failure of stakeholders to cooperate and collectively apply their diverse capacities to ensure effective project management and successful implementation.

Sustainable Living and Livelihoods
Sustainable urban and housing designs, technologies, methods and materials only provide the starting point for sustainable ways of living and livelihoods, which are essential if human settlements or communities are to be truly sustainable. This requires ongoing community leadership, education and a variety of organic and managed development processes that maintain community organisation and sustainable living practices. Capital investment in developing infrastructure, housing and the urban environment also requires ongoing maintenance, otherwise assets deteriorate and housing estates degenerate into slums, compromising services and the quality of life, and requiring premature and costly rehabilitation or replacement. Research has shown that levels of crime and social problems are lower in neighbourhoods where people appreciate and care for their environment, and are involved in community relationships processes.

Creating Sustainable Human Settlements
The development of sustainable human settlements clearly provides a significant, multi-dimensional and exciting challenge. Municipal and provincial officials and politicians responsible for implementing progressive policies such as Breaking New Ground must take the lead in mobilizing other stakeholder partners to address this challenge. This manual will have served its purpose if it has helped to inspire readers with a vision of sustainable human settlements and communities, and provided principles, practical solutions and innovative approaches for the progressive realization of this necessary development vision.
## Chapter 2: Sustainable Housing Options

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<th>Organization</th>
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<td>9 Wynne Street, Southernwood, East London 5200, South Africa</td>
<td>043 743 3830</td>
<td>043 743 2200</td>
<td><a href="http://www.afesis.org.za">www.afesis.org.za</a></td>
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<tr>
<td>Built Environment Support Group (BESG)</td>
<td>371 Jabu Ndlovu Street, Pietermaritzburg 3201</td>
<td>033-394 4980</td>
<td>033-394 4979</td>
<td><a href="mailto:cameron@besg.co.za">cameron@besg.co.za</a></td>
<td><a href="http://www.myggsa.co.za/connect/receivers/built_environment_support_group/">www.myggsa.co.za/connect/receivers/built_environment_support_group/</a></td>
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<tr>
<td>Development Action Group (DAG)</td>
<td>101 Lower Main Road, Observatory, Cape Town</td>
<td>021 448 7886</td>
<td>021 447 1987</td>
<td><a href="mailto:dag@dag.org.za">dag@dag.org.za</a></td>
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<tr>
<td>Habitat for Humanity South African</td>
<td>P.O. Box 23113, Claremont, Cape Town 7708 Western Cape South Africa</td>
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<td>021 670 2045</td>
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<tr>
<td>Isandla Institute</td>
<td>The Grimley, Unit 202, 2nd Floor, 14 Tuin Plein Gardens, Cape Town</td>
<td>021 465 8751</td>
<td>021 465 8769</td>
<td><a href="mailto:admin@isandla.org.za">admin@isandla.org.za</a></td>
<td><a href="http://www.isandla.org.za/home">www.isandla.org.za/home</a></td>
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<tr>
<td>PLANACT</td>
<td>15th Floor, 209 Smit Street, Braamfontein, 2001.  PO Box 30823, Braamfontein, 2017</td>
<td>011 403 6291</td>
<td>011 403 6982</td>
<td><a href="mailto:info@planact.org.za">info@planact.org.za</a></td>
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<td>Shack / Slum Dwellers International – SDI</td>
<td>P.O. Box 14038, Mowbray 7705, Cape Town</td>
<td>021 689 9408</td>
<td>021 689 3912</td>
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## Chapter 3: Sustainable Building Materials
### Chapter 3: Sustainable Building Materials (continue)

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### Chapter 4: Renewable Energy Options for Domestic Use

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<td><a href="http://www.bioman.co.za">www.bioman.co.za</a></td>
</tr>
<tr>
<td>Earth Power</td>
<td>Small Wind Turbines, PV panels, Pico Hydro Turbine</td>
<td>Tel: 021 702 1102</td>
</tr>
<tr>
<td></td>
<td></td>
<td><a href="mailto:info@earthpower.co.za">info@earthpower.co.za</a></td>
</tr>
<tr>
<td></td>
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<td><a href="http://www.earthpower.co.za">www.earthpower.co.za</a></td>
</tr>
<tr>
<td>Energy Cybernetics</td>
<td>Consulting</td>
<td>Tel: 018 299 1328/9</td>
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<tr>
<td></td>
<td></td>
<td><a href="mailto:lj@energycybernetics.com">lj@energycybernetics.com</a></td>
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<td><a href="http://www.energycybernetics.com">www.energycybernetics.com</a></td>
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<tr>
<td>Extenda Summer</td>
<td>Solar products</td>
<td>Tel: 021 851 8562</td>
</tr>
<tr>
<td></td>
<td></td>
<td><a href="mailto:info@atlanticsolar.co.za">info@atlanticsolar.co.za</a></td>
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<td><a href="http://www.extendasummer.co.za">www.extendasummer.co.za</a></td>
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<tr>
<td>Flexopower</td>
<td>Solar products</td>
<td>Tel: 011 465 0022</td>
</tr>
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<td></td>
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<td><a href="mailto:info@flexopower.com">info@flexopower.com</a></td>
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<td><a href="http://www.flexopower.com">www.flexopower.com</a></td>
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<tr>
<td>FreePower</td>
<td>Solar water heaters</td>
<td>Tel: 021 531 6471</td>
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<tr>
<td></td>
<td></td>
<td><a href="mailto:kobus@freewater.co.za">kobus@freewater.co.za</a></td>
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<td><a href="http://www.freewater.co.za">www.freewater.co.za</a></td>
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<td>Gilder Geyser</td>
<td>Solar products</td>
<td>Tel: 082 941 8467</td>
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<td><a href="mailto:briangilder@gmail.com">briangilder@gmail.com</a></td>
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<td><a href="http://www.gildergeyser.com">www.gildergeyser.com</a></td>
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<tr>
<td>Grand Battery Technologies SA</td>
<td>Renewable energy products</td>
<td>Tel: 012 665 0819</td>
</tr>
<tr>
<td></td>
<td></td>
<td><a href="mailto:h_kwak@grandcell.co.za">h_kwak@grandcell.co.za</a></td>
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<td><a href="http://www.grandcell.co.za">www.grandcell.co.za</a></td>
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<tr>
<td>Grand Solar</td>
<td>Solar water and pv products</td>
<td>Tel: 0860 100 332</td>
</tr>
<tr>
<td></td>
<td></td>
<td><a href="mailto:gbr@grandcell.co.za">gbr@grandcell.co.za</a></td>
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<td><a href="http://www.grandsolar.co.za">www.grandsolar.co.za</a></td>
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<tr>
<td>Its Solar</td>
<td>Solar products</td>
<td>Tel: 021 851 2892</td>
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<tr>
<td></td>
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<td><a href="mailto:info@its-solar.com">info@its-solar.com</a></td>
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<td><a href="http://www.its-solar.com">www.its-solar.com</a></td>
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<tr>
<td>Company</td>
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</tr>
<tr>
<td>Kestrel</td>
<td>Small wind turbines</td>
<td>Tel: 041 4012500  Fax: 041 394 5066  <a href="mailto:info@kestrel.co.za">info@kestrel.co.za</a>  <a href="http://www.kestrel.co.za">www.kestrel.co.za</a></td>
</tr>
<tr>
<td>Michel Maleneget</td>
<td>Consulting</td>
<td>Tel: 021 683 3310  <a href="mailto:mmalen@eng.uct.ac.za">mmalen@eng.uct.ac.za</a></td>
</tr>
<tr>
<td>Omnicon</td>
<td>Installer for wind turbine systems</td>
<td>Tel: 021 905 0958</td>
</tr>
<tr>
<td>Plan My Power</td>
<td>Solar products</td>
<td>Tel: 011 678 9184  <a href="mailto:steve@planmypower.co.za">steve@planmypower.co.za</a>  <a href="http://www.planmypower.co.za">www.planmypower.co.za</a></td>
</tr>
<tr>
<td>Solar Beam</td>
<td>Solar products</td>
<td>Tel: 031 583 9585  <a href="mailto:solarbeam@webmail.co.za">solarbeam@webmail.co.za</a>  <a href="http://www.solarbeam.co.za">www.solarbeam.co.za</a></td>
</tr>
<tr>
<td>Solar Con</td>
<td>Solar products</td>
<td>Tel: 011 201 3260  <a href="mailto:dieter@solarcon.co.za">dieter@solarcon.co.za</a>  <a href="http://www.solarcon.co.za/Web/">www.solarcon.co.za/Web/</a></td>
</tr>
<tr>
<td>Solar dome/Sunflare</td>
<td>Solar Water Heaters</td>
<td>Tel: 021 6866321  <a href="http://www.solar">www.solar</a> dome.co.za</td>
</tr>
<tr>
<td>Solar Energy Society of Southern Africa (SESSA)</td>
<td>Energy education and information</td>
<td>Tel: 011 789 1364  <a href="mailto:info@sessa.org.za">info@sessa.org.za</a>  <a href="http://www.sessa.org.za">www.sessa.org.za</a></td>
</tr>
<tr>
<td>Solar Powered Led Home</td>
<td>Light System</td>
<td>Tel: 022 783 0752  <a href="mailto:it00436@mweb.co.za">it00436@mweb.co.za</a></td>
</tr>
<tr>
<td>Solar Tube</td>
<td>Solar lighting products</td>
<td>Tel: 011 646 8680  <a href="mailto:solatube@iafrica.com">solatube@iafrica.com</a>  <a href="http://www.solatube.co.za">www.solatube.co.za</a></td>
</tr>
<tr>
<td>Solien</td>
<td>Solar, pv, biogas, wind products</td>
<td>Tel: 044 877 1268  <a href="mailto:info@solien.co.za">info@solien.co.za</a>  <a href="http://www.solien.co.za">www.solien.co.za</a></td>
</tr>
<tr>
<td>Sonpower</td>
<td>Solar products</td>
<td>Tel: 021 556 9244  <a href="mailto:sales@sonpower.co.za">sales@sonpower.co.za</a>  <a href="http://www.sonpower.co.za">www.sonpower.co.za</a></td>
</tr>
<tr>
<td>Southern African Association for Energy Efficiency Consulting</td>
<td></td>
<td>Tel: 018 293 1499  <a href="mailto:nikki@saee.org.za">nikki@saee.org.za</a>  <a href="http://www.saee.org.za">www.saee.org.za</a></td>
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<tr>
<td>Sun Power</td>
<td>Solar products</td>
<td>Tel: 086 146 8786  <a href="mailto:robin@sunpower.co.za">robin@sunpower.co.za</a>  <a href="http://www.sunpower.co.za">www.sunpower.co.za</a></td>
</tr>
<tr>
<td>Sunstove Organization</td>
<td>Solar ovens</td>
<td>Tel: 011 989 2818  <a href="mailto:sunstove@iafrica.com">sunstove@iafrica.com</a>  <a href="http://www.sungravity.com">www.sungravity.com</a></td>
</tr>
<tr>
<td>Suntank</td>
<td>Solar products</td>
<td>Tel: 012 362 3311  <a href="mailto:info@suntank.com">info@suntank.com</a>  <a href="http://www.suntank.com">www.suntank.com</a></td>
</tr>
<tr>
<td>Sustainable Energy Africa Consulting</td>
<td>Consulting</td>
<td>Tel: 021 702 3822  <a href="mailto:mark@sustainable.org.za">mark@sustainable.org.za</a>  <a href="http://www.sustainable.org.za">www.sustainable.org.za</a></td>
</tr>
<tr>
<td>Sustainable Living Projects</td>
<td>Solar, wind and water solutions</td>
<td>Tel: 021 702 3822  <a href="mailto:info@sustainableprojects.co.za">info@sustainableprojects.co.za</a>  <a href="http://www.sustainableprojects.co.za">www.sustainableprojects.co.za</a></td>
</tr>
<tr>
<td>Telecom Techniques</td>
<td>Solar, wind &amp; hydro products</td>
<td>Tel: 041 365 5073  Cell: 083 326 0665</td>
</tr>
<tr>
<td>Tricon</td>
<td>Consulting</td>
<td>Tel: 021 552 2929  <a href="mailto:ebrahim@tricon.co.za">ebrahim@tricon.co.za</a>  <a href="http://www.tricon.co.za">www.tricon.co.za</a></td>
</tr>
<tr>
<td>Wi-Fi -Parts</td>
<td>Vertical axis wind turbines</td>
<td><a href="mailto:ralph@wifiparts.com">ralph@wifiparts.com</a>  <a href="http://www.wifi-parts.com">www.wifi-parts.com</a></td>
</tr>
<tr>
<td>ZMSA</td>
<td>Solar, wind &amp; hydro products</td>
<td>Tel: 011 240 6900  <a href="mailto:jo@papersmith.co.za">jo@papersmith.co.za</a>  <a href="http://www.zmsa.co.za">www.zmsa.co.za</a></td>
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**Chapter 5: Solid Waste Management**

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<th>Company</th>
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<tr>
<td>Abalimi Bezekhaya</td>
<td>(food gardens)</td>
<td>Tel: 021 447 1256</td>
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<tr>
<td>City of Cape Town Refuse Removal Cleaning and Disposal Services (Queries about drop-off facilities / reporting of illegal dumping)</td>
<td>Tel: 086 010 3089</td>
<td></td>
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<tr>
<td>City of Cape Town’s Waste Wise Campaign Waste education and information</td>
<td>Tel: 021 400 3298  Tel: 021 400 2229  <a href="http://www.wastewise.org.za">www.wastewise.org.za</a></td>
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<tr>
<td>Collect-A-Can</td>
<td>Recycling network</td>
<td>Tel: 011 484 3623  /012 804 9408  Tel: 016 988 1330  /031 709 5935  Tel: 021 534 7010  Botswana: 00267 392 2717  Namibia: 00264 123 0006  Mozambique: 00265 2147 2602  <a href="mailto:info@collectacan.co.za">info@collectacan.co.za</a>  <a href="mailto:seth@info.bw">seth@info.bw</a>  <a href="mailto:cacnam@iway.na">cacnam@iway.na</a>  <a href="mailto:pagalata@yahoo.com">pagalata@yahoo.com</a>  <a href="http://www.collectacan.co.za">www.collectacan.co.za</a></td>
</tr>
<tr>
<td>Footprints</td>
<td>Recycling organisation</td>
<td>Tel: 021 794 5863  <a href="mailto:gsdouglas@worldonline.co.za">gsdouglas@worldonline.co.za</a></td>
</tr>
<tr>
<td>Don’t waste Systems</td>
<td>Recycling services</td>
<td>Tel: 031 207 9059  / 021 386 0206  / 011 466 8096  <a href="mailto:jeremy@dontwaste.co.za">jeremy@dontwaste.co.za</a>  <a href="http://www.dontwaste.co.za">www.dontwaste.co.za</a></td>
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<tr>
<td>ZMSA</td>
<td>Solar, wind &amp; hydro products</td>
<td>Tel: 011 240 6900  <a href="mailto:jo@papersmith.co.za">jo@papersmith.co.za</a>  <a href="http://www.zmsa.co.za">www.zmsa.co.za</a></td>
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### Chapter 5: Solid Waste Management

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<td>Free Water</td>
<td>Tel: 021 531 6471; <a href="mailto:kobus@freewater.co.za">kobus@freewater.co.za</a>; <a href="http://www.freewater.co.za">www.freewater.co.za</a></td>
<td>Water products</td>
</tr>
<tr>
<td>Freecycle Network</td>
<td>Recycling network; <a href="http://www.freecycle.org">http://www.freecycle.org</a></td>
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<tr>
<td>Heath Nash</td>
<td>Tel: 082 403 6958; <a href="mailto:elevator3000@mweb.co.za">elevator3000@mweb.co.za</a></td>
<td>Recycled art</td>
</tr>
<tr>
<td>Kommetjie Environmental Action Group</td>
<td>Tel: 021 783 3433</td>
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<tr>
<td>Kronental Recycling Centre</td>
<td>Tel: 072 738 2038</td>
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<tr>
<td>Mondi Recycling</td>
<td>Recycling organisation; Tel: 021 931 5106; <a href="http://www.mondigroup.com">www.mondigroup.com</a></td>
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<tr>
<td>Mr Recycle</td>
<td>Recycling services; Tel: 078 138 9252; <a href="mailto:mrecycle@gmail.com">mrecycle@gmail.com</a>; <a href="http://www.mrecycle.co.za">www.mrecycle.co.za</a></td>
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<tr>
<td>NAMPAK Recycling</td>
<td>Recycling organisation; Tel: 021 534 5346; <a href="http://www.nampak.co.za">www.nampak.co.za</a></td>
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</tr>
<tr>
<td>National Department of Environmental Affairs and Tourism</td>
<td>Waste manuals; Tel: 012 310 3911; <a href="http://www.environment.gov.za">www.environment.gov.za</a></td>
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<tr>
<td>Oasis Recycling</td>
<td>(Waste Management Project); Recycling organisation; Tel: 021 671 4698; <a href="mailto:info@oasis.org.za">info@oasis.org.za</a>; <a href="http://www.oasiscycling.co.za">www.oasiscycling.co.za</a></td>
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<td>Petco</td>
<td>Recycling services; Tel: 086 014 7738; <a href="mailto:info@petco.co.za">info@petco.co.za</a>; <a href="http://www.petco.co.za">www.petco.co.za</a></td>
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<tr>
<td>ROSE Foundation</td>
<td>Oil recycling; Suite A 9, Waverley Court, 7 Kotzee Rd, Mowbray 7700; Tel: 021 448 7492; Fax: 021 448 7563; Faxmail: 086 652 7384; Cell: 082 378 8556; <a href="mailto:usedoil@iafrica.com">usedoil@iafrica.com</a>; <a href="http://www.rosefoundation.org.za">www.rosefoundation.org.za</a></td>
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<tr>
<td>Rubber Tyre Recycling Plant</td>
<td>Recycling Services; Rubber tyre recycling; Tel: 011 864 1722; <a href="mailto:vredestein@icon.co.za">vredestein@icon.co.za</a></td>
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<tr>
<td>Sappi Waste Paper</td>
<td>Recycling organisation; Tel: 021 552 2127; <a href="http://www.sappi.com">www.sappi.com</a></td>
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<td>Scarab Paper</td>
<td>Recycling paper; Tel: 044 343 2455; <a href="mailto:scarabpaper@mweb.co.za">scarabpaper@mweb.co.za</a>; home.mweb.co.za/si/scarab/index.htm</td>
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<tr>
<td>Strand Waste &amp; Scrap Metal</td>
<td>Recycling services; Tel: 021 854 8898</td>
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<td>The Institute of Waste Management</td>
<td>Recycling and waste education and information; 011 675 3462; <a href="mailto:iwmsa@telkomsa.net">iwmsa@telkomsa.net</a>; <a href="http://www.iwmsa.co.za">www.iwmsa.co.za</a></td>
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<tr>
<td>The Natural Step</td>
<td>(puts the principles of sustainable development into practice by introducing the framework into organisations); <a href="http://www.naturalstep.org">www.naturalstep.org</a></td>
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<tr>
<td>The National Department of Environmental Affairs and Tourism</td>
<td>Has developed good waste manuals. Waste Management Directorate: Tel (012) 310 3911; <a href="http://www.environment.gov.za">www.environment.gov.za</a></td>
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<tr>
<td>Tsoga Environmental Centre</td>
<td>Recycling organisation - Langa; Tel: 082 542 3356 / 021 694 0004; <a href="mailto:nospidi@iafrica.com">nospidi@iafrica.com</a>; <a href="http://www.urbansprout.co.za/?q=node/407">www.urbansprout.co.za/?q=node/407</a></td>
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<tr>
<td>Timber Plastics</td>
<td>Recycled products and furniture; Tel: 0861 846 7527; <a href="mailto:info@timberplastics.co.za">info@timberplastics.co.za</a>; <a href="http://www.timberplastics.co.za">www.timberplastics.co.za</a></td>
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<tr>
<td>Xanita</td>
<td>Recycled products; Tel: 021 852 0606; <a href="mailto:info@xanita.com">info@xanita.com</a>; <a href="http://www.xanita.com">www.xanita.com</a></td>
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### Chapter 6: Water and Sanitation

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<tr>
<td>Akwadoc</td>
<td>Water analysis products</td>
<td>Tel: 012 349 1678 <a href="mailto:gerrit@akwadoc.co.za">gerrit@akwadoc.co.za</a> <a href="http://www.aquadoc.co.za">www.aquadoc.co.za</a></td>
</tr>
<tr>
<td>Anyways Solutions</td>
<td>Storm Water Management</td>
<td>Tel: 021 713 2570 <a href="mailto:info@anywaysolutions.com">info@anywaysolutions.com</a> <a href="http://www.anywaysolutions.com">www.anywaysolutions.com</a></td>
</tr>
<tr>
<td>Biobox Systems</td>
<td>Water management products</td>
<td>Tel: 012 803 7601 <a href="mailto:info@biobox.co.za">info@biobox.co.za</a> <a href="http://www.biobox.co.za">www.biobox.co.za</a></td>
</tr>
<tr>
<td>Biolytx</td>
<td>Water purification</td>
<td>Tel: 044 532 7544 <a href="mailto:info@biolytx.co.za">info@biolytx.co.za</a> <a href="http://www.biolytx.co.za">www.biolytx.co.za</a></td>
</tr>
<tr>
<td>Ecosmellstop</td>
<td>Urinals</td>
<td>Tel: 011 483 0212 <a href="mailto:info@addicom.co.za">info@addicom.co.za</a> <a href="http://www.addicom.co.za">www.addicom.co.za</a></td>
</tr>
<tr>
<td>Enviro Loo</td>
<td>Waterless sanitation</td>
<td>Tel: 011 762 1624 <a href="mailto:info@envirooptions.co.za">info@envirooptions.co.za</a> <a href="http://www.eloo.co.za">www.eloo.co.za</a></td>
</tr>
<tr>
<td>Enviro Options</td>
<td>Waterless toilet</td>
<td>Tel: 011 762 1624 <a href="mailto:info@envirooptions.co.za">info@envirooptions.co.za</a> <a href="http://www.eloo.co.za">www.eloo.co.za</a></td>
</tr>
<tr>
<td>Gardenresq</td>
<td>Water recycling</td>
<td>Tel: 062 762 3927 / 063 409 3585 / 079 673 6240 <a href="mailto:info@gardenresq.co.za">info@gardenresq.co.za</a> <a href="http://www.gardenresq.co.za">www.gardenresq.co.za</a></td>
</tr>
<tr>
<td>Gauteng Environmental Service</td>
<td>Environmental Consulting</td>
<td>Tel: 012 343 7803 <a href="mailto:danie_eloff@yahoo.com">danie_eloff@yahoo.com</a> <a href="mailto:danie@aquahhelt.co.za">danie@aquahhelt.co.za</a></td>
</tr>
<tr>
<td>Lilliput</td>
<td>Water recycling</td>
<td>Tel: 011 880 2800 / 031 783 2476 <a href="mailto:marius@globalmouse.co.za">marius@globalmouse.co.za</a> <a href="http://www.sewageworks.co.za">www.sewageworks.co.za</a></td>
</tr>
<tr>
<td>Sanix</td>
<td>Waterless sanitations</td>
<td>Tel: 011 762 1467 <a href="mailto:info@sanix.co.za">info@sanix.co.za</a> <a href="http://www.sanix.co.za">www.sanix.co.za</a></td>
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<tr>
<td>Sonpower</td>
<td>Water purification</td>
<td>Tel: 021 556 9244 <a href="mailto:sales@sonpower.co.za">sales@sonpower.co.za</a> <a href="http://www.sonpower.co.za">www.sonpower.co.za</a></td>
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<tr>
<td>Water Rhapsody</td>
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<td>Tel: 021 531 9864 <a href="mailto:info@water-rhapsody.co.za">info@water-rhapsody.co.za</a> <a href="http://www.water-rhapsody.co.za">www.water-rhapsody.co.za</a></td>
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<td>Water4All</td>
<td>Water purification</td>
<td>Tel: 021 852 5663 <a href="mailto:werner@water4all.co.za">werner@water4all.co.za</a> <a href="http://www.water4all.co.za">www.water4all.co.za</a></td>
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### Chapter 8: Urban Agriculture and Food Security

<table>
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<tr>
<th>Organisation</th>
<th>Address/Contact</th>
<th>Tel/Fax/Website</th>
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<tbody>
<tr>
<td>ABALIMI</td>
<td>Non-Profit Organisation Khayelitsha, Nyanga &amp; Cape Flats (surrounding areas)</td>
<td>Tel: 021 371 1653 <a href="http://www.abalimi.org.za">www.abalimi.org.za</a></td>
</tr>
<tr>
<td>LINDROS</td>
<td>P.O. Box 68929 Bryanston 2021</td>
<td>Tel: 082 719 7263 Fax: 086 654 9103 <a href="mailto:alan@lindros.co.za">alan@lindros.co.za</a></td>
</tr>
<tr>
<td>SEED Cape Flats Office</td>
<td>P.O. Box 40, Philippi Cape Town, 7781</td>
<td>Tel/Fax +27(0) 21 391 5316 <a href="mailto:admin@seed.org.za">admin@seed.org.za</a> <a href="http://www.seed.org.za">www.seed.org.za</a></td>
</tr>
<tr>
<td>AFESIS</td>
<td>9 Wynne Street, Southernwood East London 5200, South Africa P.O Box 11214, East London 5213 Tel: 043 743 3830 Fax: 043 743 2200 <a href="http://www.afesis.org.za">www.afesis.org.za</a> <a href="http://www.sangonet.org.za">www.sangonet.org.za</a></td>
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<tr>
<td>Built Environment Support Group (BESS)</td>
<td>371 Jaba Ndlovu Street, Pietermaritzburg 3201 P.O. Box 1369, Pietermaritzburg 3200 Tel: 033-394 4980 Fax: 033-394 4979 <a href="mailto:cameron@beeg.co.za">cameron@beeg.co.za</a> <a href="http://www.mypggsa.co.za/connect/receivers/built_environment_support_group/">www.mypggsa.co.za/connect/receivers/built_environment_support_group/</a></td>
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</tr>
<tr>
<td>Development Action Group (DAG)</td>
<td>101 Lower Main Road, Observatory, Cape Town.</td>
<td>Tel: 021 448 7886 Fax: 021 447 1987 <a href="mailto:dag@dag.org.za">dag@dag.org.za</a> <a href="http://www.dag.org.za">www.dag.org.za</a></td>
</tr>
<tr>
<td>Foundation for Contemporary Research (FCR)</td>
<td>17th Floor, Main Tower, Standard Bank Centre, 2 Heerengracht, Foreshore, Cape Town P.O Box 1498, Cape Town 8000 Western Cape, South Africa.</td>
<td>Tel: 021 418-4173 Fax: 0 21 418-4176 <a href="mailto:info@fcr.org.za">info@fcr.org.za</a> <a href="http://www.fcr.org.za">www.fcr.org.za</a></td>
</tr>
<tr>
<td>Habitat for Humanity South African</td>
<td>P O Box 23113, Claremont, Cape Town 7708 Western Cape South Africa Tel : 021 670 2046 Fax: 021 670 2045 <a href="http://www.habitat.org.za">www.habitat.org.za</a></td>
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<tr>
<td>Impumelelo Innovations Award Trust</td>
<td>Director: Rhoda Kadale 6 Spin Street, Church Square, Cape Town 8000 Tel: 021 461 3783 Tel: 021 461 1340 <a href="http://www.impumelelo.org.za">www.impumelelo.org.za</a></td>
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### Chapter 9: Socio-ecological strands of public participation
### Chapter 9: Socio-ecological strands of public participation (continue)

<table>
<thead>
<tr>
<th>Organization</th>
<th>Address</th>
<th>Contact Information</th>
</tr>
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<tbody>
<tr>
<td>Isandla Institute</td>
<td>The Grimley, Unit 202, 2nd Floor, 14 Tuin Plein, Gardens, Cape Town, PO Box 12263, Mill Street, Gardens 8010, South Africa</td>
<td>Tel: 021 465 8751, Fax: 021 465 8769, <a href="mailto:admin@isandla.org.za">admin@isandla.org.za</a>, <a href="http://www.isandla.org.za/home">www.isandla.org.za/home</a></td>
</tr>
<tr>
<td>Ocean View Development Trust</td>
<td>Trevor Edwards, Tel: 021 783-4178, Fax: 021 783-4178, <a href="mailto:ovrdp@yahoo.com">ovrdp@yahoo.com</a>, <a href="http://www.myggsa.co.za/connect/receivers/ocean_view_development_trust/">www.myggsa.co.za/connect/receivers/ocean_view_development_trust/</a></td>
<td></td>
</tr>
<tr>
<td>PLANACT</td>
<td>15th Floor, 209 Smit Street, Braamfontein, PO Box 30823, Braamfontein, 2017</td>
<td>Tel: 011 403 6291, Fax: 011 403 6892, <a href="mailto:info@planact.org.za">info@planact.org.za</a>, <a href="http://www.planact.org.za">www.planact.org.za</a></td>
</tr>
<tr>
<td>Shack / Slum Dwellers International – SDI</td>
<td>P.O. Box 14038, Mowbray 7705, Cape Town</td>
<td>Tel: 021 689 9408, Fax: 021 689 3912, <a href="http://www.sdinet.org/documents/doc16.htm">www.sdinet.org/documents/doc16.htm</a></td>
</tr>
<tr>
<td>uTshani</td>
<td>Utshani Fund, Cnr of Surrey &amp; Raapenberg Rds, Mowbray 7700, PO Box 34639, Groote Schuur, 7937</td>
<td>Tel: 021 659 6680, Fax 021 685 0279, <a href="mailto:admin@utshani.org.za">admin@utshani.org.za</a>, <a href="http://www.utshani.org.za/contact_us/details.html">www.utshani.org.za/contact_us/details.html</a></td>
</tr>
</tbody>
</table>
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Chapter 2: Sustainable Housing Options


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Chapter 4: Renewable Energy options for Domestic Use


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Chapter 5: Solid Waste Management


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