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Evaluation of design criteria for economically viable sustainable housing in Gauteng, South Africa¹

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Abstract

As a result of the 1992 United Nations Conference on Environment and Development (UNCED) Earth Summit Conference in Rio de Janeiro, 180 nations adopted a program called *Agenda 21*: an international attempt to create a normative blueprint for sustainable development worldwide. It is, however, not really possible to define a normative blueprint for the whole spectrum of human settlements worldwide, as economical, ecological, geographical, topographical and social contexts differ. In informal settlements, especially, design criteria for sustainable development are of paramount importance. While this paper examines these problems from an international point of view, it does so in a South African context. Problems in five subsystems (political, economical, socio cultural, environmental and technological) are examined. Recommended solutions are summarised in tables of design applications concerning the site selection; passive solar design; water saving measures; sanitation options and applicable energy conservation measures. To dispel possible doubts concerning the use of traditional materials and practice, a further summary has been compiled to show the benefits gained by using these alternative construction methods, expounding vernacular building methods that have traditionally been used in South Africa and in similar climatic conditions elsewhere.

Keywords: Agenda 21, sustainable development, South Africa

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Abstrak

As 'n uitvloeisel uit die 1992 *United Nations Conference on Environment and Development (UNCED) Earth Summit* Konferensie te Rio de Janeiro het 180 lande 'n program genaamd *Agenda 21* aanvaar, as 'n internasionale poging om 'n normatiewe bloudruk daar te stel vir volhoubare ontwikkeling wêreldwyd. Dit is egter beswaarlik moontlik om 'n normatiewe bloudruk vir die hele spektrum van menslike nedersettings wêreldwyd te definieer, aangesien ekonomiese, ekologiese, geografiese, topografiese en sosiale kontekste verskil. Ontwerp kriteria vir volhoubare ontwikkeling van veral informele nedersettings is van die uiterste belang. Hierdie probleme word aangespreek uit 'n internasionale oog punt, maar in 'n Suid Afrikaanse konteks. Probleme in vyf substelsels is onder soek, te wete die politiese, ekonomiese, sosio kulturele, omgewings en tegnologiese substelsels. Voorgestelde oplossings word opgesom in tabelle van ontwerpstoepassings aangaande die keuse van perseel, passiewe sonenergie ontwerp, waterbesparingsmaatreëls, sanitasie opsies en toepaslike energie besparingsmaatreëls. Om moontlike bedenkinge aangaande die gebruik van tradisionele materiale en boumetodes te weerlê, is 'n verdere opsomming saamgestel om die voordele van hierdie alternatiewe boumetodes aan te dui. In hierdie opsomming word inheemse boumetodes wat tradisioneel in Suid Afrika en in soortgelyke klimaatstoestande elders gebruik is, uiteengesit.

Sleutelwoorde: Agenda 21, volhoubare ontwikkeling, Suid Afrika

1. Introduction

One of the main purposes of *Agenda 21* is to try to ensure inter-generational equity. *Agenda 21* fully embraces the concept of sustainability and recognises the fact that a growing population cannot take natural resources for granted. Programmes to reduce global poverty can, and should improve the environment and economic situation of the poverty-stricken.

South Africa is faced with a growing indigent population, increasing water-shortage, inadequate housing and inadequate financial resources. There is a dire lack of sanitation for the poor in their shacks, and limited access to unpolluted water. They moreover suffer from poor nutrition, are minimally employed and consider themselves to be 'second-class' citizens (Black, 2000: 9). This can be causative to a society that respects neither the law, nor the broader society.

Williamson, Radford & Bennetts (2003: 84) perceive sustainable development as a three-legged stool – each of the legs being a subsystem (socio-cultural, environmental and economical) that cannot exist in isolation from one another. In the South African context of instability at local government level and technological backlog, it makes sense to add two additional subsystems, namely a political and a technological one.

2. The political subsystem

Political agendas are a deciding factor in the housing arena, since foreign donations may go to waste or are misspent due to political manoeuvring and mismanagement (SABC News, 2004).

Information on housing subsidies does not seem to reach the semi-literate people it is supposed to help (Makwela, 2004). An intricate subsidy system explained on the website of the Department of Housing is of no help at all. Officials at building sites seem not to be able to explain the system in understandable terms, either.

Regularisation of informal housing settlements cannot be carried out without the approval of local authorities, as many informal sites are laid out on dangerous areas, such as potential flood and landslide sites. Houses built in such areas not only pose a danger to inhabitants, but are also dangerous to service and are thus incompatible with the norms of sustainable urban development (Allen, You & Atkinson, 2002: 167).

3. The economical subsystem

The economical aspects of designing for sustainability, like those of any building project, are concerned with the input of capital, materials and labour; and to provide services and assets. A life-cycle assessment can be a useful planning tool in considering the life span, serviceability and durability of a building and its components. In South Africa an additional dilemma is that housing solutions should not only satisfy potential beneficiaries, but also have to be affordable in terms of existing governmental housing subsidies.

4. The socio-cultural subsystem

Laure & Wiedenhoff (2000: 48-50) advocate taking into account the values, attitudes, behavioural and norm systems of the society, besides the climate and morphology. All of these will determine the way in which inhabitants use available resources and the social patterns by which they respond and relate to their built environment.

It follows that sustainability and the eventual architecture has to be specific to culture, place and time. In many of the rural areas of South Africa, a resentment regarding traditional earth dwellings exists, opposed to a desire for 'modern' houses of brick or concrete blocks and mortar, as well as a perception that traditional dwellings do not qualify as 'real' houses (Macleod, 2002: 2). It would be important to instruct these people in the potential benefits of the traditional building methods, otherwise the product may well be affordable, structurally sound and thermally superior, but remain unacceptable to the beneficiaries.

Although the thermal performance of the new structures built by owners usually are notably inferior to that of the traditional dwellings, residents of new structures feel that they have advanced socially. This problem is exacerbated during hot summer months by superstition that is still rife. In a survey done by the Nova-team (February 2004), 78% of rural and urban respondents indicated that they did not open their windows at night for fear of witchcraft, and 96% did not open their windows for fear of crime.

Education will contribute to helping future inhabitants of sustainable villages to understand the environmental, social and ecological implications. These people might grow less wasteful if they understand these processes and see progress through their own efforts.

Emphasis should be placed on self-sufficiency, trying to reduce levels of urban migration and the depletion of resources. By investing in the training of villagers as craftsmen, to help build their own villages and understand the processes involved, a chain reaction of empowering presently redundant squatters can be possible. Possible 'teachers' can be identified who in turn can start their own programme to teach villagers how to build their own sustainable homes (Tholego village: North West Province, Ivory Park: Midrand) who can eventually be absorbed into the building industry (Irurah *et al.*, 2002: 79, 82).

Communities where historical systems and management have disintegrated and which have been deprived socially, politically and economically, can possibly be revived with the help of Community Asset Management (CAM) (De Villiers, 2003). This will entail time and careful, sustainable planning. A part of solving the problem will be the creating of work opportunities to create an income for the inhabitants of such a village. The community will also have to be taught to maintain and manage the facilities according to their needs and expectations.

In some villages, like Nthuthukoville in Pietermaritzburg, the success of environmental management is consolidated by a door-to-door environmental education and management programme, which has proven successful and has provided permanent job opportunities for vulnerable households where there previously was no breadwinner. Cleaning and maintenance of public sites, door-to-door refuse removal, planting and maintenance on public land and managing community facilities all provided new job opportunities (Irurah *et al.*, 2002: 26).

5. The environmental subsystem

Local waste management systems to recycle glass, paper, plastics, organic wastes and sewage have proven to be successful in supporting local small businesses, e.g. the Ivory Park Iteke recycling project (Midrand), started in 2000, and the Durban Solid Waste Project (Irurah *et al.*, 2002: 56, 83).

Permaculture is the creation of an ecologically sound environment where the infrastructure (i. e. available water and energy) and humans, plants, animals and buildings are placed in the landscape in a way so as not to pollute and to be ecologically sound

Acta Structilia 2006:13(1)

and viable. According to Mollison (1991: 1) permaculture is based on the observations of natural systems, creating a cultivated ecology creating more animal and human food than is generally found in nature.

Availability of water affects the type of permaculture chosen for the site, whether the main source of water is runoff (surface and underground), springs, (ground seepage), streams, or rainfall that would have to be harvested.

Vegetation has a profound effect on the microclimate of sites and can modify the temperature by transpiration, convective transfer of heat, shading, wind protection and insulation. Domestic fowl produce extremely useable manure, eggs, meat and feathers and are cheap to feed. Poor soil should never be a limiting factor, as it can be changed and improved with proper attention.

6. The technological subsystem

Johannesburg falls into the Highveld climatic zone (Holm, 2000: 64-70) while Pretoria can be categorized as falling into the Northern Transvaal region (Holm, 2000: 64-70). The climatic descriptions are similar in some ways: having "distinct rainy and dry seasons with large daily temperature variations and strong solar radiation, with moderate humidity" (Holm, 2000: 64-70). Rainfall measures between 250-900mm per year (Holm & Viljoen, 1996: 3).

Table 1: Design applications regarding the site selection

<i>Temperatures</i>	<p>In still conditions, cold air sinks to hollows creating cold 'pools' with lower temperatures than hillsides.</p> <p>Larger water features like rivers and rivulets act as cooling zones. Large areas of heat absorbing materials increase local temperatures.</p>
<i>Solar access</i>	<p>Involves the right of every building owner to sufficient sunshine; Solar access is necessary for solar power;</p> <p>Is important because of possible shading by neighbouring buildings;</p> <p>The level of pollutants in the air affects the solar radiation received;</p> <p>Slopes have an effect on solar access. Northern slopes allow denser building than southern slopes, and western slopes should better be avoided (Holm & Viljoen, 1996: 9).</p>
<i>Airflow</i>	<p>The site should be assessed as to the level of exposure provided, and should be selected to maximize exposure to breezes for summer cooling.</p> <p>Features like trees that create buffers to buildings can modify and reduce the level of exposure, if necessary.</p>
<i>Optimum orientation</i>	<p>Up to 3°C difference can be acquired by optimum orientation. Optimum orientation will reduce radiation to a minimum during the summer months (Konya, 1980: 38).</p>

Table 2: Passive solar design recommendations regarding cost-effective housing

<i>Plan form</i>	<p>A compact plan form affords the least heat loss during winter. The east and west walls should be kept as short as possible. The houses should be orientated by establishing true north (Holm, 2003).</p> <p>Inhabited areas, such as living rooms, should be situated on the north side of the building.</p> <p>Planning housing rows to form open, planted courtyards can help to modify the microclimate, as long as the spacing between buildings allows the sun to reach the buildings on the south (Holm & Viljoen, 1996; Konya, 1980; Holm, 2003).</p>
<i>Walls (mass)</i>	<p>Used for heat storing capacity to retard heat flow (Holm & Viljoen, 1996).</p> <p>In Gauteng, thermal mass is advisable, for its heat storing capacity and time lag properties.</p> <p>Massive walls on the north side will absorb heat, to heat the interior when most needed during the cold morning hours (Holm & Viljoen, 1996; Holm, 2003).</p>
<i>Partitions (interior walls)</i>	<p>Thermal mass is advisable. Massive walls, painted white for reflection. (The building will rely mainly on natural daylight).</p>

Table 2: Passive solar design recommendations regarding cost-effective housing (continued)

<i>Floors</i>	Massive floors with a high density and heat storing capacity are effective in inland areas, which are prone to a higher temperature swing.
<i>Windows</i>	<p>Glazing can be the source of the most pronounced heat loss and heat gain and should be designed to capture solar radiation in winter and eliminate it in summer, to ensure superior thermal performance of any building.</p> <p>Design criteria for windows determined by radiation/heat gain: Larger windows allow greater heat gain, but also more heat loss unless they are temporarily insulated Position: if situated under eaves or in courtyards, the windows will be exposed to diffuse radiation. Orientation: West facing windows are best avoided, as they receive most radiation. North facing windows are preferred in a South African climate.</p> <p>Deciduous trees and/or pergolas with vines can be used to shade windows on northern side, as solar control (Holm, 2003)</p>
<i>Insulation</i>	Prevents heat loss: winter and heat gain: summer. Heat loss through the roof can be extreme and insulation is of the utmost importance. Lightweight insulated roofs are feasible, provided that the structure (walls, partitions and floors) has enough mass. Useable isolation materials are 'Blown cellulose fibre' insulation (made of 70% recycled newsprint and harmless household chemicals, fire retardant and rodent resistant). It is cheap and very effective. Dust does not reduce its insulating properties (trade name Thermguard, 1986 1995) and 'straw' (compressed, wire bound or stitched).
<i>Roof</i>	<p>Will take the greater thermal impact during summer, and loose most heat in winter.</p> <p>'Umbrella' form serves to spread heat and form an insulating roof cavity (preferably flat ceiling).</p> <p>Overhangs: It is convenient for the inhabitants if the entrances of their houses are shielded from sporadic thunderstorms (Holm, 1996: 70). Good overhangs are also seen as advantageous, especially in buildings built of materials like stabilized earth blocks.</p> <p>General guidelines for 'Roof overhang, window height and positioning' (Holm, 1996: 67, 72) can be consulted.</p>
<i>External Surfaces</i>	Light coloured/ reflective, to minimize solar heat gain during overheated periods.
<i>Sun angles</i>	The summer sun should be screened, and the winter sun should be allowed to penetrate. Holm (2000) provides for sun angles: p.66 for Johannesburg and p.71 for Pretoria.
<i>Ventilation</i>	<p>Ventilation can effectively alleviate overheating on hot days. If thermal mass is exploited, it may not be necessary.</p> <p>Night ventilation can be implemented to compensate for insufficient mass if socio cultural implications can be overcome.</p>

Table 3: Water-saving measures

<p><i>Rainwater harvesting</i></p>	<p>Rainwater from tile and galvanised iron roofs can be collected in gutters and directed to 'storage tanks' for drinking purposes. Water from thatched roofs and roofs painted with poisonous paint are not fit for drinking purposes.</p> <p>Galvanised iron tanks are relatively cheap, but rust easily. Moulds are available for making concrete tanks.</p> <p>Mollison (1991: 81) advocates that rainwater tanks should be placed on the shaded side of the houses, (i.e. south) preferably under a trellis, to cool water down for drinking.</p> <p>'Retention ponds' (swales) can be built to harvest rainwater and to hold water that is led away from the houses by diversion ditches, to be used for permaculture.</p>
<p><i>Conservation of household water</i></p>	<p>Teach inhabitants to check for dripping taps and leaks and repair/ report them.</p> <p>Install efficient showerheads and flow restrictors on taps.</p> <p>Install low flush toilets or composting toilets if the inhabitants will find this option acceptable /desirable.</p>
<p><i>Recycling grey water</i></p>	<p>A simple but effective grey water filter can be built from materials which are cheap and easily available.</p> <p>Successful systems have been designed for individual houses, as well as for groups of four to six houses (Sowman & Urquhart, 1998: 170).</p> <p>Grey water can also be collected in cisterns below the showers and hand basins to flush the toilets (Holm, 2003: 4).</p>

Environmentally safe and suitable sanitation systems are necessary to reduce the risk of diseases. Some of the main issues in South Africa are acceptability/desirability of certain systems to users, water supply, affordability and management participation. For these reasons only the most suitable systems were selected and are compared in Table 4.

Factors such as pollution caused by coal-burning power stations, coal burning stoves and traditional braziers should be considered when designing new housing schemes. Renewable energy systems such as solar power using photovoltaic panels have higher initial costs, but it also has very low running costs. This has to be compared to the monthly electricity bills and running costs of electricity plants. Table 5 summarises applicable energy conservation measures.

Table 4: Sanitation options (South Africa. Department of Water Affairs and Forestry. 2001)

<i>Sanitation system</i>	<i>Description</i>	<i>Advantages</i>	<i>Disadvantages</i>
Conventional sewerage	Full flush, in house toilet connected to a municipal sewer network that drains to a wastewater treatment facility.	Minimal health risks Preferred system by majority of users.	High initial and ongoing costs. Significant volumes of water is used, 10 20 litres per flush. Trained plumbers required for installation and maintenance. Requires piped water supply to site. Stormwater enters the system, leading to overloading.
Low flush (Loflow) sewerage	An in house toilet is flushed by a low volume of water, about 1 litre of water per flush. Smaller diameters sewers are needed. An on site digester can be used.	Pilot studies done by the Dept. of Water Affairs have indicated savings of up to 50% over conventional sewerage. Can be connected to grey water system. Easy to install. If maintained, can last a long time: (Holm, 2003: 4).	Sludge in digester needs to be pumped out every 3 5 years if the system is not connected to municipal sewerage. Training of users to maintain soak away is necessary.

Table 4: Sanitation options (South Africa. Department of Water Affairs and Forestry. 2001)
(continued)

<i>Sanitation system</i>	<i>Description</i>	<i>Advantages</i>	<i>Disadvantages</i>
Ventilated Improved Pit (VIP) toilet.	<p>A top structure over a pit, preferably lined, with a concrete slab on top of the pit.</p> <p>Vented by a pipe over which a fly screen is attached.</p> <p>Organic material decomposes in darkened pit. If lined, pit has to be emptied yearly. If not lined, liquids seep into the surrounding soil.</p>	<p>Low initial and ongoing cost.</p> <p>Hygienic if properly constructed.</p> <p>Local materials and labour can be used for construction.</p> <p>No water necessary for flushing.</p>	<p>Toilet has to be outside the house.</p> <p>Soakage from pits without linings can pollute groundwater.</p> <p>Not suitable for areas with collapsing soil or very high water tables.</p> <p>Regular pit emptying is necessary.</p> <p>Resistance to handling of decomposed waste by homeowners has not yet been overcome</p>
Composting toilets (Enviroloo). (Trade name)	<p>A bought, sealed container with adequate ventilation, converts human waste into dried, compost like matter that is air dried.</p>	<p>No water is used.</p> <p>Fertiliser is produced.</p> <p>Can be installed indoors</p> <p>It can be installed in rocky areas or where there is a high water table, with no risk of pollution to the environment.</p> <p>Fertiliser can be used for permaculture.</p>	<p>Unconventional: not in general use with the white population (Holm, 2003).</p>

Table 5: Applicable energy conservation measures (Holm & Viljoen, 1996: 8-30)

<i>System</i>	<i>Description</i>	<i>Design considerations</i>	<i>Problems</i>
Passive solar design	Space heating accomplished by using direct solar radiation.	<p>Sun heats the building through the windows, which must be correctly oriented.</p> <p>Heat is retained in massive walls, floors and partitions. Insulating the ceiling/roof also helps.</p> <p>Optimise the flywheel effect, by balancing mass, window size, and ventilation.</p> <p>Compact plan form with inhabited areas situated on the northern side.</p>	Requires design effort (Holm, 2003).
Photovoltaic system	Photovoltaic modules made of silicon wafers that are sandwiched between plastic or glass. These modules are put together in arrays, allowing a significant amount of electrical energy to be generated from the sun. The energy that is generated during daytime can be stored in a battery.	<p>Arrays are mounted on roofs or mounting frames.</p> <p>Arrays should be positioned to use the minimum cable length.</p> <p>Orientation of the array: preferably due north.</p> <p>Tilt angle should be approximately equal to the latitude of the site + 10°.</p> <p>Arrays should be placed to be in full sun all day; not overshadowed by trees and buildings.</p> <p>Wind shear can be a design consideration on arrays with substantial surface areas.</p> <p>Direct mounting on correctly angled roofs obviates this problem.</p>	<p>Mass can be a problem when using sizeable arrays.</p> <p>Roof structures will then have to be strengthened.</p> <p>Security: modules should be mounted out of reach where possible.</p> <p>The use of locknuts may reduce the chance of theft.</p> <p>Renewable energy Grid feeder</p> <p>Law is not yet in place in S.A.</p> <p>This encourages PV by setting a premium on surplus green electricity fed back to the grid (Holm, 2003).</p>

Table 5: Applicable energy conservation measures (Holm & Viljoen, 1996: 8-30) (continued)

<i>System</i>	<i>Description</i>	<i>Design considerations</i>	<i>Problems</i>
The treatment of common internal elements (The type of wiring and approach depends on the system voltage).	Wiring: DC systems (12 volt)	Direct current at low voltage is used.	Length and thickness of wiring is critical. Wiring lengths must be as short as possible, to reduce reduction in voltage over length.
	AC systems	Direct current from the battery is changed to a higher voltage alternating current. Standard wiring practices are followed for the high voltage part.	
	Lighting	Fluorescent lighting generally used for buildings relying on renewable fuels: these lights use less electrical energy.	
	Switching	Straight or coiled tubes. Pull switches is cheaper and shorter lengths of wiring is needed.	
Solar hot water systems (SWH)	3 basic types of collector: Flat plate direct Flat plate heat exchanger Cylindrical and other In most of the systems the heated water is stored either in a geyser or in a close coupled unit.	Minimise long runs of piping when positioning the SWH, in relation to geyser, bathroom and kitchen. The collector needs to be oriented due north. In direct systems the geyser must be well above the collector, to keep the system from cycling cold water through the geyser on cold nights. The tilt angle should be approximately equal to the latitude of the site + 10 Mass of the solar water heater when full should be considered when designing the roof structure.	Water availability and quality should be determined. Water from a borehole can clog up the system and reduce its effective life. Low winter night temperatures on the Highveld preclude the use of direct systems (if without anti frost design) where freezing can rupture the system.

Table 6: Benefits gained by using alternative construction methods

<i>Material</i>	<i>Benefits</i>	<i>Doubts</i>	<i>Comments</i>
Straw bale building	<p>Pollution reduction: as a waste product, straw does not easily decompose.</p> <p>Super Insulation: especially if used for walls and ceiling.</p> <p>Low cost</p> <p>Low tech</p> <p>Fire resistant: a plastered bale wall does not contain enough air to keep a fire going.</p>	<p>Rotting: only long term, repeated exposure to water (moisture content more than 20% of the bale) will support fungal growth and decomposition.</p> <p>Architectural detailing to maintain 'breathing' of straw is the best insurance against rot.</p> <p>Vermin: Infestations by insects and rodents can be avoided by denying access (applying a plaster coat).</p>	<p>Because of its inherent variability and flexibility, building with bales does not demand specialised skills. The work provides camaraderie and encourages the creativity and hand working skills of novices (Lerner <i>et al.</i>, 2000: 232)</p> <p>Examples: House Christiaan van Zyl, Orania; House Sandra Prinsloo, Verloren Vlei (Du Plessis, 2002).</p>
Rammed earth technique	<p>Labour intensive: provide workless people with jobs. (making shutters, hand ramming).</p> <p>Excellent insulator</p> <p>Fireproof</p> <p>Termite proof.</p>	<p>Damp: Rammed earth, even if stabilised with cement, should not be used where (i.e. foundation walls with high water table) it will stay damp for long. Rainfall: High rainfall will not damage it. Is it strong enough: In Europe and North Africa, buildings of hundreds of years old exist, built of rammed earth. Aesthetics: Especially when plastered, a rammed earth dwelling can be very appealing.</p>	<p>The method depends on having suitable soil at hand (Bolton, 2001: 34). Most sites in South Africa either have suitable subsoil, or access to soil nearby.</p>
Stabilised earth blocks	<p>Labour intensive: uses local skills and knowledge of traditional building methods, to provide jobs for the workless.</p> <p>Energy efficient: houses with thick earth walls are excellently insulated.</p> <p>Cheaper: than concrete blocks or bricks. Using local soil saves transport costs as well.</p>	<p>Damp: commonly seen as a problem, especially when building in an area with a high water table.</p> <p>Providing a roof with overhangs to shield the walls, like an umbrella; damp proofing the house and selecting a site without water problems will protect the house from damp. Is it strong enough: Especially when using the correct (straw, cement, bitumen) binder for the soil, this method will provide a very sturdy structure.</p> <p>Aesthetics: Very appealing, can be plastered or painted with mixture of linseed oil and turpentine which makes it resistant to water.</p>	<p>Soil is usually freely available on or near to the building site.</p> <p>It is important to do the necessary soil tests, and to use a binder if it is deemed necessary (Bolton & Burroughs, 2001).</p>

According to Irurah (2003: 16) the use of natural and semi-processed materials and components will contribute to the mitigation of the negative influence that the use of high impact construction materials currently have on the environment.

Affordable alternatives can be found in semi-processed materials, (table 6) and blended or composite materials can also be considered (for example bitumen reinforced earth blocks, called 'Betablocks'). The application of useable second-hand materials or components like used door and window frames and roofing sheets, should be promoted. Recycled materials like aggregate from recycled concrete and paper/cellulose based ceilings needs considering. It also makes economical sense to make use of locally procured materials, which will add minimal distribution energy consumption and in this way lower building costs.

6. Conclusion

To attain sustainability, planners will have to shift their focus to the establishment of self-supporting settlements in their quest to build permanent housing for squatter communities. In urban context, the benefits will be health, (adequate sanitation, clean water and access to health care), safety (secure living environment and reduced exposure to natural disasters) and the eventual edification of the urban environment. It should be possible to attain this goal using vernacular building techniques, local skills and appropriate, comprehensive education programmes.

These education programs need to disseminate information on topics like alternative energy, building materials and maintenance to future homeowners. It is also crucial to explain the government's housing subsidy system in detail to the aspiring homeowners before starting the building process. For projects to succeed, it is imperative that household energy awareness campaigns will be instated. The promotion on the use of low-impact and re-used or recycled building materials, as well as alternative sanitation systems will also be useful at this level.

It is necessary to gain the enthusiasm and co-operation of the communities that are to be developed into sustainable villages. The benefits of waste management and the possibility of starting recycling projects should be explained and explored. Enthusiasm for a local permaculture project will also have to be kindled by the per-

sons commissioned to educate the homeowners. Procedures and techniques used in the eventual building process will have to be plain enough to be understood and maintained by communities that are mostly without formal education.

A productive life with access to livelihood and education for all will hopefully be the result.

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