Enhancing Crop Production in Zimbabwe Through the use of Information and Communication Technology

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Abstract
Agriculture forms the backbone of Zimbabwe's economy and accounts for 17% of the GDP. Agricultural production is ideally considered to be the gate-pass to food security .The National Information and Communications policy encourages the adoption and use of Information and communications Technologies as a way of contributing directly to food security at national and household levels. In this paper we demonstrate how crop production can be enhanced through the use of Information and communication using a prototype web based crop information system which implores internet web technologies to deliver information and services to users. The web based information system empowers the resource poor farmers with up to date knowledge and information on crops and their varieties to be produced in each of the five farming regions by farmers. The system also provides information about agricultural technologies for crop improvement, pest control, soil and climatic requirements, best practices, markets, sources of finance and related inputs. The system thus improves the competency of the farmer by speeding up the circulation of agricultural information, affording easy access to systems of technology by the farmer, production efficiency resulting in a quality crop as well as access to national and international markets. The system is easily affordable to both the large and small scale farmer

Introduction

Agriculture forms the backbone of Zimbabwe's economy and accounts for 17% of the GDP [7].A major challenge to the farmers both commercial and small holders is that of lack resources when it comes to the production of food crops[4]. The government has through the National Information and Communications policy [15][17] encouraged the adoption and use of information and communications technologies as a way of contributing directly to food security at national and household levels. In this paper we demonstrate how crop production can be enhanced through the use of Information and communication technology using web based crop information system[16] which implores internet web technologies to deliver information and services to users. The web based information system provides information about technologies for crop improvement, pest control, soil and climatic requirements, best practices, markets, sources of finance. The system is serves also serves as a decision support tool for the farmers. The rest of the paper is follows section 2 gives an overview of the theoretical background of crop production in Zimbabwe, section 3 deals with the methodology and section 4 presents the design of the web based crop information system, section 5 shows the implementation and finally section is a Discussion.

Background

Agricultural production is ideally considered to be the gate-pass to food security [2], but this has not been the case due to a series of challenges such as low produce, pre-harvest losses, climate changes, disasters and poor information and knowledge links [11]. The Food and Agricultural organisation sites have used ICTS by installing agricultural information systems such as Food security statistics [9], Famine early warning systems [8], Global information and early warning system [10], Agricultural knowledge and information systems for rural development [1], farmer information and network for agricultural and rural development [3]. In Zimbabwe agricultural information has been made available through the Agricultural research extension services (AREX) which falls under the Ministry of Agriculture, Mechanisation and Irrigation Development[14][13] .Arex provides professional agricultural services, research, extension and farmer training, advisory and technical support to farmers. Arex is also involved in agricultural information production, analysis and promotion. The shortage of manpower, transport and a constrained budget has been the main challenges that have hampered Arex. The government of the day has tried to go round this challenge by trying to provide the bulk of agricultural information through print and electronic media. This has had its own pitfalls as it has proved difficult to reach the majority of rural farmers who have no access to both radio and television transmission.

The government of Zimbabwe has also embarked on some ICT driven projects to promote agriculture such as Zarnet [12] which is an initiative of the research council of Zimbabwe. A local company has developed a software package e-Hurudza [6] to help support government's agrarian reform. This software package provides agricultural information for all regions, tutorial on how to grow crops, planting methods, information on inputs, farm equipment and is also concerned with livestock.

Methodology

The incremental model was adopted because of its advantages such as report back facility, resource management and early functionality. For the documentation and representation of the system the unified modelling language was used. The proposed system is then developed using PHP which is a server-side scripting language that can be used on a host of web platforms and HTML.A database server is developed using MySQL and Apache is used for the web server. The data used to design the information system was obtained through interviews granted by the Ministry of Agriculture, Mechanisation and Irrigation and staff at the Matopo research centre. The questionnaire contained information such as farm locations, sources of information and crops grown.

Design

We propose a web based crop information system which comprises of the following basic elements, a database, and a user interface. We begin our design process by presenting a sequence diagram of the overall web based crop information system in figure 1 followed by that of a Database which is the heart of the system in figure 2.(Application software, Database, hardware). The sequence diagram of the proposed information system is a kind of interaction diagram that shows how processes operate with one another and in what order.

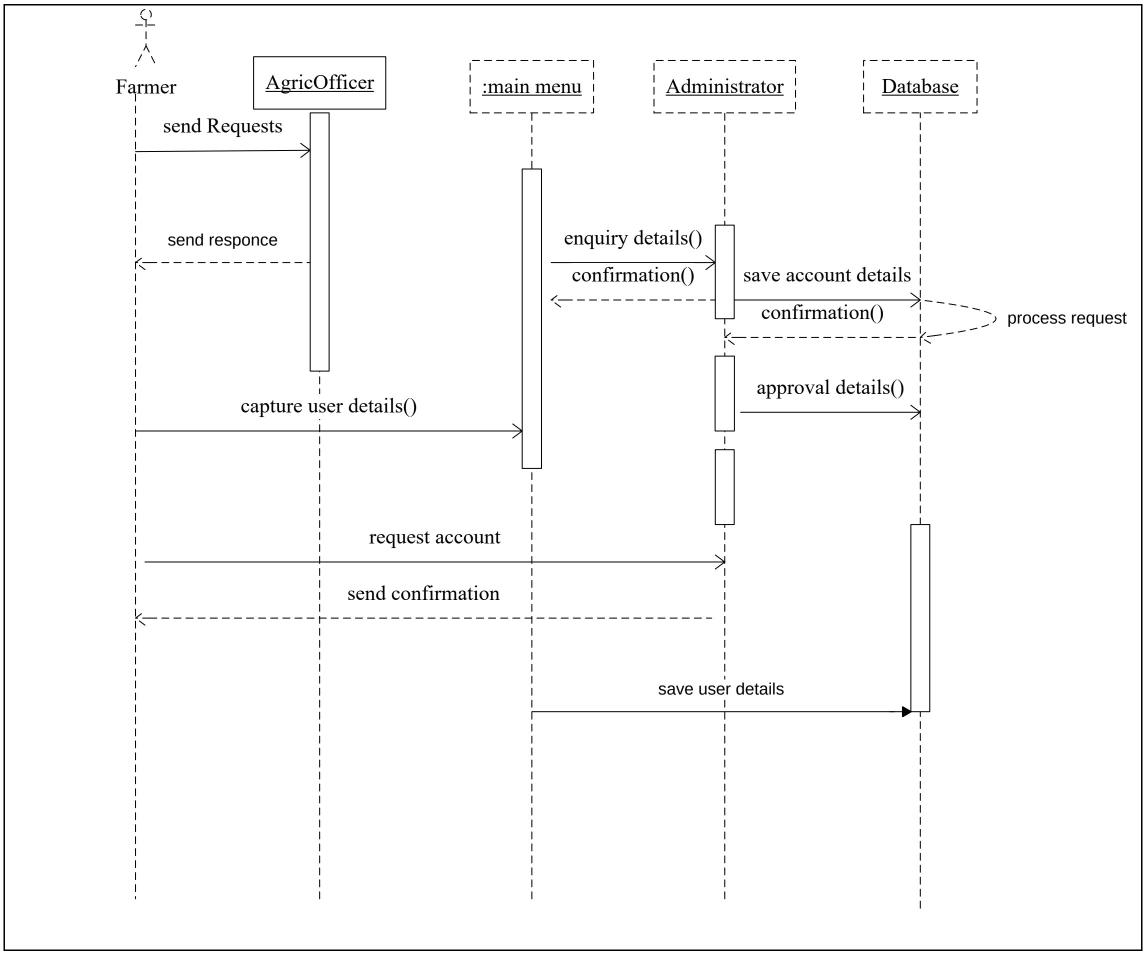

Figure 1: Proposed Information System

It also shows how the system is triggered and what iniates activity in the system, the type of processing and the changes that occur as well as the outputs produced at the end of the system. The system comprises the farmer who is the targeted user, the main menu which is also the user interface that allows the user to interact with the system database. The system database is depicted in figure 2 and contains the following tables

- **Login table**- holds details about the system users, their username and passwords and access level. This table is accessed every time a user logs or attempts to log on. All this information is encrypted.
- **Details table** contains the detailed information about the system users, who happen to be the farmers and agric officers
- **Crops table** contains crop information and their characteristics, regions where they are grown, their pests and their diseases.
- **Crop variety table** records all the crop varieties of the selected crops and their characteristics, soil type and region names
- **Region table** holds details about all the regions in Zimbabwe and their characteristics, cities, provinces and farming systems found in each region

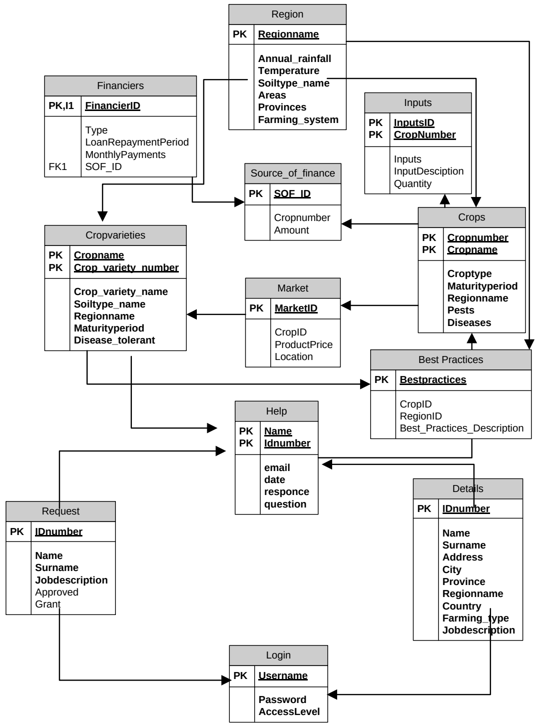

Figure 2: Proposed Database

Implementation

The prototype system has been designed and is ready for implementation. The following are presented as case scenarios in the testing of the system.

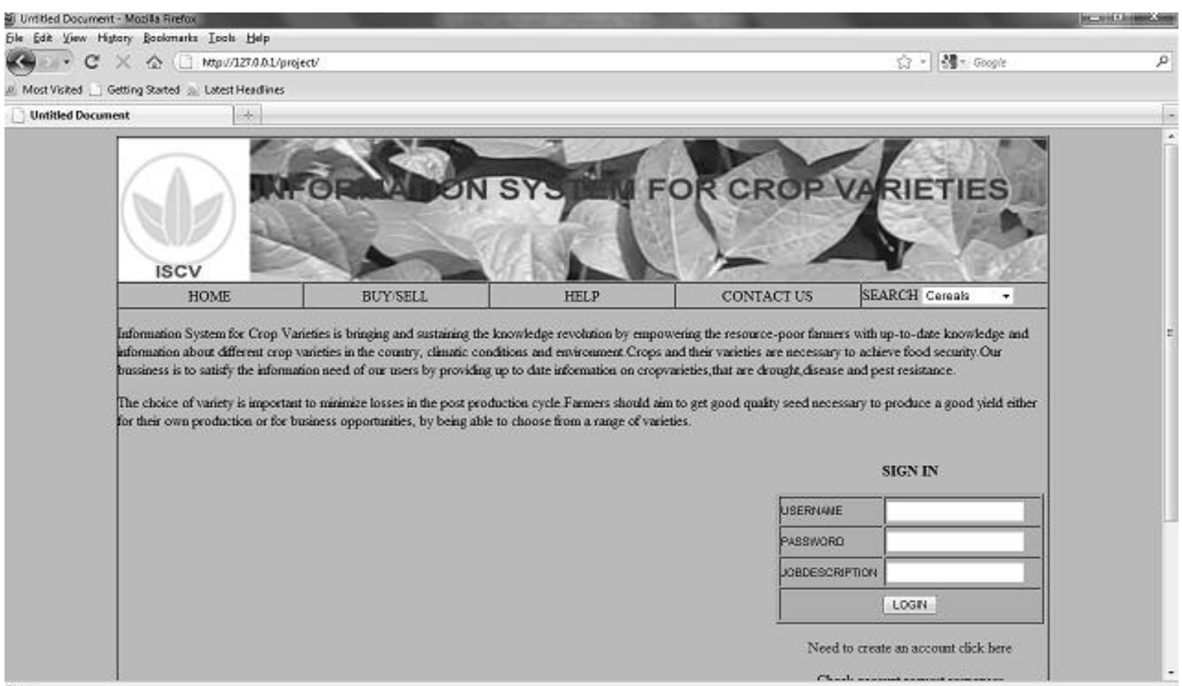

Figure 3: Home page

Figure 2 shows the screen shot for the home page of the web based crop information system. A registered user can sign in. The user is at this stage able to view information on where they can either buy or sell the produce and inputs. They are also a search facility for searching other related information. The system also provides information on crops which have been classified as cereals, legumes, oilseed and others. Particular choices of crop will advice the user on the best area in terms of the region to grow the crop as well as the associated conditions in that particular region.

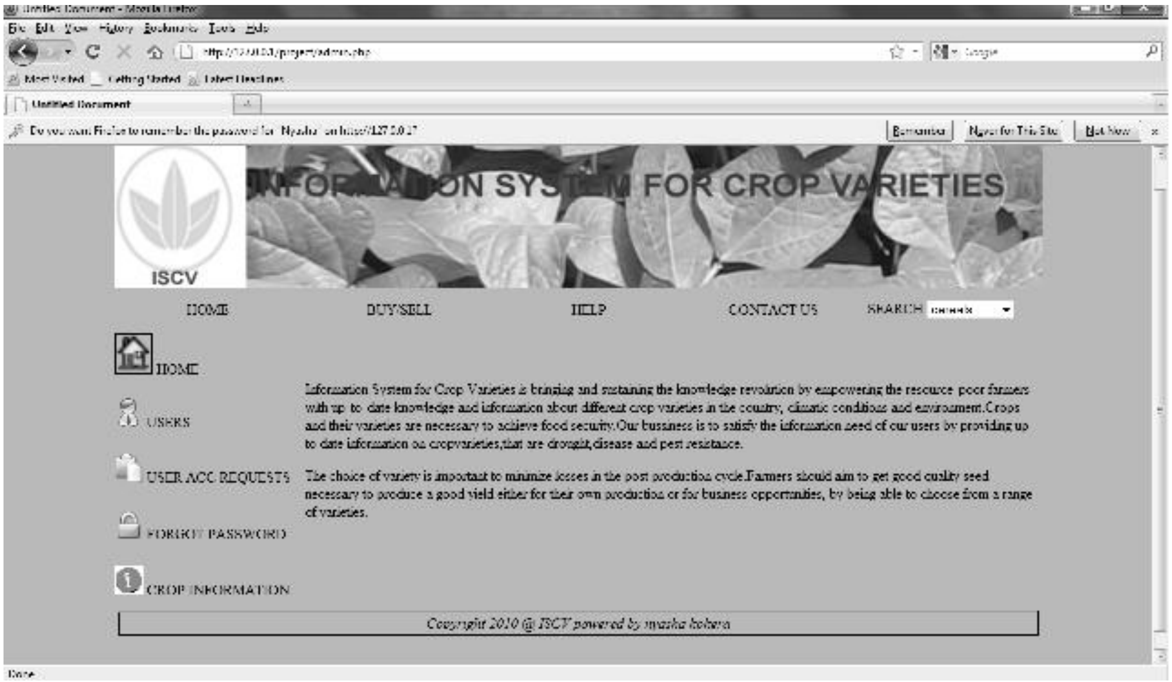

Figure 4: screen shot for farmer's home page

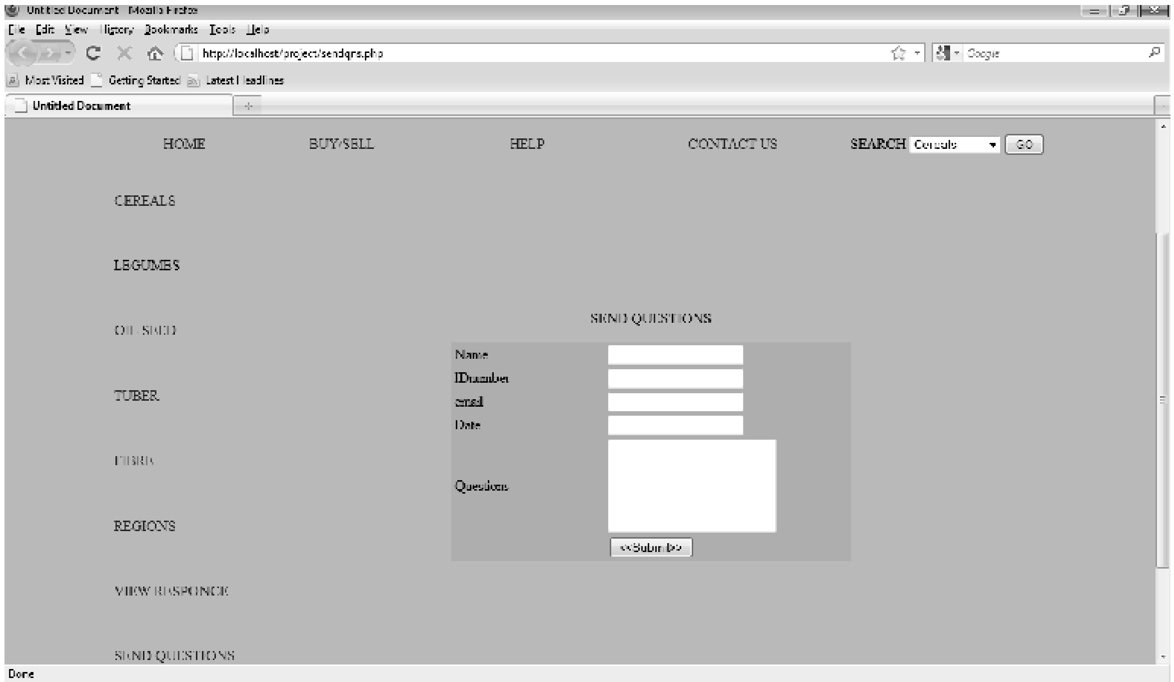

Figure 5: Interactive page (posting questions)

The system is also interactive meaning farmers are able to post questions on the web as shown in figure 5.

Conclusion

The use of Information and communications technology in farming improves the competency of the farmer by speeding up the circulation of agricultural information especially with the deployment web based crop information system. The availability and exchange of information also leads to increased production efficiency as farmers are exposed to information on the high yielding varieties, sources of inputs, finance improved management practices, pest management crop health, crop diversification and adoption of integrated crop production technologies. The system also exposes and gives the farmer access to national and international markets as well as easy access to the systems of technology. The web based crop variety information system is also easily affordable to the both the large and small scale farmer as it is not expensive to access the web. Crop production is challenged by factors such as lack of infrastructure and power supply in some remote parts, population growth and land scarcity, Global warming and sea level rise which may still threaten food security

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Potentialities of contemporary earth construction addressing urban housing crisis in Africa – A lesson from Zimbabwe

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Key words: housing crisis, earth construction, appropriate technology, urban.

Abstract

Several studies have shown that contemporary earth construction has the potentials to address the urban housing crisis in the developing countries. On the other hand there is a wrong perception among the users and the professionals that, „earth houses are only used by the poor people‟. In this regard political support would help to overcome people‟s wrong perception, citing the example of existing earth houses in Africa. This paper identifies and discusses the potentialities of contemporary earth construction to address urban housing crisis in Africa in the light of the successful examples.

Introduction

Hundreds of millions of people in the world today live in poor housing under adverse climatic conditions that stress their undernourished bodies toward the limits of human endurance and occasionally beyond (Shearer, 1986). There is an urban housing crisis in most of the developing countries and this is largely attributed by the rapid urbanisation (Dwyer et al, 1981, 33). According to Kamete (2006), the housing crisis is often sold and pushed onto the agenda in pre-dominantly quantitative terms and the mismatch between supply and demand is perhaps the scariest indicator used by proponents of increased housing delivery. The majority of the urban local authorities and central governments did and do not have a tradition of providing shelter to a large permanent population; there has been a lag of supply to demand of urban housing (Zami and Lee, 2007). According to UN Habitat (1996), housing shortage in African cities ranges from 33% to 90%. To meet housing needs, many people have resorted to renting backyard shacks and squatting on illegal land. According to the South African census report of 1996, 1,049,686 households lived in informal dwellings. People reside in squatter settlements, where there are no provisions for social services and utilities. UN Habitat (1996) also estimates that approximately 60% of the African population resides in shantytowns, slums and uncontrolled settlements. The unprecedented boom in the construction industry since independence resulted in the high demand of building materials that superseded the production capacity of the manufacturing sector in most of the African countries (Zami and Lee, 2008). A house is composed of several materials such as brick, cement, timber, window frames and several other building materials and the use of bricks as a standard building material began in the early 1900s in most of the African countries. Brick, cement, sand and timber are the major construction materials in Africa up to date which is unaffordable nowadays and an appropriate building material and construction technique needs to devise to solve the urban housing crisis. For example, „earth‟ can be used as an appropriate construction material in Africa. The aim of this paper is to evaluate earth as an affordable alternative material to housing in such a way, that if compared to established materials, it should prove to be an ideal alternative. The experiences and example of practice of using the earth construction will be borrowed from other societies and countries and demonstrate the dynamism of the material and construction in Africa.

Historical background of earth as a construction material in Africa

It is essential to look at historical evidence of the success of earth construction. It is currently estimated that over one third (Dethier, 1981) to over one half (Smith and Austin, 1989) of the world‟s population lives in some type of earthen dwelling. The history of earth building lacks documentation, because it has not been highly regarded compared to stone and wood (Houben and Guillaud, 1989, p8). There are cities built of raw earth, such as: - Catal Hunyuk in Turkey; Harappa and Mohenjo-Daro in Pakistan; Akhlet-Aton in Egypt; Babylon in Iraq; (Easton, 1998, p3). "*30% of the world‟s population, or nearly 1,500,000,000 people, live in a home built in unbaked earth. Roughly 50% of the population of developing countries, the majority of rural populations, and at least 20% of urban and suburban populations live in earth homes*" (Houben and Guillaud, 1989, p6). Figure 1 illustrates the world geographic locations of where earth structures are used and Figure 2 shows the spread of different kinds of earth structure being used by different regions of the world.

Figure 1
Geographic locations of earth structure.
Source: Houben and Guillaud, 1989, p6.

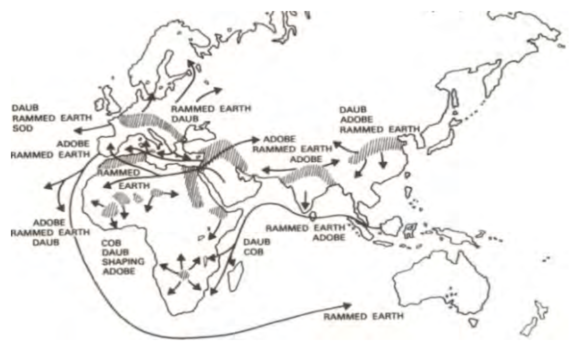

Figure 2
Different forms of earth structure being used by different region of the world.
Source: Houben and Guillaud, 1989, p12.

In Africa, the Egyptian civilisation provides abundant evidence of the use of earth in building as found in the early human settlements at the Merimd and Fayum sites in the Nile delta, which dates from the fifth millennia before Christ. The dominance of the Egyptian dynasty promoted buildings of prestigious structures made of brick from the Nile clay, desert sand and straw from the grain fields. These bricks were made by hand and dried in the sun before the development of the mould. The excavation at Saggarah and Bbydos show the use of bricks which were covered by stone. The art of brick vaulting was also developed in the lower Nubia, between Luxor and Aswan (Rastorfer, 1985, 32).

The Egyptian architect, Hassan Fathy devoted himself to housing the poor in developing nations. According to Iskander (2005), Fathy aimed to create affordable and liveable spaces suitable to the surrounding environment, thus improving the economy and the standard of living in rural areas. His buildings were surprisingly inexpensive. He encouraged local materials and saw a more appropriate method of building in the Vernacular Architecture of the Nubians (region of southern Egypt). Nubian craftsmen were masters at constructing domed and vaulted roofs of mud brick which they also used for the walls. While implementing the Nubian building techniques, he aimed to train Egyptian craftsmen to build their houses using mud brick or Adobe, which was ideally suited to the local conditions of Upper Egypt (Serageldin et al, 1985). In eastern Africa, movements by the Indian Ocean, the migrating Kushites and the influence of the Axum Kingdom (3rd to 8th BC) from Nubia as far back as Kenya have spread the use of sun dried bricks. As a result there was a great change in the architecture of the surroundings with the introduction of mosques. These were mainly built of earth using local expertise. In Zimbabwe, building in earth dates back as far as the 12th century when Great Zimbabwe was built and earth has been used progressively mainly in the rural areas (Mubaiwa, 2002, p10). Existing urban structures of earth can be seen mainly in the houses of the Crainbone suburb of Harare and in Bulawayo‟s Sourcetown suburb.

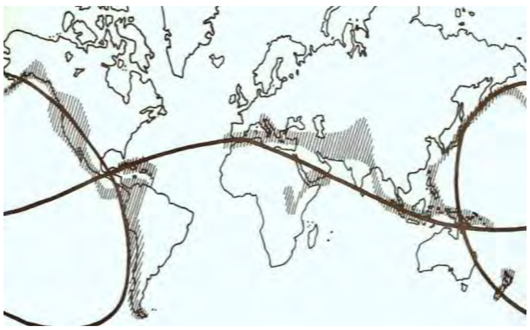

Figure 3
Seismic regions of the world.
Source: Houben and Guillaud, 1989, 306.

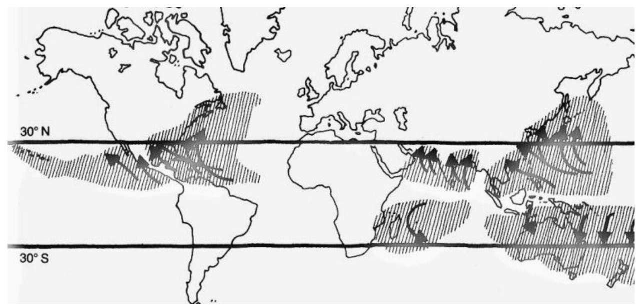

Figure 4
Storm regions of the world.
Source: Houben and Guillaud, 1989, 320.

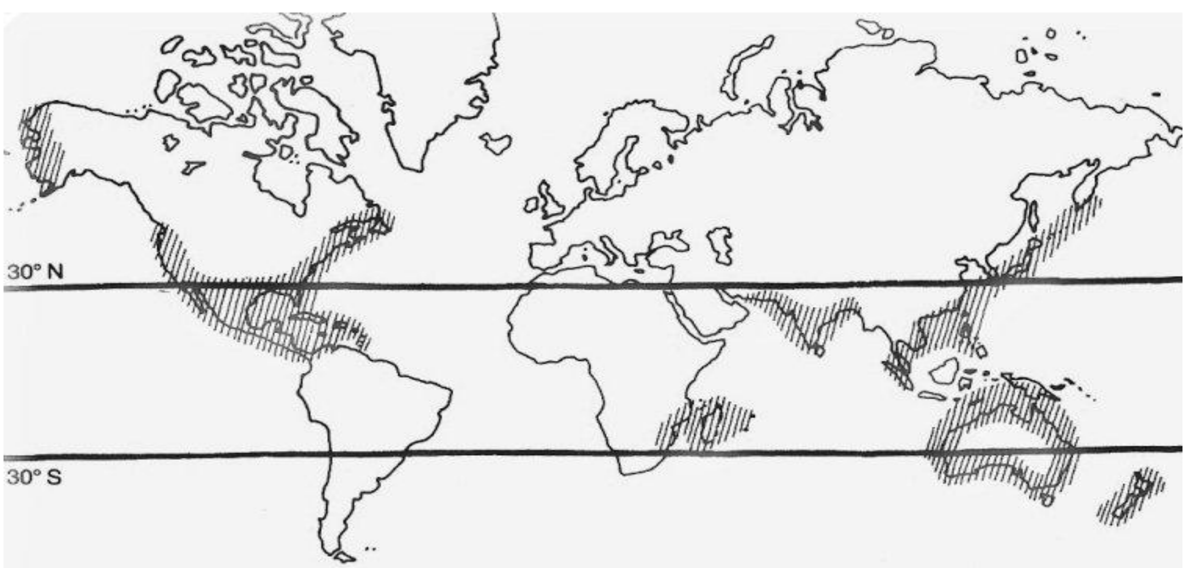

Figure 5
Flood regions of the world. Source: Houben and Guillaud, 1989, 324.

According to Denyer (1978), *"earth architecture should not of course be considered a miraculous solution to neither all our housing problems, nor one which can be applied successfully anywhere, everywhere."* Before any building is constructed with earth, it is essential to identify the soil to be used. The identification process involves various tests, which need the use of a laboratory. Apart from the laboratory identification process, local knowledge of the soil and traditional skills are necessary. In Africa, suitable soil is found in most of the countries. According to Houben and Guillaud (1989, p305), in 1976 alone seismic activity in the Philippines, Indonesia, Turkey, Italy and China caused the loss of more than 500,000 lives. Figure 3 shows the seismic areas of the world; most of the countries in Africa are not within seismic area. Figure 4 shows storm regions of the world and the whole of Africa is almost out of storm area except Madagascar. Flood is another form of natural disaster which causes many deaths. Figure 5 shows the flood areas of the world in which it is very clear that Africa is less affected by flood. So, from the above discussion it can be posit that earth construction is safe in terms of natural disasters in majority countries in Africa.

The benefits of earth construction

The advantages of a mastery of earth construction are multiple and complementary and are as follows summarized in Table 1: -

Benefits	Author
1. Earth construction is economically beneficial.	Lal, 1995; Easton, 1998; Minke, 2006; Zami and Lee, 2007; Morton, 2007; Kateregga et al, 1983; Cassell, 1993; Walker et al, 2005; Hadjri et al, 2007; Morris and Booysen, 2000; Adam and Agib, 2001, p11; Maini, 2005;
2. It requires simple tools and less skilled labour.	Kateregga, 1983; Easton, 1998; Minke, 2006, p15; Hadjri et al, 2007; Morris and Booysen, 2000; Adam and Agib, 2001, p11; Maini, 2005;
3. It encourages self-help construction.	Kateregga, 1983; Minke, 2006, p15;
4. Suitable for very strong and secured structure.	Lal, 1995, p119; Houben & Guillaud, 1989; Walker et al, 2005;
5. It saves energy (low embodied energy).	Morton, 2007; Lal, 1995, p119; Minke, 2006; Hadjri et al, 2007; Adam and Agib, 2001, p11; Maini, 2005;
6. It balances and improves indoor air humidity and temperature.	Cassell, 1993; Howieson, 2005; Alphonse et al, 1985; Minke, 2006; Kateregga et al, 1983; Lal (1995, p119); Walker et al, 2005; Hadjri et al, 2007; Adam and Agib, 2001, p11;
7. Earth is very good in fire resistance.	Alphonse et al, 1985; Walker et al, 2005, p43; Hadjri et al, 2007; Adam and Agib, 2001, p11;
8. Earth construction is regarded as a job creation opportunity.	Adam and Agib, 2001, p11;
9. Earth construction is environmentally sustainable.	Minke, 2006; Easton, 1998; Walker et al, 2005; Hadjri et al, 2007; Adam and Agib, 2001, p11; Maini, 2005; Ngowai, 2000.
10. Loam preserves timber and other organic materials.	Minke, 2006, p15.
11. Earth walls (loam) absorb pollutants.	Cassell, 1993; Minke, 2006;

12. Easy to design with and high aesthetical value.	Morton, 2007; Houben and Guillaud, 1989; Walker et al, 2005; Hadjri et al, 2007.
13. Earth buildings provide better noise control.	Kateregga, 1983; Alphonse et al, 1985; Hadjri et al, 2007;
14. Earth construction promotes local culture, heritage, and material.	Frescura, 1981.
15. Earth is available in large quantities in most regions.	Adam and Agib, 2001, p11; Easton, 1998; Lal, 1995; Hadjri et al, 2007; Morris and Booysen, 2000; Adam and Agib, 2001, p11;

Table 1
Bnefits of earth construction. Source: compiled by author, 2009.

The drawbacks of earth construction

The following are drawbacks of earth (un-stabilised) in building construction: -

Drawbacks	Authors
1. Less durable as a construction material compared to conventional materials.	Kateregga, 1983; Lal, 1995, p119; Cassell, 1993; Blondet & Aguilar, 2007; Maini, 2005; Morris and Booysen, 2000; Hadjri et al, 2007; Adam and Agib, 2001, p11; Minke, 2006; Walker et al, 2005, p13;
2. Earth construction is labour intensive.	Lal, 1995, p119; Cassell, 1993;
3. Mud houses behave poorly in the event of earthquakes.	Blondet and Aguilar, 2007;
4. Structural limitations.	Maini, 2005; Hadjri et al, 2007;
5. Need high maintenance.	Hadjri et al, 2007;
6. Professionals make less money from earth building projects.	Robinson, 1939.
7. Special skills needed for plastering.	Hadjri, et al, 2007
8. Loam is not a standardised building material.	Minke, 2006.
9. Need higher wall thickness.	Walker et al, 2005.
10. Suitable only for in situ construction.	Walker et al, 2005.

Table 2
Drawbacks of earth construction. Source: compiled by author, 2009.

Success of contemporary earth construction in Zimbabwe – a lesson for Africa

Initially Zimbabwean professionals did not recognise the use of earth for construction of „descent" shelter for the urban environment (Mubaiwa, 2002; Kannemeyer, 2006; Zami and Lee, 2007). The recognition of stabilised earth construction was expedited by the adoption of Zimbabwe Standard Code of Practice for RE structures which was first published in 1996 (Kannemeyer, 2006) and included in the Zimbabwe Model Building Bylaws in 2004. The In-situ

Rammed Earth Company (ISREC) founded by Mr. Rowland Keable who has over 15 years‟ experience working with RE in Africa, Australia and the UK, initiated the request to the Standards Association of Zimbabwe (SAZ) and was seconded by the then newly formed Scientific and Industrial Research and Development Council (SIRDC). Mr. Rowland Keable pioneered many RE projects in Zimbabwe; among them some of the first officially recognised in Zimbabwe since the country‟s independence and worked largely in conjunction with the SIRDC in the late 90s to revive RE construction in Zimbabwe.

The performance of experimental RE and CSEB construction in Zimbabwe is a great success to date (Mubaiwa, 2002; Kannemeyer, 2006). One of the first stabilised earth projects was the British government‟s Overseas Development Administration (ODA) funded, the DfID School block at the SIRDC centre, Hatcliffe, Harare, Zimbabwe. This project was mainly constructed to demonstrate that RE could successfully support a roof span of 8m whilst at the same time being a test bed for the publication of RE Structures: A Code of Practice. The building was inexpensive, and showed that wide span roofs are possible with the technology, important for classrooms and clinics. In the Hatcliffe building, concrete was used for the foundations. This house/classroom block built on SIRDC premises attests to the versatility of RE construction. The construction cost of this block was 60% cheaper than the traditional concrete brick and blocks construction. The ISREC also carried out a number of RE projects in the country among some of them were a private house in Bonda, Manicaland commissioned by pioneering passive solar architect Mick Pearce in 1997, Office and housing in Chimanda on the North East border with Mozambique (Zami, 2010).

SIRDC built a RE teacher‟s house at Rukanda Secondary School in Mutoko. The house‟s appearance is impressive. Costs incurred in building the two roomed Rukanda teacher‟s house shows that construction using RE and roofing with MCR (micro-concrete roofing) tiles resulted in a low cost of 18 million Zimbabwe dollars compared to $45 million when using conventional technologies. An important point to note is that a good part of the $18 million was used for peripheral expenses such as transport, accommodation and allowances of SIRDC technical staff who supervised the project. Besides making housing affordable to the majority of the population, these two SIRDC initiatives have the added advantage of employment creation amongst young people (the same as the Mutoko project).

The use of CSEB construction is fairly new in Zimbabwe (Zami, 2010). The Chitungwiza House is one of the few known buildings made of CSEB. This was a deviation from fired bricks or cement bricks/ blocks and asbestos roof used for most of the low income houses in Zimbabwe. This pilot project by the Intermediate Technology Group (ITG) was implemented with the participation of the Chitungwiza municipality in 1993 as a low income house. The aim of this project was to evaluate the response of the people towards earth structure and the performance of low tech and sustainable materials used in the construction of low cost housing. The use of local labour and the absence of imported materials sent a message to the local communities that the solution of affordable sustainable and low cost housing is possible. Until now this structure stands as a success to all participants working in the housing industry in Zimbabwe. Therefore, all the experimented low cost stabilised earth construction housing projects have been a success. Surprisingly stabilised earth construction technology has not been adopted to address the low cost housing crisis in Zimbabwe despite the fact that the experimental projects are successful

(Zami, 2010). Therefore, it is essential to investigate the factors influencing the widespread adoption of contemporary stabilised earth construction.

Conclusions

Earth is affordable and available and would be appropriate in the case of low cost house construction in Zimbabwe and as well as in many African countries. This paper has argued the promotion and implementation of earth as an alternative material is worthwhile. It is possible to use un-stabilised raw earth as rammed earth or compressed earth blocks; but the stabilised form is more suitable for the African situation in terms of by-laws and housing standards. The only challenge that prevents earth becoming the preferred choice of building material amongst the general population is the acceptability of this material by that same population. An awareness and understanding by people to environmental issues such as air pollution, deforestation, land degradation and energy conservation would help them change their attitudes and views towards earth building. The flexibility and simplicity in technology incorporated in earth building affords adaptability and easy transfer of knowledge between different stakeholders in the building industry. Individuals and community as a whole can easily participate in building their own homes in affordable ways.

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THE ROLE OF ADVANCED CONSTRUCTION TECHNOLOGIES IN PROMOTING SUSTAINABLE SHELTER, WATER AND DEVELOPMENT IN SOUTH AFRICA

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Advanced Construction Technologies, Next generation materials, Modular houses, Housing and Shelter, Water, Sanitation, Development, South Africa

Abstract
This paper presents a brief overview of the role and contribution of advanced construction technologies (hereafter ACTs) in promoting the provision of sustainable shelter, water and development in South Africa. South Africa faces acute shelter, water and sanitation challenges as a result of partly rural-to-urban migration, legacy of apartheid, geography and climatic zone. This paper traces the origin and development of ACTs, which is largely attributable to advances in material science, building components production and assembly technologies. In the process, issues are highlighted while potential solutions are discussed. The paper is evidence based making use of primary and secondary data/information examples of shelter and sanitation backlogs and challenges in areas such as Western Cape (Cape Town); Mpumalanga (Mbombela formerly Nelspruit), Province of the Eastern Cape (Buffalo city) and Limpopo Province (Capricorn & Vhembe District Municipality). The evidence is analyzed with ACT indicators taking into account the sustainable shelter and water sector requirements. The analysis is further situated within the overall context of desiring to promote sustainable and productive housing settlements that are a pleasure in which to live, recreate and produce in. The paper further argues and confirms that ongoing commercialization of ACTs technologies in the shelter and water sector will lead to a significant improvement in building performance, reduce environmental impact and provide a better framework for guiding the growth and development of sustainable human settlements. The next-generation of construction materials will most probably be mainly led by polymeric-fiber based products, light-metals alloys, with high performance with qualities such high tensile and compressive strengths.

INTRODUCTION AND BACKGROUND

About one billion people in the developing world (40 - 50 percent of the total world urban population) dwell in shacks or squatter camps. These settlements are generally defined as informal settlements or slums. In the Southern African Development Community (SADC) region

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alone, South Africa (SA) has an estimated informal settlement population of 4.5 million [4][7]. The South African government's housing statistics backlog is estimated at approximately 3 million [3][5][8]. As an example, the Eastern Cape Province (one of the ten provinces constituting South Africa) has an estimated backlog of about 800 000 units. In Cape Town (SA) informal settlements are growing at an estimated rate of approximately 10% each year [15].Contemporary water supply and sanitation in South Africa is still characterized by both achievements and challenges since the advent of democracy in 1994. In 1994, about 15 million people were estimated to be without access to safe drinking water and at least 20 million were without adequate sanitation services [8]. South Africa is one of the few countries in the world that formally recognize water as a human right. The country has established a national water and sanitation program, which is undergirded by the following principles and values, namely rights based water supply and provision philosophy, basic needs provision and delivery of sanitation services pathway approach and public-private partnerships in South Africa . While encouraging evaluations that point to improvements in housing, water and sanitation in South Africa since 1994 exist, the major headline issue remains the backlogs and service gaps that still need attention [8, 18].

Purpose of the Paper

This paper presents a brief overview of the role and contribution of advanced construction technologies (ACTs) in promoting the provision of sustainable shelter, water and development in South Africa. The paper's departure point is that the demand for innovative and appropriate construction technologies for shelter, sanitation and development places great responsibility on alternative shelter, water construction, service delivery and deployment technologies.

Linking Water and Sanitation Gaps with Housing Challenges

Sustainability challenges exists in present day SA regarding not only water and sanitation but also housing delivery, which are driven by economic, social and environmental factors as will be discussed in sections that follow.

Housing Backlog in South Africa

Housing backlog can be said to be higher than official count of 2.2 million due to increased inter-regional migration from neighboring Zimbabwe, Botswana, Angola, Mozambique, Zambia up to Nigeria, Kenya, India, Ethiopia and Somalia. Inadequate supply of low cost Reconstruction Development Programme (RDP) housing accompanied by poor service delivery is largely credited to the xenophobic attacks on foreign nationals experienced during the early periods of the year 2008. This resulted in huge internal population displacement of foreigners and long term effects much of which is still felt today.

Electricity Supply and Demand

Currently, SA and SADC regional countries have a huge energy supply side deficit in terms of electricity generation. In 2008 Electricity Supply (ESKOM) the SA power utility supply company introduced electricity load-shedding. Statistics for SA reveal that the country needs 41 539 mega watts (MW) of electricity by 2013. Renewable energy supply projections are estimated to provide 1 667 MW (4%) by 2013. About 44% of SA households do not use electricity for cooking but fossil fuels such as wood and about 20% of SA households do not use electricity for lighting [15].

Water Supply and Demand in South Africa (water stress)

South Africa is also experiencing water stress. The following quote illustrates this:

"Up to 1000 people from informal settlements in South Africa are estimated to be using contaminated water for domestic purposes. Greenbelts, dams, wetlands and a canal that hundreds of people in informal settlement use for washing, have been identified as radioactive or toxic, especially those located within 100 kilometers of South Africa's biggest cities such as Johannesburg, Tshwane (Pretoria), eThekwini (Durban) and Cape Town. Fifteen sites close to Johannesburg have been named in a 210-page report as being toxic. Some of these sites register a radiation levels above 200 times the legal limit. Long-term exposure to toxic chemicals and radioactivity has serious health side effects and may cause cancer (Source). However, the pollution could be far worse than the report suggests, and perhaps the document should be used as a basis for further studies." This is according to The Sunday Times, South Africa, 19 July, 2009 [8,18].

Global Warming Impacts on South Africa

Climate change causes less precipitation generally in some parts of SA but also increased rainfall with flash flood in some. Informal settlements especially along the coast e.g. in Cape Town suffer perennial flooding and destructions of their shacks. Other factors such as land distribution, legislation, standards and norms and political and economical instability in form of war, famine and flooding affect sustainability [12].

Table 1: Sample of Low Cost Technologies in Zimbabwe and SADC Region

SYSTEM	COMPOSITION	DIS/ADVANTAGES
1. Frametech	Gypsum panel boards	**Standards / Easy, fast construction**
2. Frametech	Concrete / Wire Mesh (durawall)	**Standards / Easy, fast construction**
3. Frametech	Wood panels	**Standards / Easy, fast construction**
4. Wood Cabins	Wood planks / boards	**Standards / Easy, fast construction**
5. SSB / CB	Earth cement / Earth	**Quality of product**
6. SFB	Earth, Agric waste, (Saw Dust, Bagasse, cement, Pozzolana)	**Quality / Easy, fast construction**
7. Rammed Earth	Earth / Cement	**Quality / Easy fast construction**
8. MCR Tiles	Cement, Sand, BFS	**Quality, Cheap**
9. Earth Domes / Vaults	Earth Bricks	**Quality, Climate Stability**
10. Reinforced Earth	Grass, Bamboo, Wood, Earth	**Standards, Easy, fast construction**
11. Concrete Blocks	**Cement, Sand, PFA**	**Quality / Easy, fast construction**

Source:[9][11][12]

Current ACTs Delivery Methodologies and Technologies

There are basically three different ways to classify building of houses including Toilets, namely: Conventional, Elemental or panel prefabrication, and Modular also known as volumetric units prefabrication. Table 1 that follows summarizes existing technologies in the SADC region with particular referencing to South Africa, which have to date, for a number of reasons have failed to adequately achieve desired housing delivery. These are mostly a mixture of the conventional/traditional and elemental prefabricated technologies. Industrial product driven technologies are less applied relative to distances from the cities or reliable trunk road networks.

Appropriate Sanitation Technologies
A range of toilet technology types are currently used in South Africa, including: buckets, chemical toilets, simple pit toilets, ventilated improved pit toilets – with the possible addition of micro-organisms to reduce cleaning frequency. On average VIP's are unsuitable in most parts of the major cities in South Africa due to the prevalence of generally high water tables. Consequently dehydrating and composting toilets, vacuum technology toilet systems, anaerobic toilets, aqua-privies, flush toilets with septic tanks, flush toilets with conservancy tanks, flush toilets with small bore solids free sewers, and flush toilets with full waterborne and central treatment works are the more popular option. Table 2 presents levels of service for sanitation, Mbombela (formerly Nelspruit).

Table 2: Levels of Service for Sanitation, Mbombela (Nelspruit) South Africa.

Sanitation Types	2004	2009
Connected to sewer	21,935	24,329
Septic Tank	500	500
VIP		2,325
Other, bucket	30,127	46,446

Source:[2]

It is however important to point out that the choice of technology is influenced by many factors, including the following criteria:

1. ***Affordability*** to the household.
2. ***Operation and maintenance*** (O&M) requirements. High service levels, such as flush toilets, have onerous and costly O&M requirements. Local community members can readily undertake maintenance of on-site toilets.
3. ***Sustainability***: The system should be manageable making use of the local community and be sustainable over the long-term. "The sustainability of a sanitation system is usually the most important consideration when selecting a specific technology option for a community. Sustainability not only refers to measures to minimize breakdowns and costs in the operation of a scheme, but also to measures taken to maximize its positive social impact while minimizing any negative environmental impacts."[8]
4. ***Anchoring healthy and sustainable communities*** in terms of overall improvements to health of community members in particular and the community health in general.

5. ***Sustainable environmental development and exploitation of resources.*** This can be measured in terms of the level of compliance with existing environmental protection regulations.
6. ***Inclusive small contractor empowerment and development programs***. This relates to the ability of community based contractors to implement water, sanitation and housing technology interventions for example. (Table 3 presents sanitation service levels for the city of Cape Town)

Table 3: Sanitation Service Level Categories for the City of Cape Town

Service Level Hierarchy	Observation and Comment
Inadequate	• No or limited access to sanitation • Residents share sanitation facilities with other residents, supplied at a basic or full level of supply • Residents self-provision of sanitation facilities – often through unhygienic means. • In many instances Residents are being serviced by the CCT through the weekly removal of 20 litres open stercus "black bucket" containers, a service to be replaced.
Essential	• Partial access to sanitation (more than 5 households per toilet), as dictated by site-specific constraints (e.g., high dwelling densities)
Basic	• The provision of a shared toilet (at a ratio of not more than 5 families per toilet) which is safe, reliable, environmentally sound, easy to keep clean, provides privacy and protection against the weather, well ventilated, keeps smells to a minimum and prevents the entry and exit of flies and other disease-carrying pests; and • The provision of appropriate health and hygiene education.
Full	• On-site Waterborne, Conservancy Tank or Suitable Waterless Technology

Source:[6]

STRUCTURE AND ORGANIZATION OF PAPER

The paper is organized in four sections. ***Section one*** has provided the introduction and problem setting. ***Section two*** explains the research methodology. ***Section three*** discusses the major issues regarding water and sanitation and advanced construction technology interventions interface. ***Section four*** is dedicated to the conclusion and recommendations emanating from this article.

RESEARCH METHODOLOGY

This paper draws heavily on creative secondary analysis of existing literature regarding water and sanitation, housing and advanced construction technology interventions in South Africa. In addition the authors draw from over fifty years experience shared working in the water, sanitation, and housing and construction industry in Europe, Asia, Latin America and Africa for different research and development institutions, universities, consultancies and engineering firms.

FINDINGS AND RESULTS OF SUSTAINABLE SHELTER, WATER AND DEVELOPMENT IN SOUTH AFRICA

The CSIR study spot check assessment report for the Department of Water Affairs and Forestry [8]carried out in the year 2007/8 compared study results with those of the pilot study in 2006/7. The rationale behind spot checks is that they are carried out randomly thereby assisting in validating and verifying existing programme /project data in order to promote lesson learning and assist in the identification of challenges and problem areas so as to provide timeous solutions and corrective measures and/or interventions. Some of the results and findings are summarized as follows.

Household water projects

The completed rural household water projects that were assessed are generally non-compliant to the water and sanitation programme specifications. A number of problem areas should be addressed to ensure higher compliance levels with technical design standards. These include water metering, leakages, the non-existence of tap mechanisms, poor piping, poor tap stands, and the many households that have not received any training in good water use or in the operation and maintenance of their taps. Using a scorecard scale rating scale technique with **A** being compliant and **F** being non-compliant, a **C** scorecard rating was achieved for this category. This evaluation technique is applied throughout the analysis of section 3.1 to 3.4 of this article. A positive finding is the lack of vandalism counter-balanced however, by a worrisome indicator in terms of the number of illegal connections that have been identified, perhaps evidence of the inadequate water and sanitation delivery in rural households. The incomplete rural household water projects that were assessed are generally partially noncompliant mainly due to problems with tanks, water meters and taps. Illegal connections are prevalent at 7% of projects even before the project has been completed and commissioned.

Bulk sanitation projects

Completed rural bulk sanitation projects that were assessed are generally partially noncompliant. Attention should be focused on a variety of aspects to improve the daily functioning and operation of treatment works, also ensuring the safety of personnel. A **B** scorecard rating category was attained. The incomplete rural bulk sanitation projects that were assessed are generally non-compliant. Though nearly a third of the projects were compliant in terms of health and safety, about a fifth is extremely non-compliant (**F**), suggesting urgent rehabilitation. All three types of treatment works scored low compliance ratings on their technical design standards, a major indication that intervention and restoration are needed, before projects are commissioned, to ensure future sustainability.

Household sanitation projects

The results highlight a range of components that are problematic (therefore the **C** rating of non-compliant) for the completed rural household sanitation projects that were assessed. Most critical is the lack of communication with the communities and beneficiaries on sanitation, hygiene and the operation and maintenance of their newly built toilets. A worrisome observation is the non-availability and non-use of hand washing facilities (soap and water) and also problems identified on technical design standards regarding the safety aspects of walls, roofs and floors, the accessibility of pits for cleaning purposes, the condition of vent pipes of VIP toilets, the installation of proper sewer systems and the maintenance of cisterns for flush toilets. The incomplete rural household sanitation projects that were assessed obtaining non-compliant **C** ratings mainly due to problems with the floors being lower than the surrounding ground, roofs with holes and not secured well, walls that are not durable, doors that are broken, damaged or cannot lock, poor quality pedestals and inadequate sewer systems for Flush toilet projects, as well as the pit lining and collar, the pedestals and the vent pipes of VIP toilets. Intervention, restoration and rehabilitation are widely needed to ensure the future sustainability and the physical safety of the beneficiaries before these projects are handed over to them.

Comparison of MIG-funded Water supply and Sanitation Projects

The Overall Compliance ratings for the MIG-funded rural water supply and sanitation projects that were assessed show no difference between the ratings for 2006/07 and 2007/08 when all MIG funded water and sanitation projects are grouped together - these projects generally remained within the partially non-compliant category (**B**) for both years [7].

CONCLUSION

This paper has confirmed that ACT has a role to play in improving housing, water and sanitation infrastructure and services especially with special emphasis in rural areas, peri-urban areas, and informal settlements. However for the full potential of ACT to be realized it is essential that research and development (R and D) support and funding be channeled in this important area.

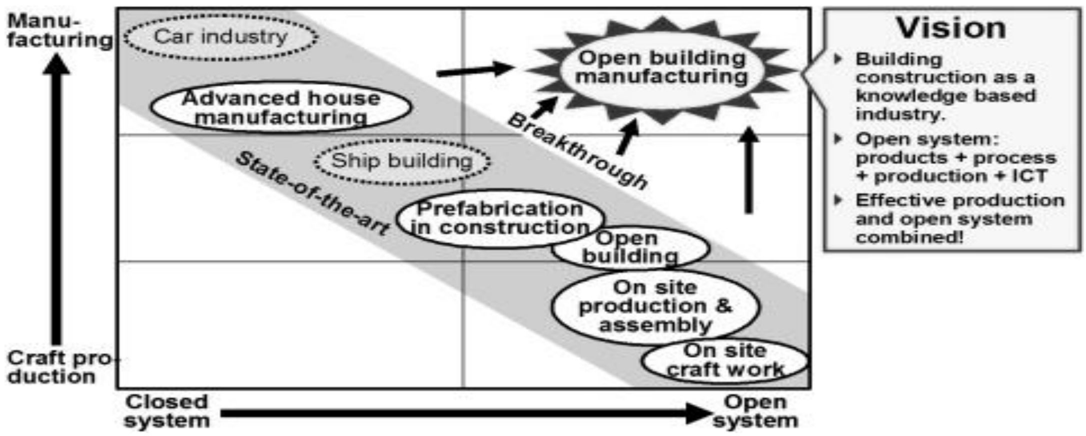
Recommendations on contribution and application of ACTs: Some perspectives

Emanating from this review, the major recommendations regarding tackling the headline issues in the water, sanitation, and housing and construction industry include some of the under-listed.

Simulation and prospecting on the next-generation of construction materials that can be used in addressing the water, sanitation and housing infrastructure backlogs in South Africa point in the direction that this will most probably be mainly led by polymeric-fiber based products, light-metals alloys, with high performance with qualities such as high tensile and compressive strengths.

The learning outcomes of the demonstration projects and trial houses at test sites in South Africa such as the CSIR should be keenly investigated with a view to incorporating the outcomes for rolling out of the successful ACT model in the country. The existing ACTs Strategy for SA leans on the ECT (European Construction Technology) and is carried under the ACTP (European Construction Technology Platform) a national project under CSIR since 2007. Various technologies are conceptualized, adopted and tests within the ACTP laboratory are shown in Figure 1.

Figure 1: Open Building Manufacturing, ACT for SA



Sources: [1][15][16]

The spirit and purpose of the ACT Vision should be continuously promoted and perhaps seriously jealously guarded if greater impact and influence is to be realised from this discipline for enhanced construction outcomes. This vision is reconfirmed because of its importance in the wider debate of alternative building materials and technologies to address the construction industry challenges. The vision is to create “A future where customers will be able to purchase high quality manufactured buildings having a high degree of design flexibility and at low cost compared to today” Current Material Research Areas being carried out focus on advanced light metals, thin concrete and fibre composites using advanced production technologies, logistics, LCA and ICT. Funding and support for the continuous development and improvement of these areas remains a continuing challenge and lasting requirement.

This paper’s review has further confirmed and corroborated results of surveys, assessments by many organizations in SA which have indicated that the current approach or methodology is insufficient to remove the housing, water and sanitation backlog, leading to sustainable development. Current methods of construction of both entities until now are not conceptualized in such ways as to ensure quality, safety and rigid structures which will be easy to maintain. Commercialization of ACT technologies for shelter and water offer not only a missing link but is perhaps the ultimate solution, albeit under current conditions.

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