Infrastructural Development using Stabilized Soil Blocks as a Tool for Climate Change Mitigation and Sustainable Development in Malawi

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ABSTRACT --- *Malawi has embarked on an economic growth strategy in order to meet the Millennium Development Goals by year 2015.In its strategic plans; infrastructure development has been marked as one important factor for achievement of the stated goals (MGDS II). However, Malawi's continued use of burnt bricks (BBs) as the mains material for the development of infrastructure for schools, health and other amenities, which enhances unsustainable consumption of natural resources, has been a cause for concern for the Ministry of Environment and Climate Change This paper therefore, examines the possibility of Stabilized Soil Blocks (SSBs) as alternative building materials towards mitigating climate change impacts The study was conducted in seven nursing colleges under Christian Association of Malawi (CHAM) where construction was done using SSBs. Data for the study was collected through questionnaire, interviews, calculations, measurements, reference and inferences during desk reviews and interaction with various stakeholders.*

The findings of the study show that SSBs have a higher advantage over burnt bricks as regards environmental management. Stabilized soil blocks do not use any firewood in the production process and therefore has 100% potential of avoiding deforestation and CO_2 emissions into the atmosphere. This leads to protection of the Ozone layer for better earth life support systems and promotes regeneration of the natural environments. The findings also show that SSBs have a double economical efficiency over the burnt bricks for their regular sizes and shapes unlike burnt bricks that come in different sizes, shapes and quality that result in uncontrolled breakages. SSBs also contribute to social aspects regarding safety, improved accessibility, and aesthetics of the environment. Subsequently, the paper recommends that Ministry of Environment and Climate Change should consider adopting SSBs as an alternative material for future infrastructure development in Malawi to reduce negative environmental impact through carbon emission and attain sustainable development

Keywords--- Stabilized soil blocks, burnt bricks, climate change mitigation, sustainable development

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1. INTRODUCTION

Malawi is one of the developing countries that have embarked on an extensive infrastructure development for health, education, agriculture and transportation as key priority areas for economic growth (MDGs 2011-2016 II). High dependence on natural resource base for social security, economic gains and energy for domestic and industrial consumption has increased pressure on the natural environment that is contributing towards climate change through increase in Green House Gases(GHGs) in the atmosphere and subsequently leading to unsustainable development in Malawi (UNEP,2011). .

Use of Stabilized Soil Blocks (SSBs) for infrastructure development especially for health and education structures funded by International Community has come into the lime light in Malawi as a way of mitigating climate change effects for sustainable development through environmental, social and economic benefits to the Malawi Nation. However, the uptake of this technology still remains low due to other factors. Literature review show that SSBs are an environmentally friendly construction materials compared to locally burnt bricks that uses fire wood to strengthen and toughen the bricks hence promotes the emission of GHGs into the atmosphere which is detrimental to the biosphere. However, efforts by government, environmental watch dogs and civil society have not been effective to influence society to adopt sustainable technologies for construction due to lack of resources, knowledge, and capacity, skills, competences and policy framework

Department for International Development(DFID) initiated the use of SSBs for infrastructure for primary schools and health centers in 2003 as the sure way of protecting the natural and exotic forests from additional pressure due to the increase in population of the country and high dependence on biomass for both industrial and domestic energy supplies

Construction of health, education and other private/public institutions has been using ordinary burnt bricks which use fire wood as its primary source of energy leading to a high degree of deforestation, emission of green House Gases into the atmosphere and unsustainable land utilization (UNEP, 2011). The problem has been worsened by poor agricultural practices, charcoal burning, bush fires, flue cured tobacco and biomass use for domestic and industrial activities (UNEP, 2011). Despite, the adverse impact of infrastructure development using burnt bricks on the environment and sustainability in Malawi, the impact has not been quantified. Government continues with the approval of both private and public projects in burnt bricks as the major walling material.

Therefore this paper focuses on the comparative advantages of SSBs over BBs in respect of environmental, social and economic aspects which are the three main pillars of sustainability (Brandt Report). The paper also addresses the contribution of the Stabilized Soil Blocks technology towards climate change mitigation and sustainable development in Malawi. The results are useful in linkage of the SSB technology to the carbon trade market as a way of climate change mitigation. The paper will investigate how much the Stabilized Soil Blocks(SSBs) contribute to the reduction of GHG emissions into the atmosphere and reduce risks of climate change effects in Malawi that are associated with drought, diseases, extreme weather, floods and environmental degradation in line with MDGs 7&8. Further, the study will establish a ratio difference between use of SSBs and burnt bricks which will be used for determining both social and economic benefits associated with technology in line with the Malawi Development Goal Strategy (MDGS 2006-2011 Theme 3, sub themes 1, 3&4). This cost comparison will aid public, corporate and private entities in decision making in terms of choice of technology (SSB vs. burnt bricks) to be used for their projects.

2. STABILIZED SOIL BLOCKS DESCRIPTION

Soil Stabilized Blocks are made from soils which are mixed with a small portion of cement in the ration of (1:14) one part cement to fourteen parts soil by volume. The blend is mixed manually or mechanically with right water content to obtain desired compressive strength of about $3.4N/m^2$ (MBS, 2008) .Then the mixture is compressed in a manual machine that is able to exert forces up to one tone to produce the block which is air dried and cured for at least 14 days by sprinkling water to gain strength making it ready for construction. SSBs have a comparative economical advantage over the burnt bricks due to its regular shape that facilitates the use of less mortar (Cement: Sand mix). SSBs technology uses only a single line of block for both exterior and interior walls of the building. This reduces the total number of SSBs requirement for the project. Further, use of soil (14 parts to 1 part cement as a stabilizer) makes it even cheaper with soils sourced within the construction site from pit and foundation excavations; therefore, the transport element that forms the most expensive part of the construction industry is eliminated right away. This reduces the potential emissions from exhaust engines, making SSBs even more comparable to burnt bricks.

SSBs are environmental friendly since they do not require forest products especially firewood for their production as is the case with burnt bricks but instead uses water for curing/spraying (Auroville, 1989). This is a critical aspect of sustainable development which preserves the natural environment through avoidance of deforestation. In that way protection of the ecosystems and biodiversity is enhanced. Again, SSBs are highly bio-degradable when demolished and disposed into the natural environment because the cement quantity is very small and the soil easily merges with the natural existing soil with similar properties while the burnt bricks are generally un-biodegradable since the soil properties are transformed completely through firing (Auroville, 1989).

However, a wide application of the SSB technology has been realized in the health sector funded by the Royal Norwegian Embassy through NCA to meet the reduction of child mortality rate and improve maternal health (MGD 4&5). Training colleges have been provided with hostels, class rooms, laboratories, libraries, administration blocks, tutors houses and kitchens to train more nurses and mid wifely technicians for the above purposes. In order to compliment the training to foster attraction of the well qualified nurses the project further constructed new maternity wards, staff houses, Outpatient departments, sanitary facilities in the rural set up to reach areas of Malawi where the illiteracy and poverty levels are high, with no or limited access to social services like hospitals, portable water and energy supplies which contribute to high child and maternal mortality rates.

However, lack of information in terms of documented evidence on the tangibility of such an impressive technology exists at an expense of the natural environment in which high dependency on biomass/charcoal for energy, agriculture for economic growth and natural resources for poverty reduction poises unprecedented challenge to the fight against climate change in many sub Saharan countries Africa (UNEP 2011)

Despite the notable positive environmental protection aspects presented by the SSB technology, so far no information from previous studies on cost comparison between SSBs and burnt bricks to justify the economic competitiveness of SSBs against burnt bricks. However, the effects of climate change in Malawi are very rampant and vividly recognized from the climatic condition shift such as rainfall patterns resulting into droughts and food insecurity, rising of temperatures and water tables resulting into loose of biodiversity and uncontrolled floods that displaced close to 30000 people in various parts of the county has been a new climatic twist in Malawi (Department of Disaster Preparedness 2012).Yet Malawi continues to implement burnt brick technology as its building materials at the expense of its natural resource base in which forests continue to be depleted, ecosystems affected, discharge of substantial volume of green house gases into the atmosphere which are detrimental to the environment and the biosphere, land misuse and water bodies continue to be polluted despite the development of the Climate Change and Legal Framework in Malawi(October 2011).

3. METHODOLOGY

The study aimed at analyzing and evaluating the extent by which the Stabilised Soil Blocks contributed towards the protection of the natural environment, analyzing and evaluating the cost comparativeness of Stabilized Soil Blocks and burnt bricks through costing of all materials necessary for the construction of one square meter of SSBs and burnt bricks and evaluating the extent to which the stabilized Soil block projects have enhanced the society's perception, acceptability, adaptability, accessibility and adoption for climate change mitigation and sustainable development.

Total number of SSBs and burnt bricks used from the site visit was established through a physical count of SSBs per square metre for three selected sites and the total number recorded. A calculated amount of square areas for all infrastructures constructed was done from the drawings obtained from the architect. The total SSBs used for the project was established using the total number of square meters obtained from the drawings and using the conversion rate obtained from the site. With this the study had established comparative amounts of both SSBs and burnt brick for the entire project

A cost effectiveness schedule of the SSBs as compared to burnt bricks was drawn up showing calculations of actual number of SSBs, burnt bricks, mortar, cost of labor and transportation developed from the standard drawings for several constructed structures. 7 nursing colleges were selected from a study population of 9 colleges because of existing for five years and having been funded. Interviews were conducted with the renowned architectural firms, the Assistant Chief Architect and senior architect in the department of buildings which is under the Ministry of Housing and Physical Planning to find out their possible role in advocating for SSBs for construction in Malawi

The study analyzed the amount of fuel wood usage from 5 kilns and obtained an average consumption rate (0.7 tons of fuel wood produces 1000bricks). The SSB/brick/firewood relationship so established as stated in the foregoing section was used to calculate an equivalent amount of CO_2 that could be emitted if the host adopted the use of burnt bricks (Carbon Offsets to Alleviate Poverty -COTAP). The quantitative data was analyzed through mathematical methods of calculation of areas, perimeters and physical counting of bricks that were verified against the standard specifications. The findings from calculations were compared against standard variables as stated in sections

A record of distances from where burnt bricks are sourced was done and average consumption rate for the transporting vehicles was established to find total fuel requirement for a specific amount of burnt bricks that have been transported. The total quantity of fuel was then converted into a Carbon equivalent at 0.5kg Co2/3.79 litres of diesel (COTAP).

4. RESULTS

4.1 Environmental Sustainability Results

The study results show that Stabilised Soil Blocks would be an influential building material for the attainment of sustainable natural resource consumption in the building industry in Malawi as indicated in Table 4.1 below. The tables presents the comparative analysis of total Stabilised Soil Blocks($3.46x10^6$ million) used on the entire project to an equivalent projected total amount of fuel wood($8303x10^3$ kg) that would have been used if Burnt Bricks were for the entire project. Figure 4.1 demonstrates visually the comparative analysis of total Burnt Bricks and an equivalent firewood requirement that has $8303x10^3$ Kg that has been foregone by using SSBs.

Table 4.1- Showing calculations for Total SSBs, Burnt Bricks, equivalent firewood and CO_2 Emissions

Description	**Total # bldgs**	**Total Dimensions**			**Perimeter 2(L+W)**	**Ht**	**Area (M^2)**	**Total Area SSBs**	**Total SSBs Used**	**Total Burnt Brick Equivalent**	**Total f/wood (Tons).**	**Total CO^2 kg**
		L	W	H								
Hostels	17	320	96	3	832.00	3	2496	42432	1,485,120	5,091,840	3,564	6,772
Staff houses	56	56.52	38.7	2.75	190.44	3	571.32	31993.92	1,119,787	3,839,270	2,687	5,106
Class room	23	25.2	16.2	2.75	82.80	3	248.4	5713.2	199,962	685,584	480	912
Libraries	8	77	27.6	3.	209.20	3	627.6	5020.8	175,728	602,496	422	801
Skills Lab	8	28.2	32.4	2.8	121.20	3	363.6	2908.8	101,808	349,056	244	464
Admin	7	140	52	2.75	384.00	3	1152	8064	282,240	967,680	677	1,287
Kitchen & dining	3	105.6	45	3	301.20	3	903.6	2710.8	94,878	325,296	228	433
Total								98,844	3,459,523	11,861,222.40	8,303	15,775.43

Note: 35 # SSBs were discovered to be average total per square instead of 126 as a standard.
: 118# Burnt bricks were instead of 120 bricks.
Source: Survey field data and Drawings extraction-Appendix 7.5)

Figure 4.2, shows the potential CO_2 equivalent that would be produced by the total amount of the burnt bricks used thus validating the concern by the Ministry of Environment and Climate Change (Catherine Gotani Hara, 2012) that the form of development strategy Malawi has embarked on leads to deforestation and carbon emissions into the atmosphere.

The results shows that SSBs have unprecedented potential of cutting down on CO_2 emissions into the atmosphere by 100% because (i) the production of SSBs does not depend on firing the blocks with fuel wood to gain strength but rather depends on water for curing (ii) SSBs are produced on site, hence the technology avoids emissions into the atmosphere from exhaust of transporting vehicles. Therefore, SSBs technology would contribute highly towards reduction on GHGs into the atmosphere for climate change mitigation.

Table 4.2. - Showing Fuel wood Requirement by Quantity and CO2 Emissions Equivalent

Building	**# SSBs**	**SSB wood requirement**	**#Burnt Bricks**	**Wood in Tonnes.**	**$CO_{2\ in}$ Tonnes**
Hostels	1,485,120.00	-	5091840	3,564	6,772.00
Staff houses	1,119,787.00	-	3839270	2,687	5,106.00
Class room	199,962.00	-	685584	480	912.00
Libraries	175,728.00	-	602496	422	801.00
Skills Lab	101,808.00	-	349056	244	464.00
Admin	282,240.00	-	967680	677	1,287.00
Kitchen	94,878.00	-	325296	228	433.00
Grand Totals	3,459,523.00	0	11,861,222.00	8,303	15,775.00

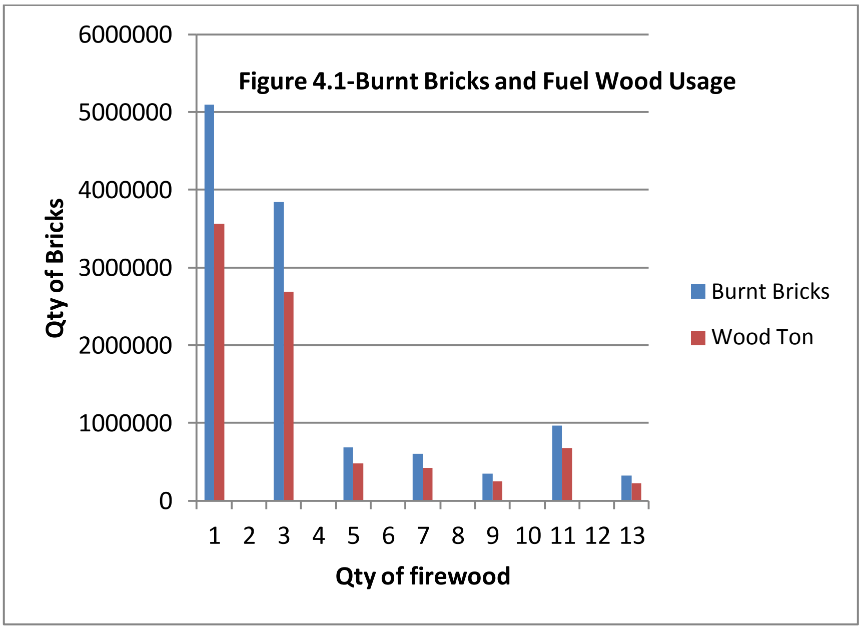
Source: Survey field data and Drawings

The need for zero kgs of fire wood as shown in Table 4.2, by the SSBs projects in the nursing colleges in Malawi have avoided cutting down of trees which reduces deforestation and soil erosion which promotes loss of fertility and subsequent food insecurity, siltation in rivers and Lake Malawi.

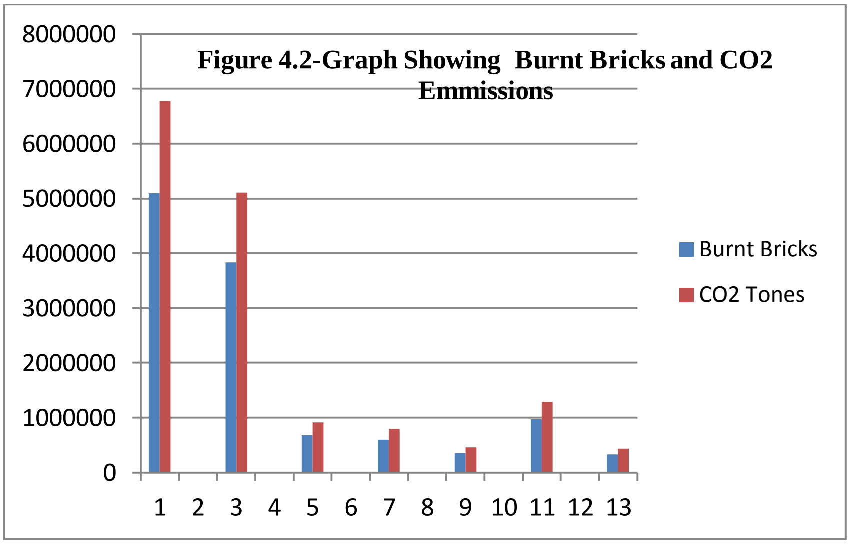
Table 4.3-Calculation of Potential CO2 emissions from transportation of bricks and fuel wood.

Item	Qty	Qty/trip	Fuel (L/km)	# of trips	Distance covered	Total fuel (litres)	Equivalent CO_2 emissions
Burnt bricks	11861222	8000	10	1483	100	14,826.53	1,956.01
							-
Firewood	8303000	10000	10	830	200	16,606.00	2,190.77
					Total	21,432.53	4,146.77

Source: Survey field data and Drawings



Source: Survey field data and calculations



Source: Survey field data and calculations

4.2 Economic Sustainability

Table 4.4 below shows the cost comparison of total number of bricks of different sizes and their equivalent cost differences within the boundaries of one square meter of three different walls (W1, W2, and W3). Table 4.4 further shows that brick sizes are inconsistent as sampled on different walls on three sites.

Findings showed that the smaller sized bricks on W1 (200x90x50mm) have the highest number per square metre (134) representing 112% when compared to the standard number of 120 bricks per square metre of sizes (230x115x85mm). The total number of the bricks accounts for total cost difference of unit area of the brick walls (200x90x50mm) at MWK1, 1206 (112%) as compared to MWK1, 1080 according to Table 4.4.

Figure 4.3 shows a graphic presentation of the differences in cost of bricks of different sizes as compared to the brick of a standard size. It displays that the smallest has the higher number and the highest cost as compared to the others and the standard size.

An interesting relationship between the size of brick and the amount of mortar shown in the Table 4.4 where the smaller the brick, the higher the mortar quantity and the number of bricks Brick wall 1 with bricks sized 200x90x50 has mortar 0.138m^3 (265%) more than the standard brick requirement at 0.52m^3. Although, the technology is supposed to be Burnt Brick wall thus the major cost of this particular item should be that of the bricks. However, due to the diminishing sizes of the Burnt Bricks, the sizes are being compensated by the use of more mortar resulting in an expensive cost of mortar on such walls (255%) more than the actual cost of bricks as shown in Table 4.4 and Figure 4.3 below as compared to standard quantities.

Table 4.5 presents the actual cost of mortar and SSBs which are used to compare with costs for mortar and burnt bricks for similar area coverage. The survey results on SSBs show a uniform trend of number of blocks to a corresponding number of mortar per unit area of coverage for the three different sites visited. This is due to their uniform sizes and regular shapes that promote consistency of mortar joints both vertical and horizontal.

When the results of SSB and Standards bricks are compared, it is shows that the cost of SSBs for one square meter is lower by (80%) than the standard cost of same for the burnt bricks. This is because there are only 35 SSBs per square meter as compared to 120 standard bricks per square meter. Also that burnt bricks uses double walls for the load bearing walls. Again, the study findings indicated that the cost of SSBs is lower than the cost of the different sizes of burnt bricks (200x90x50mm) by 239% as shown in Table 4.4 below.

Table 4.4: Comparison of Cost/m^2 of different sizes of Burnt Bricks in Malawi kwacha (MWK)

Size of bricks	**Total # of bricks/M^2**	**Cost of brick/m^2**	**Volume of mortar/m2**	**Cost of mortar/m2(MWK)**	**Cost of plaster**	**Total cost/m^2 for brick wall(MWK)**
STD Brick Wall (230x115x85)	120	1080	0.052	2913.28	1384.66	5,377.94
W1(200x90x50)	134	1206	0.138	7758.05	1384.66	10,348.71
W2(220x100x60)	112	1008	0.124	6948.51	1384.66	9,341.17
W3(220x100x50)	110	990	0.133	7450.04	1384.66	9,824.70
Averages	119	1068	0.101	7385.53	1384.66	9,838.19
	Standard volume		0.052		$	28.53

Source: Survey field data (Collected by measurements)

Table 4.5: Cost of mortar and SSBs per Square meter

Bricks Dimensions			Mortar joints			Volume per m^2	Cost of mortar/m2	Total Cost SSBs/m2
			Horizontal	perpendicular				
Brick wall Standard						0.052	2913.28	5,377.94
Wall 1	290X150X85	85	10	35		0.031	1744.61	4333.08
Wall 2	290X150X85	85	10	35		0.031	1744.61	4333.08
Wall 3	290X150X85	85	10	35		0.031	1744.61	4333.08
					∑	0.093		
					Ave	0.03	M^3	
					STD		**0.052 M^3**	

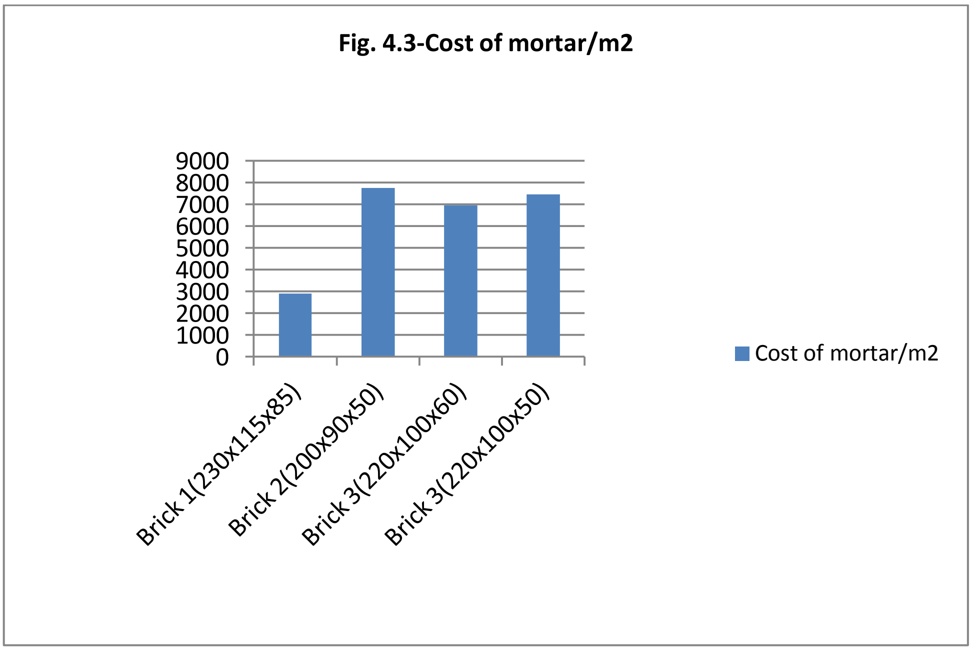
Source: Survey field data collected and analyzed.)

Field results indicates that there is use of too much river sand on brick walls as compared to SSBs ($0.03m^3$ for SSB as compared to 0.101 m^3) for a burnt brick wall.Therefore, if SSB wall uses $0.03m^3$ of mortar per unit area while burnt bricks uses 0.101m3 of mortar for the same unit area then, SSB technology is 333% more cost efficient that burnt bricks per square area. In terms of comparison, SSB (mortar cost/m^2) <BB (mortar cost/m^2)

River sand mining has an effect of altering the natural river flow regimes that causes floods, stagnation, erosion/gullies and siltation. For example Malawi experienced the worst floods in 2012/2013 rainy season which called for both government and International Corporation interventions (Department of Natural disaster Preparedness, 2013). Such environmental hazards are associated with rise in poverty levels. This directly impacts on the natural environment in terms of unsustainable resource utilization.

The results shows that if SSBs are adopted, there will be less river sand mining in Malawi and therefore sustain flow regime of rivers and control of floods, hence avoidance of social cost. This will also just like with firewood and burnt bricks, reduce the transportation element of river sand that has a direct effect on the consumption of fossil fuels. Labor cost will also be reduced resulting in an overall cost efficiency infrastructure development in Malawi.

However, the political will from the government has a bearing on the decision to barn or not to impose a barn on the burning of bricks. Loss of livelihood by the people depending on brick burning business and the fuel wood selling would have a social bearing on the poor population. For instance, the imposition of barn on Charcoal (UNEP, 2011) with the government through the Forestry Department by mounting road blocks on major roads of Malawi put pressure on the urban population to access energy for cooking and subsequently acted negatively to political support



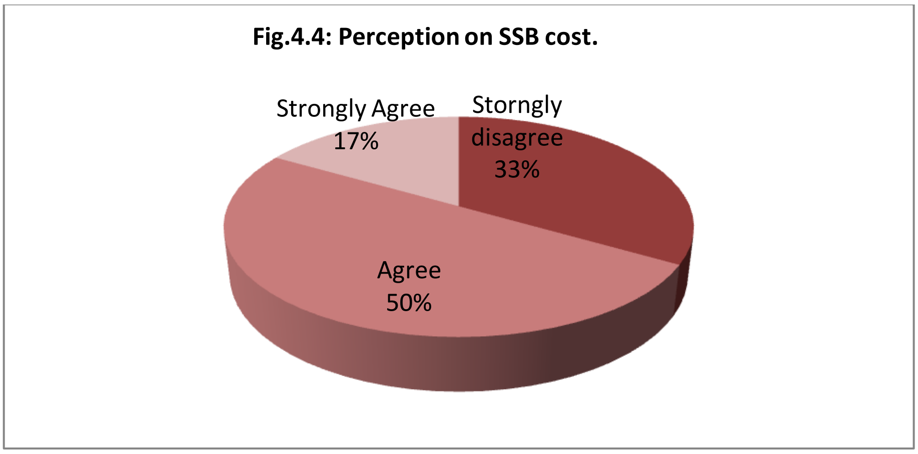
Source: Survey field data and analysis.

Though the brick burning is an informal and unorganized, they have taken advantage of the high demand for burnt bricks due to boom in the real estate industry in line with the MGDS II 2009-2016. Though brick industry is crucial for the development of the country, there have been no efforts to legalize and regulate the industry by bringing in specifications and standards that will contribute towards sustainable development. The impacts according to this study manifested themselves in the plastering of the outer faces of the burnt bricks and imitating by pasting with brick duct which in the long run call for maintenance.

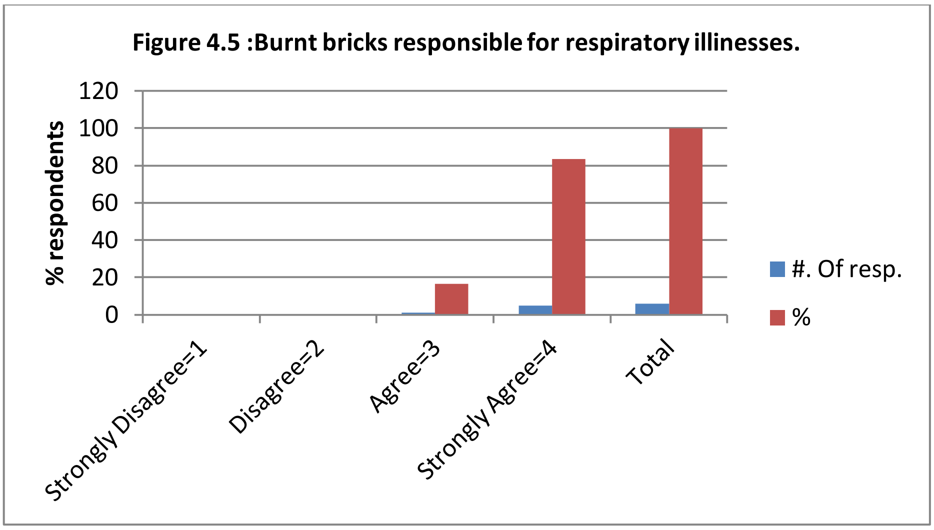
It can be concluded that SSBs remains the best alternative to any form of brick production technologies for their simplicity, none use of natural resource stock for their production and avoidance of CO_2 emissions. Even though cement prices is very high on the market, SSBs remains overall economical more than the burnt bricks.

4.3 Social Sustainability.

Study findings show that, using the Stabilised Soil Block technology, at Umoyo project by the Ministry of Health has enhanced the reduction of maternal and neonatal mortality rate(MDG 4&5) while the primary school building project by DFID has accelerated the education for project(United Nations). A further 83 % (figure 4.5) of the respondents agrees that the impact of burning bricks has negative health effects and hidden social cost that is not paid by anyone polluting the environment while SSBs have minimal effects on humans when using cement and soil dust. The information gap in the public domain influences the indecision by the society in terms of the best alternative materials for construction and linkages of the effects to climate change. However, inclusiveness, capacity building and knowledge transfer on this project has left a positive mark for the colleges so much so that if rolled out on a larger scale, the results would be positive to the Malawi society. About 67 % of respondents agree that SSBs are economical both in the short and long terms



Source: Survey field data (questionnaire Appendix 1)



Source: Survey field data

4.4 Society views on imposing barn on burnt bricks

In view of the effects associated with the brick burning industry, the study aimed at establishing if imposition of a barn on burning bricks would be welcome by the society. In this, 33 %(2/6) respondents were against the proposal while 67 %(4/6) were in favor of the proposal (Figure 4.8). This means that the barn would influence change of habits and perception for the adoption of the new technology in line with sustainable consumption models. However, it was noted that the barn on burnt bricks alone would not work unless there is reduction in price of cement to increase affordability of SSBs.

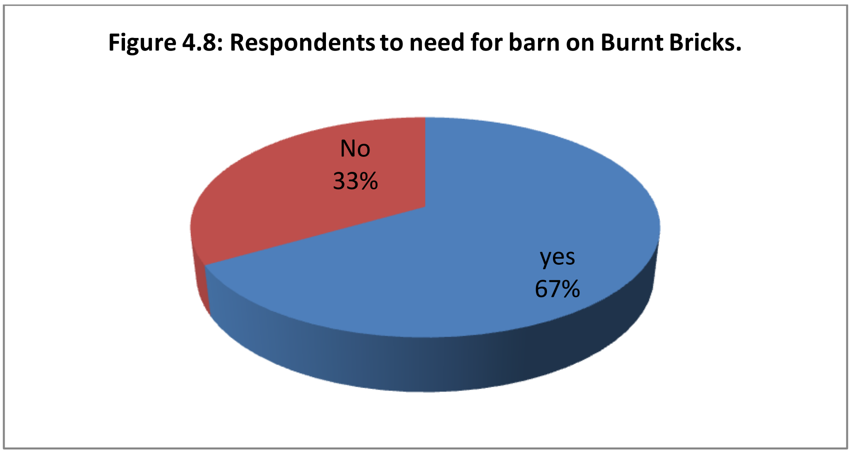


Figure 4.8: Respondents to need for barn on Burnt Bricks.

Source: Research Survey field data

4.5 Adoption of SSBs

After assessing the respondent in the area of study in terms of change in perception, attitude towards accepting and adopting SSBs for their future projects from their own funds, 17% indicated no commitment to adoption of the new technology for their future projects while 83% expressed commitment to the adoption of the new technology as indicated in Figure 4.10 However, lack of information and sensitization on the public domain influences the none adoption of SSBs by the public in Malawi as shown in Figures 4.11

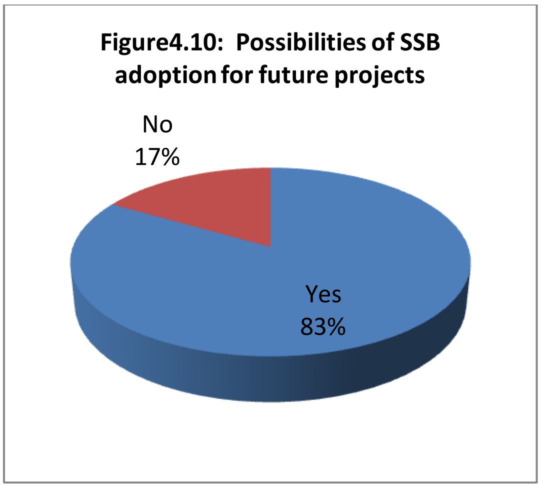


Figure4.10: Possibilities of SSB adoption for future projects

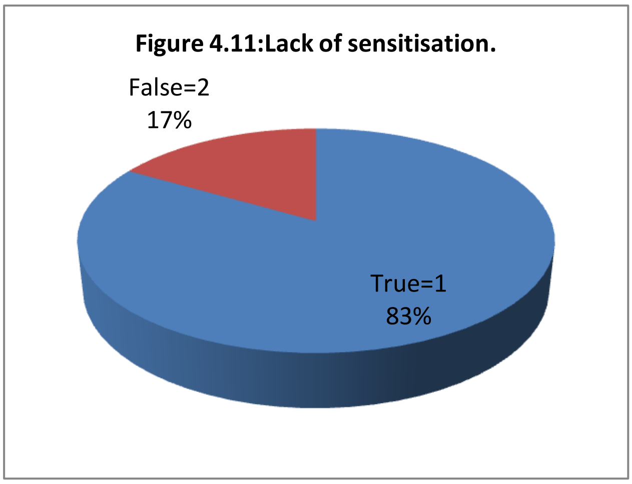


Figure 4.11:Lack of sensitisation.

Source: Research Survey field data

5. CONCLUSION

This paper concludes that SSBs are a vital tool for climate change mitigation and sustainable development when compared to burnt bricks. SSBs use Zero (0) kg of fire wood for their manufacturing. This suggests that SSBs contribute 100% towards reduction in deforestation and emission of carbon dioxide into the atmosphere. The fact that SSBs are three times more economical than burnt bricks is clear evidence that SSB projects are affordable, cost efficient and are value additional. Stabilised Soil Blocks Technology has proved to be environmentally, socially and economically viable as compared to burnt bricks but the technology, despite the foregoing, has not yet been adopted due to lack of an extensive research on the market on the technology and insufficient information in the public domain to sensitize the masses of the advantages of SSBs over burnt bricks.

It is therefore concluded that, the Stabilised Soil Blocks (SSBs) projects that have been implemented in Malawi, have contributed towards the fight against climate change effects and have positively enhanced sustainable development in the country. Therefore, the paper recommend that development of an industry to produce and supply high quality SSBs on the market would facilitate the adoption of the SSB technology and reduce emissions of carbon dioxide into the atmosphere by 100%. Burnt bricks are renowned for environmental pollution; deforestation and high percentage of breakages during transportation as such become very expensive.

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