Adoption of Soil Conservative Measures in Manufacturing Clay Bricks

A. Subrahmanayam[1], KVSG Muralikrishna[2]

[1]Research scholar, JNT University, Kakinada, India

[2] Professor of Civil Engineering JNTUK, Principal JNT University, Narasaraopet, India

Abstract: ***Soils are the one of the vulnerable resources in the world due to the Climate change, Land degradation and Biodiversity loss. Increased Urbanisation and Industrialisation in developing countries has created a huge demand for construction activities, which in turn has resulted in the fast growth of the brick-making industries established in agricultural lands. Unscrupulous promotion of top-soil for brick-making leads to severe scarcity of fertile soils for agriculture in long run. This study is the part of the research, carried in one of the major clusters of Clay brick clamps in East Godavari District of Andhra Pradesh in India. The "Machavaram" cluster is 40 km away from district headquarters Kakinada city in India. A detailed survey conducted by interacting with the brick clamp owners, land owners, technicians, skilled workers of clamps and farmers surrounding the clamp. This study quantifies the potential depletion of soil resources due to removal of top-soil for brick-making in the reporting area. To conserve the soil resources, it is proposed to use admixtures at suitable proportions with brick clay to reduce clay content in fired-clay bricks. It is possible to use coal, biomass ash as a raw material to replace clay, and Rice husk as internal fuel in the brick making clay. This paper discusses the need for "Resource efficient bricks" (REBs) such as perforated or hollow clay fired products in the present brick industry set-up, to reduce clay consumption. Due to varying the proportion of admixtures, quantity of soil saved and area of land conserved is assessed and reported.***

Keywords: Clamp; Soil organic carbon (SOC); Soil Bio-diversity; internal fuel, Resource efficient bricks (REB)

1. Introduction

The humanity on the earth relies on natural resources like soil, water, forest, wild life etc., for their livelihood and existence. Population and environment are closely related in a complex and dynamic manner and this relationship is mediated by number of socioeconomic, cultural, political, and developmental aspects whose role varies considerably from one context to other [1].Conserving earth's Biological diversity and safeguarding the benefits of ecosystem is the need of the hour. The term"Land Use" is used to denote the human activities which occupy an area of land. The term "land use impacts" denotes the environmental impacts related to physical occupation and transformation of land area. The population continues to grow rapidly in the developing countries and great pressure is being placed on arable land, water, energy, and biological resources to provide an adequate supply of food and energy requirements. Population affects the environment mainly through changes in land use and industrial operations [2].

India's massive population base of which majority are living below poverty line, non sustainable agricultural and industrial practices, and relatively small scope for further expansion of agricultural land, make it all the more important to understand the relationship between population pressure, changes in land use and environmental degradation in the country [3].The level of urbanization in India is on rise and it has to deal with problems of land intrusions on productive agricultural lands. Some estimates indicate that the footprint of human activities is already at one and a half times the capacity of planet earth and its ecosystems to bear on a sustainable basis [4].

Mayan civilization i.e. today's waste lands of Yucatan and Guatemala of USA were once rich and fertile lands similarly Sumerian civilization i.e. today's Iran and Iraq was thick forests. Deccan civilization today's South Indian infertile lands all these once rich and fertile lands have now become barren only due to unchecked exploitation of their resources for hundreds of years before[5].

2. Importance of Soil conservation

Soil is one of the most diverse habitats on earth and contains one of the most diverse assemblages of living organisms, including microorganisms such as bacteria and fungi, and macro-organism. Soil organisms provide essential services toward the sustainable functioning of all ecosystems, and are therefore important resources for the sustainable management of agricultural ecosystems. Soil Organic Carbon (SOC) is the main component of soil organic matter (SOM), as an indicator for soil health, is important for its contributions to food production, mitigation and adaptation to climate change, and the achievement of the Sustainable Development Goals (SDGs).The SOC pool stores an estimated 1500 pgC (picogram carbon) in the first meter of soil, which is more carbon than is contained in the atmosphere (roughly 800 pgC) and terrestrial vegetation (500 pgC) combined (FAO and ITPS, 2015). If SOCs are managed wisely, they have the potential to sequester large amounts of carbon in their soils, thus contributing to climate change mitigation and adaptation.

Conversion of natural habitats into agricultural and industrial landscapes, and ultimately into degraded land, is the major impact of humans on the natural environment, posing a great threat to biodiversity [6]. Globally, 33 percent of the world's farmland is moderately to highly degrade. More than 85 percent of the cultivable area had already been brought under cultivation. Taking into account the total land resources including hills, mountains, lakes, rivers and lands of all description; the availability of land per head in India comes to only 0.58 hectares [7]. The per capita availability of agricultural land in rural areas has decline consistently from 0.638 hectares in 1950-51 to 0.271 hectares in 1998-99 and is expected to decline further due to population growth (MoEF, 2006).

3. Scenario of Clay brick practice in construction world

The growth in the economy and population coupled with urbanization has resulted in an increasing demand for residential, commercial, industrial and public buildings as well as other physical infrastructure in developing countries. Asia produces approximately 1.2 trillion bricks per year. The largest brick manufacturers are China, India, Pakistan, Bangladesh and Vietnam, which account for about 75 percent of the world's total production. With 54 percent of global production, China is the world's leader brick producer and has the most advanced brick industry among all developing countries. It is estimated that about 1000 billion fired clay bricks are made every year in the developing countries of Asia [8].Indian brick industry is the second largest producer of bricks in the world after China.

Table 1: Annual production of Clay bricks in Asian countries

Country	China	India	Pakistan	Vietnam	Bangladesh	Nepal
No. of Bricks In billions	800 – 1000	240 – 260	50	26.59	17.2	3.15

Source: Greentech Knowledge solutions.www.gskpl.in [8]

The rate of urbanization in India has been rapid with a decadal growth rate of 31.8% between 2001 and 2011. The overall urban population has increased from 217.17 million to 377.10 million during 1991 to 2011[3].The number of towns and cities has also increased from 3,768 to 7,951 during this period. The government of India has determined to develop100 Smart Cities and 500 AMRUT Cities which will invite investment of 2 Trillion Rupees in the next five years. Bricks are one of the most important walling materials used in India. A 6.6% annual growth rate in construction activity would increase the annual demand for walling material to around 500 billion brick equivalent masonry units by 2030[9]. It is quite evident that India requires massive quantities of construction material over the next two decades.

There are around 125,000 clamps and kilns in the country, according to the Punjab State Council for Science and Technology. Clamps are the most commonly used in South Asia and are the most energy intensive. Clamp is the cheap form of kiln. The production capacity of a clamp ranges anywhere from 5,000 to 500,000 bricks per firing [10].

4. Problem

Fired clay brick is one of the most important building materials in the country. According to UN HABITAT (2009), most construction activities in terms of housing highly depend on earth as its core material. Use of fertile agriculture soil is the major environmental concerns related with brick industry in the country. Current annual consumption of Burnt clay bricks is $170X10^9$ Nos. and the annual consumption by 2020 is estimated as $260X10^9$ Nos. The top soil is consumed at the rate of 1000 sq.km (300mm depth) per year. Assuming 2.5% compound growth the top 300 mm depth soil available is consumed in 75 years [11]. Currently the brick production process is very traditional and bricks are mainly produced through manual processes with little knowledge on raw material (mainly clay) and its selection. High level of top soil based brick production has also resulted in large scale depletion of the agriculture soil, estimated at 350 million tonnes of top soil every year (TERI 2007).

According to many researchers around the world the brick industries cause air pollution and land degradation besides decreasing herb density and causing nutrient disorders in plants/trees in immediate vicinity. The land used for top soil loses its fertility and the land erosion is accelerated. The land area near the kiln is subjected to high temperature making it unfit for uses in agricultural activities after being abandoned. High volume of bottom ash is developed as residue. It affects the agricultural productivity of the surrounding fertile tracts [12].

About 65 per cent of bricks produced in India are manufactured in the Indo-Gangetic plains, which have one of the world's most fertile alluvial soils. Punjab, Haryana, Uttar Pradesh, Bihar and West Bengal are the major brick producing states in this region. The peninsular and coastal India accounts for 35% of the brick production [13].There is no evidence of adding admixtures in the brick clay in this region. So enormous quantity of clay reserves are depleting in this area.

Brick clamps get clay directly from fertile agricultural lands or of soils local river banks. Land degradation due to clay mining accompanied by soil erosion, has the negative effect on agricultural productivity. Depletion of topsoil with high organic content for brick-making is a major concern for agricultural production. It leads to loss of flora and fauna, diversity and reduced aesthetic values of natural terrain. Local population, agriculture and vegetation are the affected the most, from the Brick making clusters.

The land in the yard where bricks are burnt is subjected to very high temperature, which destroys all the plant life and soil organic carbon. This makes it unfit for further agricultural activities. The activity of soil organisms is strongly influenced by soil temperature, acidity and soil-water relations [14]. Decline of organic carbon stock in the soil affects its fertility status and climate change regulation capacity. Approximately 1417 billion tonnes of SOC are stored in the first meter of soil and about 2500 billion tonnes at two meters soil depth. The global loss of the SOC pool since 1850 is estimated at about 66 billion tonnes (±12); mainly caused by land use change [15].

Since soils are non-renewable considering human timescales it can be argued that soil can be put to better use for food production considering India's population. Brick clay consumption declined in U.K significantly between the 1970 and early 1990s due to the demise of common brick in Great Britan. Alternate blocks and stud walls have now almost entirely replaced common bricks in building walls. In

England recent guidance in mineral policy statement 1 (MPS 1) and annex 2 “Brick clay provision in England” draws attention to the need to safeguard the diversity of clay resources and particularly important the scarce resources [16]. In China, recent policies aim to limit the manufacture of clay bricks and encourage the use of industrial waste materials instead, in particular coal gangue. The history of the brick industry in Vietnam is quite different from that of South Asia. In Vietnam, different types of hollow bricks have now gained 40-50 % market share [17]. Comparison of density of wall materials with different building blocks in India which indirectly shows the material consumption is shown in table 2.

Table 2: Comparison of density of wall materials with different building blocks in India

Brick wall type	Density of material (kg/m^3)
Normal fired clay bricks	1700-1750
Perforated bricks	1400-1500
Fly ash bricks	1850-1900
Hollow concrete block	1350-1400
Resource efficient brick	694-783

Source: Abanda F.Henry-*Aims energy* [26]

4.1 Objectives

1) The object of this study is estimating the quantum of Clay consumed in the reporting area.
2) To verify the possibility of adding optimum quantities of admixtures to reduce the quantity of fertile top soil from agricultural lands for making bricks and to increase utilization of biomass ash and hence reducing its disposal problems.
3) Incorporation of internal fuel during blending of clay and fly ash to reduce the quantity of clay used and to reduce quantity of fuel required to burn the bricks. Quantifying the amount of clay saved due to addition of admixtures.

4.2. Research methodology

4.2.1 Study Area

East Godavari District is known as rice bowl of Andhra Pradesh with lush paddy fields and coconut groves. The main economic activity of district is agriculture and 64.8% of population is depended on it. East Godavari contributes about 10% of the total food grain production in the state.

This district is broadly classified into 3 natural divisions are Deltas, Upland, and Hill tracts. The major river is Godavari along with its distributaries Vainateya and Vasishta encapsulates $81^0$30’, $82^0$40’ East Longitude and 16^o25’, 18^o00’ North Latitude. The study area is Brick clamp clusters in Ramachandrapuram revenue division mainly covered by agriculture land use for farming, grassland and other purposes. The climatic condition of this area is semi humid with an annual rainfall of 1200 mm, temperature range between 23.5^oC and 45.9^oC. Climate is mostly hot and humid. The major types of the soils in the district are coastal alluvium, clay loams, black cotton and red soils. The alluvial types of soils are found predominantly in Godavari delta area, the tail end portions of which have sandy clay soils. Red loam is of common occurrence in upland areas and agency areas. The black cotton soils are also found in these parts of the district.

4.2.2 Materials and Methods

This study is carried out for traditional brick clamps of East Godavari District of Andhrapradesh, India. The brick clamps are located in clusters around main towns Ramachandrapuram and Mandapeta comprises around 600 small scale enterprises with a production capacity of over 0.6–1.8 million bricks per clamp per year. This area serves 80% of Clay bricks needed in the district. A sample of six clusters namely Mandapeta(MDP), Pulagurtha (PLG), Machavaram (MCH), Someswaram (SMS), Rayavaram (RAY) and Oduru (ODR) which are renounced as Machavaram cluster are selected in which 19 clamps were studied. A quantitative basis methodology is followed. Both social and resource consumption and manufacturing process data was collected through primary survey from the clamps. A predesigned questionnaire was administered in the reporting area to get the information.

About 50% of brick units are normally set up on leased-agricultural lands.The area of the each clamp is obtained from records maintained by the village revenue agency and the clamp owners. The extent of yard area of the clamp in the reporting area ranges from 1.0 acre (0.4 ha) to 2.75 acres (1.10 ha) which are previously Rice fields. There are different activities in the brick yard. Raw materials such as Clay, Fly ash, Rice husk are stocked separately. Clay is stored for long durations for seasoning purpose and also as a reserve for future use. Blending of clay with admixtures in a mortar, moulding bricks, drying yard for green bricks and burning the dried green bricks in the clamp are the other areas. In this region, bricks are produced in numerous small units from which production capacities generally range from 0.6 to 1.8 million bricks per year.

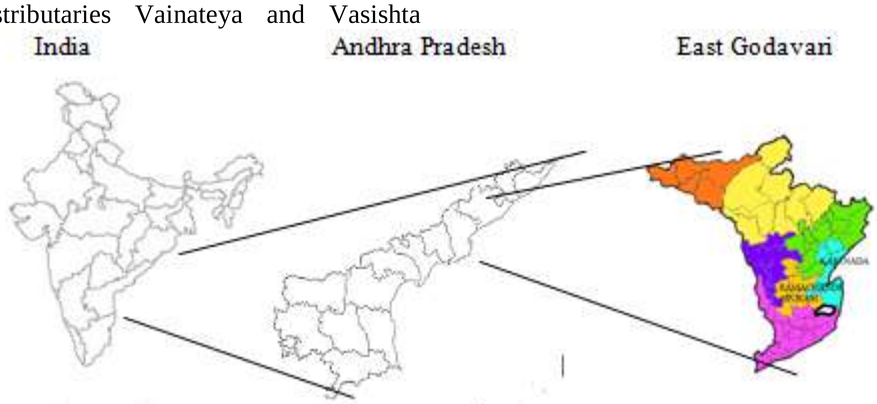

Figure 1: Map of study area.

The clay for manufacturing bricks is of alluvial soil, black cotton soil and red soil obtained from surrounding agriculture lands. Alluvial soils, contains around 20% to 30 % clay and are good for brick making. The soils in the reporting area are alluvium and black soils. The black cotton soil needs to blend with other additives before being used as it contains more fines. All the brick-clamps are established on and amidst of fertile agricultural lands. Ash (Rice husk ash) is used as chief admixture of brick clay in this area. Ash is obtained from sugar factory and boilers of rice mills around a radius of 50 km from clamp site.

Figure 2: Clamp in between Rice fields

Figure 3: Machavaram Brick cluster
*Source:*Google maps, May 2017

The inventory of clay and other admixtures which is presently following by the brick manufacturers in the reporting area is tabulated in table 2 below.

Different clamp owners are practicing mixing different quantities of admixtures in brick clay. The inventory is shown in table 3. The proportions of raw materials depend upon their availability, rates and possible consistency of clay mix obtained.

Table 3: Present consumption of different materials for Brick manufacturing

Clamp Id	Yard Area acres	Annual Prod of Bricks millions	Proportion of materials using for 1000 bricks Existing practice weight in tons					Total Weight of clay tons	Annual consumption Clay tons
			Clay	Ash	% of Ash in Clay	Rice Husk	% of RH in Clay		
MDP 103	2.50	1.80	1.61	0.70	29.05	0.10	4.15	2.41	2898
MDP 105	1.20	0.70	1.67	0.35	14.77	0.35	14.77	2.37	1169
MDP 106	1.00	0.60	1.74	0.10	5.29	0.05	2.65	1.89	1044
PLG 101	2.00	1.50	1.62	0.70	29.29	0.07	2.93	2.39	2430
PLG 102	1.60	1.20	1.61	0.45	19.91	0.20	8.85	2.26	1932
PLG 103	1.40	0.70	1.78	0.50	20.58	0.15	6.17	2.43	1246
PLG 104	2.00	1.60	1.61	0.70	29.05	0.10	4.15	2.41	2576
MCH 102	1.80	1.20	1.81	0.40	17.32	0.10	4.33	2.31	2172
MCH103	4.00	1.50	1.96	0.70	24.91	0.15	5.34	2.81	2940
MCH105	3.00	1.75	1.87	0.40	16.88	0.10	4.22	2.37	3273
SMS 101	1.75	1.65	2.14	0.15	6.33	0.08	3.38	2.37	3531
SMS 103	2.50	1.60	1.82	0.70	26.52	0.12	4.55	2.64	2912
SMS 105	1.25	0.75	1.56	0.95	33.22	0.35	12.24	2.86	1170
RAY 101	0.75	0.60	1.87	0.50	19.08	0.25	9.54	2.62	1122
RAY 103	1.60	1.20	1.87	0.35	15.15	0.09	3.90	2.31	2244
RAY 104	1.50	1.10	1.74	0.50	20.83	0.16	6.67	2.40	1914
ODR101	1.00	1.25	1.61	0.30	14.93	0.10	4.98	2.01	2013
ODR 102	1.50	1.15	2.14	0.60	21.28	0.08	2.84	2.82	2461
ODR 103	2.75	1.70	1.93	0.40	16.33	0.12	4.90	2.45	3281
Total	35.10	23.55			20.04		5.82		42327

This would consume 42327 tones of top soil and 35.10 acres of land when depth of excavation is top one foot.

The unit rates of ingredients of clay brick in the reporting area is shown in table 3. Firewood is used as main fuel to burn the bricks in clamps. Rice husk is added as filler and also to serve as internal fuel. Bricks are manufactured with the help of hand moulds, dried in open area with the help of solar energy and burned in traditional Scotch kiln type clamp.

The cost of clay is approximately 3 to 10 times less than the other admixtures (Table 4) due to which the brick manufacturers are opting for more clay content in bricks. Though the fly ash and rice husk are waste materials; the transportation of these materials making them more costly. Most of the brick kilns in the Indo-Gangetic belt have not used fly ash for manufacturing bricks [18].

Table 4: The cost of different admixtures in clay brick at the yard in the year 2017

S No	Admixture	Rate Rs./ ton
1	Clay	240-300 (4 -5 US $)
2	Fly ash	1500-200 (23-31 US $)
3	Rice husk	2500-3500 (38-54 US $)
4	Firewood	1600-2000 (25-31US $)

In South India also majority brick manufacturers adding nominal quantity of fly ash that too different proportions are mixing in reporting area due to following reasons.

- Difficulty in logistic arrangements by individual brick clamp entrepreneur for procurement of less quantity of fly ash from Thermal Power plant and transportation of it to the brick making sites.
- Mixing of fly ash with clay is difficult by hand. No appropriate technology is available for mixing of clay and fly ash at the scale that is presently being produced by hand moulding.
- Increase in the cost of the product (brick) due to increase in transportation and mixing cost of admixtures with no additional premium being fetched by the product in the market.

The literature review indicates a number of studies have been carried out to compare various brick manufacturing methods with different proportion of admixtures and corresponding strengths. Brick strength in the case of black and red soils is increased by almost one and a half times (30% - 50%) mixing of biomass material is utilized. Clay saving in brick manufacture is possible by adding admixtures 10% - 40% by weight [19]. A maximum of 40% fly ash in the weight of brick can be added without compromising the required strength of the brick. A 2008 law says that a brick must have a minimum 50 per cent fly ash content [20] .The percentage of fly ash by weight that can be mixed in soil for manufacturing fired clay bricks depends upon the physical properties of soil and it should not be mixed arbitrarily.

Waste fuels or other carbonaceous materials can be added to the clay to enable green bricks to burn internally during the firing process. Any waste material which has a calorific value of more than 1000 kCal/kg can be used as an internal fuel in green brick-making [21]. The organic materials such as Rice husk, Bagasse, Coconut coir, Saw dust etc., are used as internal fuel for green bricks.

Rice husk of a maximum 10% can be added to serves the purpose of internal fuel [22]. Such process not only saves fuel for brick firing but also makes the brick lighter, cheaper, portable during transportation and contributes to faster drying rates. It also reduces the losses through breakage. Internal fuel such as ash with carbon, powdered coal or other waste with fuel value can be used in clay. Better mixing of fuel in clays can be achieved using mechanical means. Use of internal fuel will reduce the feeding requirement thus leading to reduced emissions [23].

Clay fly ash bricks can be manufactured according to IS: 3102–1976. Fuel saving in the range of 15% - 35% (coal consumption) or coal saving up to 3 – 7 tonne per lakh brick can be obtained using considerable amount of fly ash in the bricks. Use of fly ash bricks result in reduced energy use, conservation of top soil and qualifying under clean development mechanism. [18].

Table 5: Characteristics of bricks with various percentages of admixtures

Type of soil	Brick making site	Fly ash proportion %	Compressive strength MPa	Water absorption %
Alluvial soil	Kanpur	20	17-20	10-12
Red soil	Bokaro	40	10-12.5	20-21
Red soil	Durgapur	35	8.5-12	15-17
Black soil	Nasik	40	13-15.5	13.5-15.7

Source: TIFAC report on Fly ash bricks page no. 180, Technology Information, DST, New Delhi [19]

According to TIFAC report on Fly ash bricks as shown in table 5, the proportion of fly ash in brick clay is varying from 20% to 40%. In the present study ash is assumed at 30% and Rice husk at 10%.The amount of clay saved is calculated and tabulated below. The modified percentage proportions of materials are shown in Fig 4.

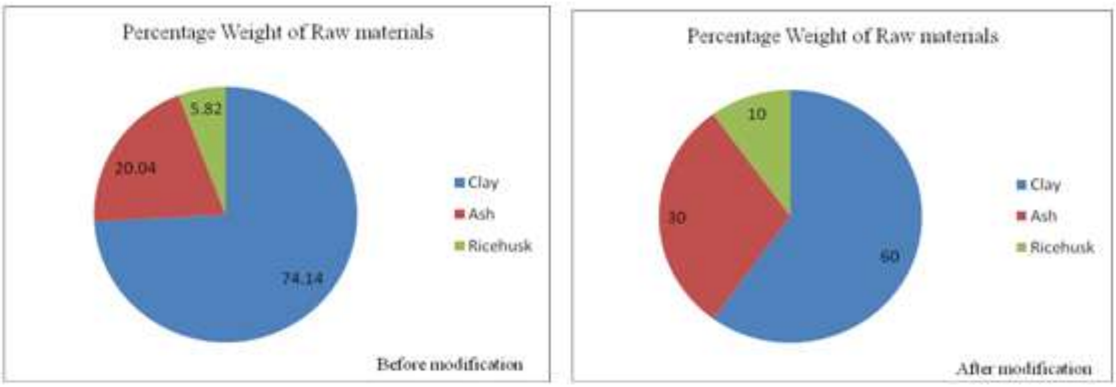

Figure 4: Average proportions of raw materials for brick production before and after modification

Table 6: Recommended proportion of admixtures proposed in Brick manufacturing and saving of clay Volume

Clamp Id	Yard Area acres	Annual Prod of Brks Millions	Total Weight of clay mix	Material proposed for1000 Bricks(tons)					Annual consumption Clay in tons		Saving in consumption of clay tons
				Clay	Ash	% of Ash in Clay	Rice Husk (RH)	% of RH in Clay	After modification	Before modification	
MDP 103	2.50	1.80	2.41	1.45	0.72	0.30	0.24	0.10	2603	3485	882
MDP 105	1.20	0.70	2.37	1.42	0.71	0.30	0.24	0.10	995	3370	2375
MDP 106	1.00	0.60	1.89	1.13	0.57	0.30	0.19	0.10	680	2143	1463
PLG 101	2.00	1.50	2.39	1.43	0.72	0.30	0.24	0.10	2151	3427	1276
PLG 102	1.60	1.20	2.26	1.36	0.68	0.30	0.23	0.10	1627	3065	1437
PLG 103	1.40	0.70	2.43	1.46	0.73	0.30	0.24	0.10	1021	3543	2522
PLG 104	2.00	1.60	2.41	1.45	0.72	0.30	0.24	0.10	2314	3485	1171
MCH102	1.75	1.20	2.31	1.39	0.69	0.30	0.23	0.10	1663	3202	1538
MCH103	4.00	1.50	2.81	1.69	0.84	0.30	0.28	0.10	2529	4738	2209
MCH105	3.00	1.75	2.37	1.42	0.71	0.30	0.24	0.10	2489	3370	882
SMS 101	1.75	1.65	2.37	1.42	0.71	0.30	0.24	0.10	2346	3370	1024
SMS 103	2.50	1.60	2.64	1.58	0.79	0.30	0.26	0.10	2534	4182	1647
SMS 105	1.25	0.75	2.86	1.72	0.86	0.30	0.29	0.10	1287	4908	3621
RAY 101	0.75	0.60	2.62	1.57	0.79	0.30	0.26	0.10	943	4119	3175
RAY 103	1.60	1.20	2.31	1.39	0.69	0.30	0.23	0.10	1663	3202	1538
RAY104	1.50	1.10	1.74	1.04	0.52	0.30	0.17	0.10	1148	1817	668
ODR101	1.00	1.25	2.40	1.44	0.72	0.30	0.24	0.10	1800	3456	1656
ODR 102	1.50	1.15	2.01	1.21	0.60	0.30	0.20	0.10	1387	2424	1037
ODR 103	2.75	1.70	2.82	1.69	0.85	0.30	0.28	0.10	2876	4771	1895
								Total clay saving/annum			32018

Clay saving by modified proportions of admixtures is assessed according to Table 6.There is a saving of clay of 32,018 tons/annum is possible out of 19 clamps studied in the reporting area. There are about 500 to 600 such clamps in the reporting Ramachandrapuram division.

5. Reasons for unsustainable practices in clay bricks manufacturing

There are different reasons for unsustainable practices in clay brick manufacturing. About 50% clamps are setup on rented lands. It is a common practice that some brick manufacturers shift clamps for every few years from one place to another. So clamp owners are unable to follow soil conserving measures, due to the relative economic risk of implementing a new practice or the unpredictability of changing land ownership. Therefore, finance is considered a main driver of Brick manufacturer's practices.

In several regions of South Asia, particularly the northern plains, brick kiln owners are typically politically/socially influential landlords or businessmen having some cash. They are reluctant to make long-term investment in fixed assets [24].This is true in the case of present research area.The clamp owners have limited knowledge on clamp operation and unable to hire technical skills.

Financial and knowledge barriers are preventing the modernisation of brick kilns to reduce their impacts on environment. Financial barriers which may discourage clamp owners from implementing kiln technology, mechanization practices can be in the form of budget deficits or limited finances and access to capital investment. Knowledge barriers in the form of lack of information or awareness are one of the major obstacles to introduce machinery and technology relating to manufacturing resource efficient bricks.

There is lack of enough policies in India related to encourage the use of fly ash, and other industrial by products for making bricks.

5.1 Environmental regulations towards Brick kilns in India

The Central Pollution Control Board has identified brick kiln units under 'orange' category in terms of pollution potential and therefore, it is, clear that the excavating Brick Earth for manufacturing bricks without obtaining Environmental Clearance is a violation of the provisions of EIA notification, 2006 and operating the brick kiln without obtaining consent from the State Pollution Control Board is violation of the Water Act, 1974 and the Air Act, 1981.

The NGT (The National Green Tribunal) made "Preparation of proper Mining Plan" by each and every brick kiln operating in the country as mandatory to control environment degradation. It was also specifically directed by the NGT that the licenses of brick kilns shall be renewed only after grant of environmental clearance. But majority of the brick kiln operators have been openly defying the notices issued by the Deputy Commissioners on seeking environment clearance, which has been made mandatory by the Union Ministry of Environment and Forest (MoEF) and NGT[25]

Much of the additional land available on the globe is not suitable for agriculture. Bringing that land into agricultural production would carry heavy environmental, social and economic costs (FAO, 2014). Another issue is, expansion of agricultural land continues to be the main driver of deforestation.

6. Recommendations

The National Brick Mission aims to transform the Indian brick sector by facilitating large-scale adoption of technologies for cleaner fired brick production, finding alternatives to fired clay brick. The strategy include moving away from solid fired clay bricks in the market to hollow clay fired and fly ash products.

Use of fertile soil in large quantities for brick making is a grave area of concern. In geographical regions having thin topsoil, this result in reduction in the productivity of land and in extreme cases the land does not remain fit for agriculture use. To reduce this wastage following steps can be taken:

a) In many areas brick making is an extending practice of agriculture or a substitutive. This is due to less return from cultivation or expecting more income by changing cultivation to brick making practice. It is essential to make the farmers aware of the relevant technologies suiting their farming situations and practice them to realize higher income from their holdings.
b) There is no official record about the activities of brick clamps; regarding number of bricks manufacturing per annum, amount and source of clay and admixtures used for manufacturing which camouflage the exploitation of natural resources due to brick clamps on surrounding environment.
c) Promoting deep mining of clay for brick making instead of surface mining should be encouraged. At present only top surface (1 ft to 3 ft) is utilized for brick making, resulting in large surface area being affected due to excavation of soil for brick making. Deep mining of clay can reduce the area affected due to excavation of soil for brick making.
d) Creation of a National Management Information System for natural resources as in the case of US would be given priority in, setting priorities for land use planning and management. There should be an amendment, such that each brick clamp has to report regularly to the board on its level of clay consumption, admixtures and usage of firewood for burning the bricks.
e) The brick industry has to seek new ways to address sustainability, altering certain time honored practices. Producing brick from recycled fly ash, boiler ash, stone dust etc. can reduce to use of fertile agriculture soil and consumes less energy and emits less CO_2 because it does not require firing the admixtures used in brick clay to harden the masonry units.
f) Financial barriers may be overcome through financial incentives or regulations that account for local conditions, including incentives provided by the government; for example encouraging use of more percentage admixtures such as fly ash, rice husk in brick clay is possible by supplying admixtures at subsidised rates.
g) A policy should be made for transfer of consistent communication of information that provides relevant from research, to the industry.
h) Development of appropriate low cost machinery for making perforated/hollow products as well as support for popularising these products on large scale is essential. These perforated bricks consume less fuel and soil for the same volume of solid brick production. A reduction of up to 40% (Ref Table 2) in the material use is possible by going for perforated/hollow bricks instead of solid bricks.
i) In South Asia, dominance of traditional perceptions of brick quality is there [24]. The brick should be of red colour, be solid and produce a ringing sound when clapped against each other.

Over the past few decades, the development of other materials such as solid/hollow Concrete blocks, Fly-ash bricks, Cement Stabilized Soil Blocks (CSSB), Fly Ash-Lime-Gypsum (FaL-G) blocks, Autoclaved Aerated Concrete (AAC) blocks, etc., has created viable alternatives. These blocks are alternatives to traditionally fired solid clay bricks and are comparable in cost and are gaining acceptance. The ministry of urban development should draft a building materials policy which will promote and increase the production of non-fired masonry units.

7. Summary and Conclusion

This present research reveals that soil can be conserved by adding suitable proportions of admixtures. There is a need for strict implication of Environmental regulations and reporting. There is a lack of sufficient, accurate and up-to-date data on land conversion and infrastructure deployment patterns as a serious obstacle for designing better land management and human settlement policies in India. Government should make a policy to get the admixtures at subsidized rates to brick manufacturers. Clamps should be mechanised for manufacturing REBs in the point of view of soil conservation. The study also reveals that from environmental monitoring point of view, the land use data as they are collected are of very limited use and at times they may be misleading. Thus, the present system of land use fails to capture both the quantitative as well as qualitative changes. There is a need to strengthen the land use statistics in this context, so that, the objective for which it is generated, i.e. to assess the conservative measures of soil in the region can be fulfilled.

8. Acknowledgments

We are thankful to Brick clamp owners, Brick field land owners and skilled workers of the Ramachandrapuram division for their invaluable inputs in the form of information which they provided and we are also thankful to Village Panchayat offices for their valuable support.

References

[1] Richards, John F. (1986): “World Environmental History and Economic Development” in Sustainable Development of the Biosphere, (eds.) W. C. Clark and R. E. Munn. Luxemburg, Austria: International Institute for Applied Systems Analysis.
[2] BL Turner, WB Meyer-Land use and land cover in global environmental change: Considerations for study - International Social Science Journal, 1991. asu.pure.elsevier.com

[3] Population Growth and Changes in Land Use in India - Ms Soumya Mohanty- Published in IIPS Mumbai, ENVIS center, Volume 4, No. 2-3, July-September 2007.
[4] World sustainable development summit: O5-8 October 2016 | India Habitat Centre, New Delhi October 2016 | India Habitat Centre, New Delhi
[5] Biodiversity: Lacks Logic-CVR Krishna Mohan,KVSG Mrali Krishna-*Proceedings of Energy Environment and Education-8th and 9th 2010.*
[6] Current Status of Soil Management in Andhra Pradesh- Dr. A. Sreenivasa Raju Consultant-Soil Management- Bharathi Integrated Rural Development Society (BIRDS) Strategic Pilot on Adaptation to climate Change-(SPACC
[7] FAO. 2017. *The future of food and agriculture – Trends and challenges.* Rome
[8] Over view of Cleaner Technology options-Dr. Sameer Maithel- Greentech Knowledge solutions.www.gskpl.in -accessed on 19.4.2017.
[9] Controversy over how Indian brick kilns clean up their act. *Darryl D'Monte, June 20, 2016.* https://www.thethirdpole.net/2016/06/20/controversy-over-how-indian-brick-kilns-clean-up-their-act/-accessed on 25.5.2017.
[10] Pathways to efficiency in the south Asia Brick making industry- The Carbon War room - Johns hopkins university SAIS-Nov-2012.
[11] Embodied Energy in building materials- Prof. B. V. VenkataramaReddy, Department of Civil Engineering, Indian Institute of Science Bangalore-.ppt accessed on 30.6.2012.
[12] Palash Patra, Avijit Guray, Sandipan Ganguly, A Study on Brick Kiln Industry in Pursura Block of Hooghly District, West Bengal. International Journal of Applied Research 2015; 1(9): 95-99.
[13] Small and Medium scale Industries in Asia: Energy and Environment- Brick and Ceramic Sectors- Asian Institute of Technology, 2003- Regional Energy Resources Information Center (RERIC).
[14] The origin and Development of Soil, http://passel.unl.edu/pages/informationmodule.php.
[15] FAO-UNO-2016-Soil organic carbon loss-Status of the world Soil Resources-Main report.
[16] Brick clay-Mineral planning facts sheet-British Geographical survey. Accessed on16-11-2013.
[17] Alexander lopez, Natalya lyoda, Rachel segal, and Tony tsai- Building materials: Pathways to efficiency in the South Asia brick making industry- The Carbon war room- Johns Hopkins University SAIS-Nov 2012.
[18] Fly Ash bricks, Technology Information, Forecasting and Assessment Council (TIFAC), DST, New Delhi.
[19] Paper on use of Fly ash for Brick making (Clay-fly ash bricks)- Fly Ash bricks, Technology Information, Forecasting and Assessment Council (TIFAC), DST, New Delhi .
[20] Environmental Cost of Using Top-soil for Brick-Making-*A Case Study from Tamil Nadu, India*-Vinish Kathuria R. Balasubramanian
[21] Internal fuel for clay bricks-SSD –Department of science and Technology of India http://www.ecobrick.in/internal_Fuel_For_Clay_Bricks.aspx.-Accessed on 31.8.2017.
[22] Effect of rice husk ash on the properties of bricks made from fired lateritic soil-clay mix M. A. RAHMAN Civil Engineering Department, King Abdulaziz University, PO Box 9027, Jeddah, Saudi Arabia .
[23] J.S.Kamyotra-Brick Kilns in India-Director, Central Pollution controle Board,Delhi,India.
[24] Urs Heierli and Sameer Maithel-Brick by brick: the Herculean task of cleaning up the Asian brick industry "- Natural Resources and Environment (NRU) Division of SDC – Swiss Agency for Development and Cooperation, Feb 2008.
[25] Notification issued by National Green Tribunal, Union Ministry of Environment and Forest (MoEF) vide its No.190 (E) dated January 20, 2016 for the purpose of processing and granting environmental clearance to all activities associated with quarrying and excavation of minor minerals.
[26] Abanda F.Henry , Nkeng G.Elambo , Tah J.H.M, Ohandja E.N.Fabrice , and Manjia M.Blanche - Embodied Energy and CO2 Analyses of Mud-brick and Cement-block Houses-AIMS's Energy, Volume 2, Issue 1, 18–40.