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TECHNOLOGY AUDIT REPOT FOR CLAY VALUE CHAIN REPORT

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TABLE OF CONTENTS

TABLE OF CONTENTS ii
LIST OF TABLES iv
LIST OF FIGURES v
LIST OF ACRONYMS AND ABBREVIATIONS vii
EXECUTIVE SUMMARY 9
1. GENERAL INTRODUCTION 13
1.1. Construction industry in Rwanda 13
1.2. Construction minerals available in Rwanda 14
1.3. Context of clay in Rwanda 15
1.4. Clay value chains for construction materials in Rwanda 17
1.5. Key actors in the clay value chain in Rwanda 19
1.6. The objectives of the study 21
2. DESCRIPTION OF USED APPROACHES AND METHODOLOGY 24
2.1. Desk review 24
2.2. Field data collection tools 24
2.2.1. Quantitative research and sample size 24
2.2.2. Qualitative research and sample size 26
2.3. Secondary data collection 26
2.4. Research quality assurance and ethics 26
2.5. Data analysis and report writing 27
3. ANALYSIS OF DATA AND PRESENTATION OF RESULTS 28
3.1. Demographic characteristics of respondents 28
3.2. Description of firms 30
3.3. Working conditions of employees 33
3.4. Productivity and market analysis 41
3.5. Source of capital/investments and financial capacity 50
3.6. Competitiveness of clay based construction materials on internal and external market 52
3.7. Analysis of value for money to the clay-based products 57
3.8. Infrastructure and technology in place 58
3.8.1. Infrastructure in Rwanda 58
3.8.2. Assessing the clay technology in Rwanda 59
3.8.3. Elsewhere technologies that can inspire Rwanda model 72
3.9. Contribution of clay industry to the Greenhouse emissions 77
3.10. Quality control and standards status assessment 78
3.11. Potential of clay raw material in Rwanda 82

3.12. Environmental issues resulting from the use of clay ... 84
3.13. SWOT analysis of clay value chain for construction materials in Rwanda ... 90
4. GENERAL CONCLUSION AND RECOMMENDATIONS ... 93
4.1. General conclusion ... 93
4.2. General recommendations ... 94
5. APPENDIX ... 97
5.1. Individual Questionnaire for the key actors ... 97
5.2. FGD and KII guides ... 114
5.3. List of key informant interviewees ... 116
5.4. List of interviewees during FGDs with extractors ... 119
5.5. List of interviewees during FGDs with Processors ... 120
5.6. Table of interviewed respondents by district ... 123
5.7. List of firms/companies which may participate in open call ... 124
5.8. List of clay sites and their location in Rwanda ... 127

LIST OF TABLES

Table 1: Most extensive clay deposits in Rwanda (kaolin excluded) 16
Table 2: Most extensive Kaolin clay deposits 17
Table 3: Key actors in clay value chain and their roles in Rwanda 19
Table 4: Planned and interviewed sample size to be given an individual questionnaire 25
Table 5: List of planned Key informants 26
Table 6: Working schedule by category 35
Table 7: Working hours of firm's staff per day 36
Table 8: Received incentive by employees of the firm in past 12 months 37
Table 9: Firm's annual turn over 51
Table 10: Adobe brick comparative prices in Rwf 53
Table 11: Traditional burnt (Mpunyu) brick comparative prices in Rwf 53
Table 12: Modern bricks (Row-lock with 3 holes) brick comparative prices in Rwf 53
Table 13: Cumulative number of brick kilns in Rwanda 60
Table 14: Firms/companies with modern and energy efficient kilns 60
Table 15: Estimation of firing materials to be used for specific number of bricks 66
Table 16: Operational modern brickyard in Rwanda 71
Table 17: Various technology which may be applied while constructing permanent kilns 72
Table 18: Annual average of cooking and firing fuels consumption 77
Table 19: Annual firewood and agricultural consumption per province 77
Table 20: Summary of GHG emissions from mining and quarrying industries ...78
Table 21: Confirmed clay deposits 83
Table 22: Environmental impacts of producing clay-based construction materials 84
Table 23: Environmental friendly guidelines to be put in place to contain adverse effects of clay extraction and processing 90
Table 24: SWOT analysis of clay value chain for construction materials 91

LIST OF FIGURES

Figure 1: Gross Domestic Product by Kind of secondary activities (in Rwf billion) 14
Figure 2: Categories of construction minerals in Rwanda 15
Figure 3: Illustration of chain value chain in Rwanda..18
Figure 4: Locational map of respondents 25
Figure 5: Distribution of data/respondents per category...28
Figure 6: Distribution of respondents by age 29
Figure 7: Distribution of respondents by sex 29
Figure 8: Education attainment by respondents 30
Figure 9: Firms performing either single or multiple activities...30
Figure 10: Average number of employees of the firms 31
Figure 11: Firm's legal status and registration 31
Figure 12: Firm's formality status...32
Figure 13: The origin of firm's owners 32
Figure 14: The main activity of the firms 33
Figure 15: Possession of clothes and other form of protection to reduce or and/avoid accidents..33
Figure 16: Clay value chain actors at working place without appropriate clothes and other protection materials..34
Figure 17: Possession of insurance by category of firms...34
Figure 18: Average number of firm's workers 36
Figure 19: Working days per week..37
Figure 20: Average monthly income of firm's employees 38
Figure 21: The level of satisfaction of clay value chain actors in terms of income 39
Figure 22: Types of contracts between firms and different stakeholders...............................39
Figure 23: Key aspects highlighted in contract 40
Figure 24: Existing partnership involved in stages of the clay value chain 40
Figure 25: picture of a Hydraform machine and Hydraform ISSB brick 45
Figure 26: Quantity of extracted clay (in tons) 45
Figure 27: The quantity of water used in the past 12 months in processing stage.................46
Figure 28: Annual average production by processors 46
Figure 29: Average sold quantity by processors per year 47
Figure 30: Delivery ratio to the production 48
Figure 31: Availability of market to consume various clay products 48
Figure 32: High demand for construction primary schools in 2020 49
Figure 33: Invested capital (Rwf) by key value chain actors 50
Figure 34: Source of finances to start a business linked with clay based construction materials..50
Figure 35: Payment of taxes..52
Figure 36: Destination of clay products...55
Figure 37: Comparing competitor from production technology in use...................................55
Figure 38: Main challenges hindering the competitiveness of clay products............................56
Figure 39: Solutions to the market competition 58
Figure 40: Availability of infrastructure at processing place..59
Figure 41: Permanent kilns in Rwanda...59
Figure 42: Traditional kilns..60
Figure 43: Sample of warehouses in use for clay products 62
Figure 44: Energy in use for firing clay-based construction materials.....................................62
Figure 45: Sample of smokes from kiln...63

Figure 46: Different firing materials across the country 64
Figure 47: Firing materials in use by different firms 65
Figure 48: Classification of kilns based on the ways are constructed and firing method...67
Figure 49: Main sources of firing materials...67
Figure 50: Traditional methods in use for producing bricks 68
Figure 51: Semi-automated machines in use for producing bricks..68
Figure 52: Automated machines in use for producing bricks..68
Figure 53: Types of technology in use by firms 69
Figure 54: Samples of Ruliba products...70
Figure 55: The level of professionalism of firms...70
Figure 56: Source of skills and knowledge used in performing daily duties............................72
Figure 57: Modern pricks produced by Uganda Clays Ltd at Kajjansi area in Uganda 74
Figure 58: Example of technology in use by Uganda Clays Ltd 75
Figure 59: Samples of clay processing by Kenya Clay Products Ltd in Kenya 75
Figure 60: Identification of a clay with a good quality 79
Figure 61: Some of the most important clay deposits identified in 2013 80
Figure 62: Standards followed by firms...81
Figure 63: Available standard control system by firm's category..81
Figure 64: Availability of product/quality certificates 82
Figure 65: Small scale tile and brick making units..83
Figure 66: Awareness on negative impacts of clay extraction on the environment...............85
Figure 67: Impacts of climate change on the business linked with the use of clay product in construction 85
Figure 68: Availability of capacity to deal with the impacts of climate change and variability 86
Figure 69: Samples of disrupted landscape due to clay extraction and processing 87
Figure 70: Environmental best practices used by clay value chain actors to safeguard landscape...87
Figure 71: Samples of polluted water due to the extraction and processing of clay..............88
Figure 72: Environmental best practices used by clay value chain actors to safeguard water resources 88
Figure 73: Environmental best practices used by clay value chain actors to safeguard soils..89

LIST OF ACRONYMS AND ABBREVIATIONS

CAPI	Computer-Assisted Personal Interviewing
COVID 19	Corona Virus 2019
CORAR	Compagnie Rwandaise d'Assurances et de Re-assurance
EIA	Environmental Impact Assessment
EICV	Integrated Household Living Conditions Survey
ENABEL	Belgian Development Agency
FGD	Focus Group Discussions
GDP	Gross Domestic Product
GHG	Green House Gas
GGGI	Global Green Growth Institute
GIS	Geographical Information System
GPS	Global Positioning System
GoR	Government of Rwanda
Ha	Hectare
IER	Institute of Engineers of Rwanda
ILO	International Labor Organization
KII	Key Informant Interviewees
MIFOTRA	Ministry of Public Service and Labour
MININFRA	Ministry of Infrastructure
MINICOM	Ministry of Trade and Industry
MoE	Ministry of Environment
NIRDA	National Industrial Research and Development Agency
NISR	National Institute of Statistics of Rwanda
NST 1	National Strategy for Transformation One
ODK	Open Data Kit
R&D	Research and Development
RCA	Rwanda Cooperative Agency
REMA	Rwanda Environment Management Authority
RHA	Rwanda Housing Authority
RMB	Rwanda Mines, Petroleum and Gas Board
Rwf	Rwandan Francs
SKAT	Swiss Resource Centre and Consultancies for Development
RSB	Rwanda Standards Board
RSSB	Rwanda Social Security Board
SME	Small Micro Enterprises

SPSS	Statistical Package for the Social Science
SWOT	Strengths, Weaknesses, Opportunities, and Threats
VC	Value Chain
TVET	Technical and Vocational Education and Training

EXECUTIVE SUMMARY

This report presents the findings of the value chain analysis including the technology audit of the clay value chain for construction materials. It was conducted by Sustain Consortium, on behalf of NIRDA in collaboration with ENABEL in the period of September to November 2020. The overall objective of the study was to conduct a value chain analysis including a technology audit of clay value chain for construction materials by assessing the following: (i) Evaluate each value chain in terms of efficiency, (ii) assess each value chain in terms of existing quality, (iii) assess each value chain in terms of product differentiation, (iv) assess each value chain in terms of social and environmental standards, (v) assess each value chain in terms of business environment, (vi) assess the carbon impact of clay construction materials and (vii) assess the technological capabilities of companies in the clay value chain.

Approach and methodology

A desk review of all relevant documents related to the aspects of the study, including but not limited to national development plans and strategies, legislation, market data and other studies related to clay were collected prior to the field data collection. Through the initial desk review, key stakeholders and the clay key actors were identified. Furthermore, clay product markets were assessed as well as end-user to have general view of Rwandan clay value chain including technology audit of clay value chain for construction materials.

The primary data were collected on the field from various clay value chain actors and key informants in all districts of the country except Rusizi district due to restrictions which were in place to deal with COVID-19 in the aforementioned district. Closed ended questionnaires were used to collect quantitative data while interview and focus group discussions (FGD) were used to collect qualitative data. Purposive/judgmental sampling and simple random sampling techniques were used to determine the sample size. The sample were selected in two stages: The first stage focused on the key stakeholders who will respond to the individual questionnaire. The list included all actors involved in processing clay products up to the end-users (e.g. extractors, processors, haulers, retailers and users/constructors).

At this stage, the respondents were selected using snow ball and purposive sampling methods to include different actors distributed across 29 districts of the country. These respondents were given an individual digital questionnaire uploaded on SAMSUNG Galaxy 2016 tablets. The list included all actors involved in clay value chain products up to the end-users (e.g. extractors, processors, haulers, sellers and users/constructors). At the second stage, qualitative data were collected using interview guides to the Focus Group and Key Informants. The latter includes non-profit and governmental agencies along with researchers and academia who are interested to studies related to clay.

Summary of the main findings

The results of this study were grouped according to the key aspects analyzed.

i. **Demographic characteristics of respondents:** The study revealed that retailers (60.5%), processors (58%) and constructors (47.6%) are aged between 36 and 55 years while the dominant haulers (56.8%) and extractors (46.8%) are between 18 and 35 years old. More males (more than 83%) were interviewed compared to the females (less than 17%).
ii. **Description of firms:** A high percentage of constructors are engaged in construction activities only while the majority of haulers (79.5%) and retailers (71.1%) are also

performing a single activity compared to haulers (20.5%) and retailers (28.9%) in the same groups who are engaged in multiple activities of value chain. Most of processors perform also extraction of clay at the same time. The majority of firms possess less than 50 employees where 52% of visited firms employ between 1 and 10 employees while 27% have between 11 and 50 employees. 64.9% of firms belong to sole proprietorship and 24.2% of the firms belong to cooperatives while 7.2% are owned by different people working in partnership. Thus, more than 80% of firms are owned by individuals and private firms.

iii. **Working conditions of employees:** Results from the survey revealed that only 19% of firms' employees have appropriate cloths and other protection tools to reduce or/and avoid accidents at work place but more than 85% of investigated clay value chain actors possess an activated health insurance of "Mutuelle de Santé". It was seen that the highest number of firm's employees category are full working as extractors (56.1%), processors (58.6%), traders (50.3%) and constructors (77.1%). The highest number of firms' staff work between 8 and 12 hours per day in each category and between 70% and 80% of extractors, processors and traders spend between 5 and 7 days per week at work compared with 92.9% of constructors who are at work in the same period with only 50% of haulers working the same days per week. More than 70% of extractors and processors earn between 30,000 Rwf and 100,000 Rwf on average per month. The study revealed that the majority of firms do not have any contract between the firm and various stakeholders as reported that only 18% and 12% of firms have confirmed to have written contracts with employee and with traders respectively while only 8% and 6% of firms have contract with firing material suppliers and with haulers respectively.

iv. Productivity and financial assets: Based on the information gathered from respondents, 33% confirmed to have used (1-10) tons, 22% have used (11-50) tons, 21% have used (51-100) tons while 10% and 15% have used (101-500) tons and above 500 tons respectively. However, more bricks are produced compared to the tiles. For instance 62.5% of firms have declared to have produced more than a million bricks compared to 2.3% that produced the tiles in the same range. Modern bricks dominated on the market compared to the tiles in past 12 months as 94.9% of the brick making firms and 66.7% of the tile making firms have declared to have sold about 100,000 pieces of bricks and tiles respectively. This study explored the standards followed by the firms and 44.7% of respondents revealed that they do not follow any standard in processing stages of clay product. 26.3% and 18.2% of respondents confirmed that their firms follow standards which were fixed by the client and company respectively, it was revealed that the majority of clay construction materials are used in both rural and urban areas as declared by 61.7% of respondents. The majority of clay construction materials are used in both rural and urban areas as declared by 61.7% of respondents with a small portion of bricks which are exported outside the country especially to Goma and Bukavu urban areas of Democratic Republic of Congo (DRC). The majority of respondents (85.3% and 82.4%) highlighted the cost of firing materials and limited capital respectively as the main problems hindering the competitiveness of clay products. The majority of respondents (85.9%) reported to have paid trading license and hence as the most paid tax followed by 26.9% who paid Value Added Tax (VAT), 23.4% of the firms who paid Withholding Income Tax, and 17.7% of firms who paid Rental Income tax.

v. **Infrastructure and technology in place**:

It is very encouraging to note that 92.7% of respondents confirmed to have roads reaching the processing place while 74% and 56.8% confirmed the availability of water and electricity respectively at the processing place and 26.2% declared to have access to warehouses. There are 94.1% of brick kilns which use traditional firing methods but they are not permanent. There are only 3.7% which are permanent, covered and use limited energy compared to the traditional kilns. Another 2.3% kilns are permanent but are not covered and are still using traditional firing method. Only 26.2% of the visited clay firms have warehouses, while others conduct the processing of clay products outside in the open areas. The majority of the clay value chain make use of its working experience to perform daily duties as declared by 70% of them with only 12.7% and 4% who are applying what they have learnt from the schools and trainings. 66.7% of respondents have confirmed that they sourced firing materials in various parts of the country while 31.8% and 1.5% of respondents revealed that they get them from same district in which their firms are located and outside the country respectively. Only 0.9% and 2.7% of firms use automated and semi-automated technology respectively while the remaining 96.4% are still using traditional and manual technology. Thus, 95.4% of firms are still traditional in nature against only 1.1% and 3.5% which were classified as either advanced or semi-modern firms

vi. **Quality control and standards status assessment:**

The study revealed that the identification of a clay with good quality is done using personal experience as declared by 72.9% of respondents while 20.2% use experts in the domain. It was also reported by 84.5% and 76.8% of respondents that they have standard control systems on extracted clay, and 76.8% have constructed kilns while 60.5% of respondents and 56.5% of respondents confirmed to have standard control system on processed products from clay and 56.5% have standards for firing material. It was declared by 89.6% and 77.6% of respondents that they possess exploration certificate and quarrying licence for 5 years respectively against while 41.6% and 32.6% who confirmed to have firing materials certificate and environmental impact assessment certificate respectively.

vii. **Environmental issues resulting from the use of clay**

It was further encouraging to hear that the majority of respondents (more than 70%) are aware of the negative impacts of clay extraction on the environment. However, wood is still the most used firing material for clay construction materials as reported by 59.5% of respondents followed by sawdust (35.2%) and crop waste and biogas which are only used by 4.3% and 1% of respondents respectively. Bricks are manufactured in brick kilns that emit very harmful gases which in turn affect the human health and the environment. The analysis of gas emissions showed that CO_2 has the highest contribution (95.58 %) to the total GHG emissions. The contributions of CH_4 and N_2O are 0.027% and 0.08212%, respectively. Moreover, the contribution of 30.33 Gg CO_2 eq from mining and quarrying in which clay extraction and processing are included is still low compared to the total cumulative emission of 69,187.60 Gg CO_2 eq for the same period. This study demonstrated that extraction and processing of clay for construction materials exert a negative effect on landscape through destruction of vegetation cover and creation of geomorphological structures including rills, gullies, and scars. Furthermore, clay extraction and processing for construction materials potentially cause a modification of physico-chemical properties of water, siltation and sedimentation of streams and flooding risks. Additionally, the extraction and processing of clay for construction materials may result into the degradation of soil physio-chemical properties and contamination by metals and metalloids. There are losses of agricultural soil by accumulation of clay overburden.

Value chain and market analysis

The clay value chain for construction materials in Rwanda has a large development potential and for increasing its contribution to economic growth. It has already grown faster than the overall economy, driven by a construction boom especially in urban areas. Notwithstanding that the construction materials based on clay have high demand on the markets and by 2014, the estimated total amount available clay deposits were 6 million metric tons, total available kaolin deposits were 3 million metric tons making total deposits of 9 million metric tons.

Though the majority of existing clay operators are still at small scale level with hard working conditions, poor salaries and traditional operating systems, there are also several promising clay operators who use either semi-automated or automated machines with permanent kilns. This contributes to the production of improved clay products in quantity and quality. Therefore a call is made to different stakeholders to put together their efforts to be able to respond to the governmental aspiration of using land efficiently by phasing investment strategically, integrate green principles with development, improve the quality of individual houses and build high quality new houses, and facilitate housing through appropriate financing mechanisms.

Study key recommendations: The promotion of automated, semi-automated along with the use of permanent kilns which are energy efficient should be among the priorities to be done in the process of modernizing the sectors and reducing Greenhouse gas emissions. Formalization of clay extraction and processing by providing the individual licence to all actors in the sectors will help the government to have full information on the clay value chain for construction materials. Furthermore, regular inspection and follow up on the implementation of environmental best practices are highly needed to protect our environment from progressive degradation.

Development of an up-to-date database on quantities of naturally occurring construction materials by Initiating detailed studies to confirm quantities of clay, stone and sand. Also by digitizing and making this information available online for prospective investors.

Promote innovation through establishing of innovative construction products, seeking alternative construction technology, and ensuring cleaner and safer environment for all extraction practices.

1. GENERAL INTRODUCTION

1.1. Construction industry in Rwanda

Rwanda has embarked on the holistic process of development in both rural and urban areas. This development can be framed as a modernization characterized by various changes in terms of settlement, infrastructure development, distribution of socio-economic and political services and population lifestyle. The Government of Rwanda has also put emphasis on the most appropriate technologies and principles to ensure that the progressive economic development will be maintained while protecting and conserving the environment for optimal and rational utilization of natural resources for sustainable development.

In the same context, urbanization policy was published in 2015 as separate document to land policy standing as a strategic driver of urban development and panacea for demographic pressures and sustainable land use especially in urban areas. Furthermore, the total Rwandan population increased up to 12,663,116 in 2019 with 10,032,212 (76.6%) living in rural areas where the agriculture is the main occupation (NISR, 2012[1] and 2019[2]). Therefore, Rwanda embarked on the promotion of services-based economy with a support of industrial sector which is dominated by construction sector as reported in statistical year book in 2019 (NISR, 2019).

Notwithstanding that the urbanization policy was put in place with aim of using land efficiently by phasing investment strategically and integrating green principles with development, The National human settlement policy was also formulated as along with the urbanization policy with objective to regroup, improve the quality of individual houses and build high quality new houses while facilitating housing through appropriate financing mechanisms. Furthermore, the Rwanda Housing Authority projected urban population to be 35% by 2020. This would require additional 560,000 houses to accommodate all urban population. In the same context, Rwanda embarked to the construction of model villages (imidugudu) across the country for efficient and effective land use thereby creating high demand of construction materials especially bricks and clay tiles.

It is worth to recall that the basic human need for shelter is to be supported by convenient access to goods through road transport, basic services (e.g. schools, hospitals, commercial centres, industrial areas, markets, etc.), recreation and touristic sites ultimately leading to improved quality of life for the population. All these require also enough appropriate construction materials. Thus, the use of clay to prepare adobe bricks, modern bricks, ISSB bricks, CEB bricks, clay tiles, earth flooring, ceramic bodies and glazes might be one of the solutions to look at it in the process of providing affordable construction materials to respond to the above mentioned needs for the Rwandan population.

However, there is still a gap in technology use of clay to transform it into more valuable fine products which would be internationally competitive. Therefore, the partnership between various actors in clay value chain products for construction purpose is in call to make the sector more competitive internationally. It is in this regard that NIRDA in collaboration with

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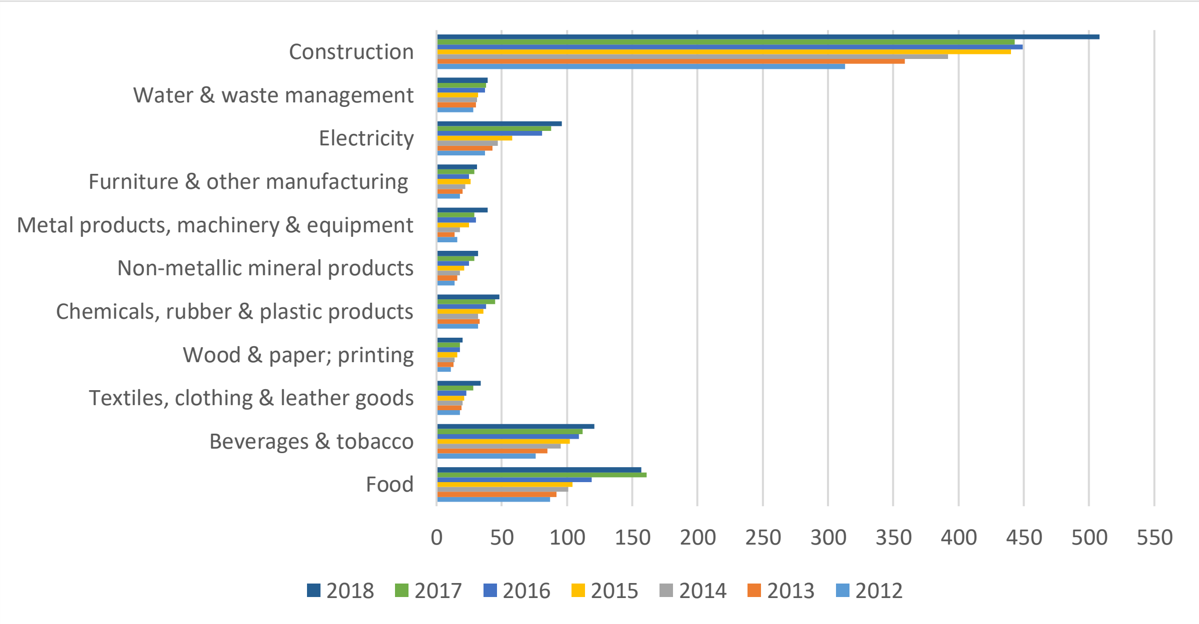
[1] National Institute of Statistics of Rwanda (NISR), (2012). Rwanda 4th Population and Housing Census, 2012.
[2] National Institute of Statistics of Rwanda (NISR), (2019). Statistical year book, Kigali, Rwanda.

Enabel have taken the lead to call upon for a competent consultant to conduct a value chain analysis of clay including access to technology, existing technological capabilities, existing green technologies and to identify possible opportunities for value chain upgrading, extending and optimizing. Hence, Sustain consortium responded to this call by submitting the present technical proposal to be considered and given the opportunity to conduct the above mentioned study.

1.2. Construction minerals available in Rwanda

Rwanda has different deposits of both industrial and construction minerals. Major products used in the construction and public works industry within the country include; lime production, clay tiles and cement. In 2011, lime production rose to 62.4% reaching 1,405 tons from 865 tons in 2010, which can be attributed to increased post-war reconstruction of damaged roads and a general increase in housing needs in both rural and urban areas. Moreover, bricks and tiles also rose by 10% while cement decreased by 11% (MINICOM, 2015[3]). Furthermore, the National Institute of Statistics of Rwanda revealed that the industrial sector was dominated by construction sector and manufacturing in 2018 as it can be depicted from the figure below (NISR, 2019).

Figure 1: Gross Domestic Product by Kind of secondary activities (in Rwf billion)



Source of data: EICV5, 2018[4]; NIRS, 2019.

The figure above depicts an important role played by construction sector specifically construction minerals in the economy of Rwanda. Furthermore, the market for construction minerals is limited to one type of economic activity, while industrial minerals have various uses in a wide range of industries. Indeed, it is difficult to identify a branch of industry that does not use industrial minerals. Therefore, specifications may vary widely and adaptation of products to particular markets is an important feature of the industry which can be critical

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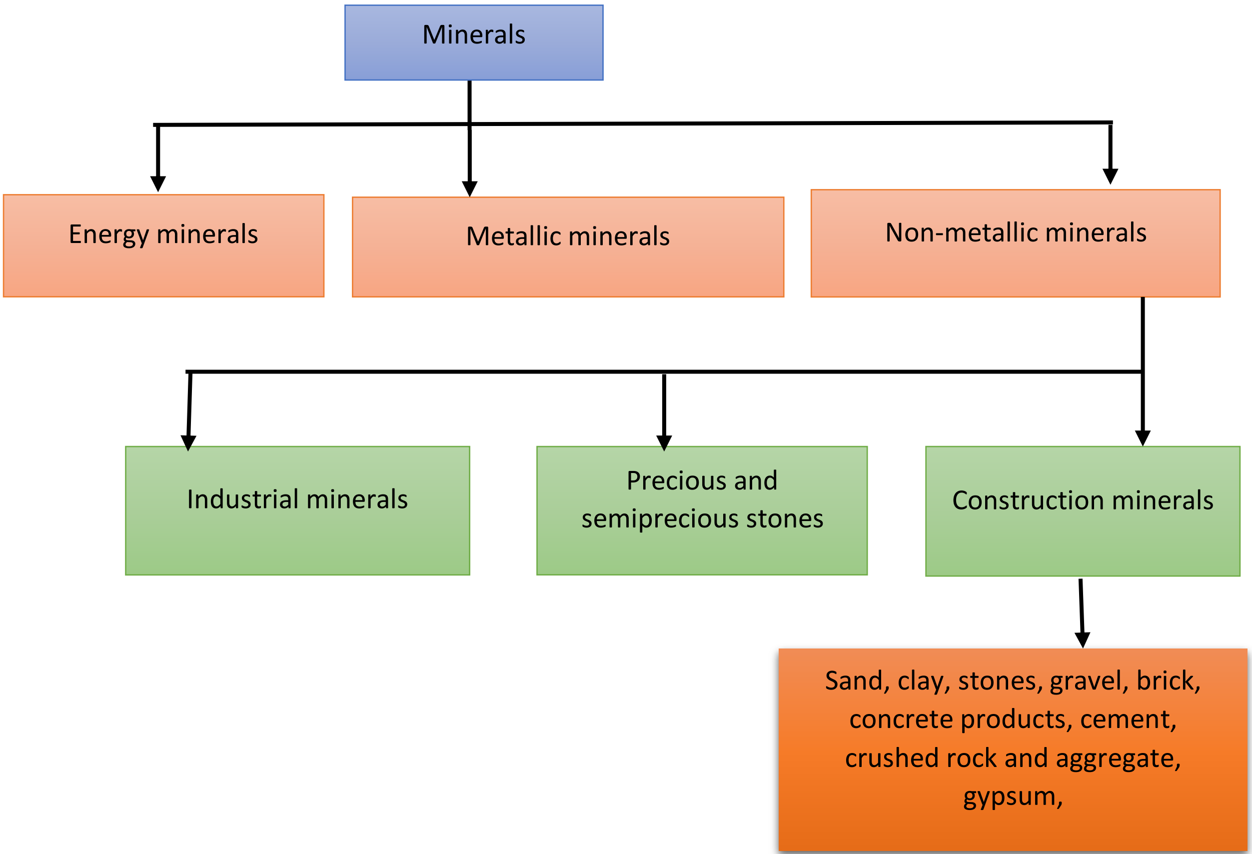
[3] MINICOM, 2015, Industrial sub-sector master plan for construction materials, Kigali, Rwanda.

[4] National Institute of Statistics of Rwanda (NISR), (2018). The Fifth Integrated Household Living Conditions Survey (2018). EICV5 Main Indicator Report, Kigali, Rwanda.

for profitability. Construction minerals are mainly used in the form that they are found in nature, with treatment limited to physical sorting or shaping. Hence, they require less processing activities compared to industrial minerals which are often subjected to chemical processes in addition to physical shaping. The figure below shows the existing construction minerals in Rwanda.

Figure 2: Categories of construction minerals in Rwanda



Source: Ministry of Trade and Industry, 2015

The construction minerals include sand, clay, stones, gravel, bricks, concrete products, crushed rock and aggregate along with gypsum. However, the current study will only focus on clay value chain analysis for the construction sector in Rwanda.

1.3. Context of clay in Rwanda

According to the general lithology of Rwanda, three types of clay deposits are found: clay that results from alteration of granite and related rocks, clays from volcanic rocks, and those from shale. Clay from granite and related rocks are sandy clays with silt or particles of sand or pure clay. Highly weathered pegmatite produces a mixture of kaolin and quartz. They are a high quality source of kaolin that is very pure, white in color and with a minimum of iron oxides. Iron oxides are considered as impurities and are of great importance to determine the quality of the raw material. Clay from volcanic rocks is of a good quality but can contain pieces of non-decomposed lava. Clay from shale is found in mountainous parts of Rwanda. This clay is generally of good quality for brick making. Potential uses of clays in Rwanda include bricks and tiles for construction, tableware, sanitary ware and ceramics, porcelain, insulating and electric fittings, refractory and various elements for decoration, pottery and drainage pipes. The potentially most valuable clay is kaolin, which is used in paints and ceramic glazes to help with opacity. Clays rich in kaolin can be used for refractory products, thin ceramics (dishes, sanitary ware, tiles etc.), and sanitary ceramics. The provisional database contains 16 sites with kaolin and 158 sites with other clays (MINICOM, 2015). Some studies on quality and quantity of clay deposits have been made by Switzerland cooperation and Rwanda geological survey. The results of these studies were also reported by MINICOM in 2015. The tables below summarize the most extensive clay deposits of Rwanda reported in these studies.

Table 1: Most extensive clay deposits in Rwanda (kaolin excluded)

Province	**District**	**Sector**	**Deposits**	**Reserves**
Southern Province	Huye	Mbazi	Gihindamuyaga	600.000 m^3
	Gisagara	Save	Rwasave	1.000.000 m^3
	Gisagara	Save	Kigoma	80.000 m^3
	Muhanga	Shyogwe	Rugeramigozi	310.000 m^3
	Muhanga	Shyogwe	Ruli	310.000 m^3
Eastern Province	Ngoma	Rurenge	Kanyirangoli	Low
	Rukira	Murama	Kibaya	Low
	Rwamagana	Mwulire	Kariko	30.000 m^3
City of Kigali	Nyarugenge	Kigali	Ruliba	700.000 m^3
	Gasabo	Kinyinya	Kinyinya	400.000 m^3
	Gasabo	Kacyiru	Gacuriro	10.000 m^3
Northern Province	Rulindo	Rukozo	Rukozo	540.000 m^3
	Rulindo	Buyoga	Muyanza	36.000 m^3
	Musanze	Nkotsi	Ndali	500.000 m^3
	Gakenke	Rwaza	Mukinga	Low
Western province	Karongi		Munzanga	Low
	Karongi		Rukoko	Low

Source: MNICOM, 2015

Table 2: Most extensive Kaolin clay deposits

Deposit	Region	Kaolin (%)	Reserves
Bahimba	Gatumba	90%	600.000 t
Mbuye	Kibungo	92%	50.000 t
Ntunga	Rwamagana	85%	30.000 m^3
Nsinda	Rwamagana	85%	100.000 m^3
Mulindi	Byumba		
Muyanza	Rutongo		
Ruyenzi	Gitarama	85%	
Busoro	Gatumba		
Ruhanga	Gatumba	88%	2.000 m^3
Nyamase	Gatumba		5.000 m^3
Nyamisa	Gatumba		60.000 m^3
Gitaba	Gatumba		50.000 m^3
Mpatsi	Kibuye		2.000.000 t

Source: Ministry of Trade and Industry, 2015

The above mentioned locations are the main clay deposits which have been identified across the country. Others small deposits have been annexed to this document (annex 2).

1.4. Clay value chains for construction materials in Rwanda

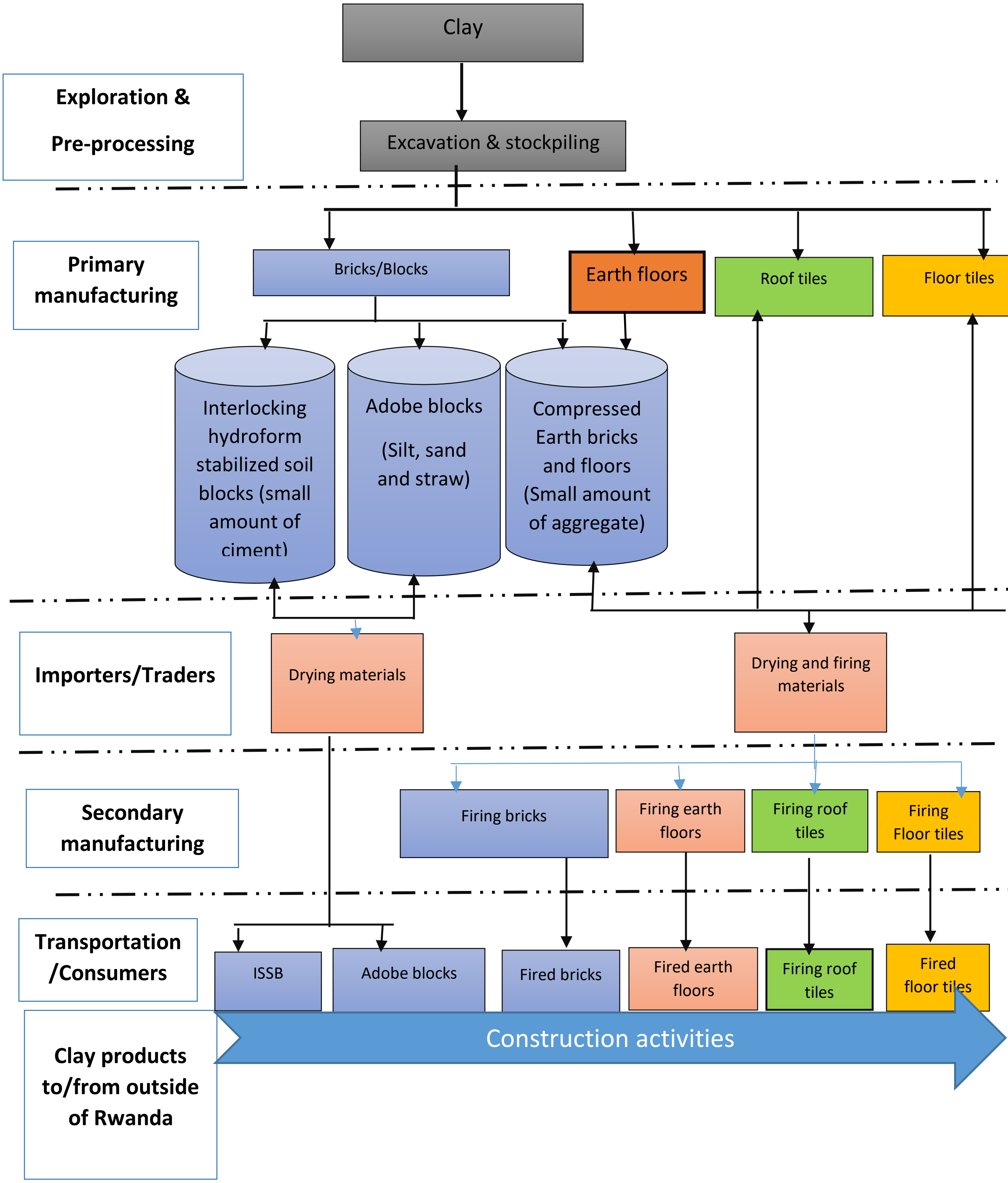
Notwithstanding that exploration is a key step in mining activities to identify an ore deposits of a good quality and high quantity, it is also recommended by Ministry of Environment and Rwanda Mines, Petroleum and Gas Board (RMB) to make sure that mining activities are undertaken at the right place. The excavation and stockpiling of clay are among the key activities undertaken during exploration. Once clay has been identified, the primary manufacturing may take place by producing adobe bricks, modern bricks, ISSB bricks, CEB [5]bricks, clay tiles, earth flooring, ceramic bodies and glazes.

These clay products are either produced using the clay alone or by mixing it with other products. For instance, blocks are produced by mixing clay with small amount of cement while adobe blocks are made by mixing clay silt, sand and straw. Additionally, these clay products are used after drying them and some of them require to be fired with firewood, sawdust, coffee husk and rice husk to get final product. These firing materials are imported by traders to the firing place. Finally, the clay products (e.g. fired bricks, tiles and earth floors, ceramics, etc) are processed and transported to the end users/constructors to be used in construction

[5] Explain these types to the reader?

activities despite cases of some constructors who prefer to use clay products from outside the country. The figure below (Figure 3) shows ideal clay value chain taking place in Rwanda.

Figure 3: Illustration of chain value chain in Rwanda



It is worth noting that firing bricks and tiles requires the construction of kilns. This is necessary because Rwandans still prefer the fired bricks hence the market is already assured and demand is high compared to that of cement products which in most cases are imported.

1.5. Key actors in the clay value chain in Rwanda

The Clay Value Chain starts from the stage of mining policy making and exploration up to the end users of clay products. Therefore, there are many actors who are involved in various processes. Normally, clay is often extracted from wetlands that are owned by the Government and/or plots of land owned by different people/private institutions. This may require also the expropriation and/or acquiring exploitation certificate before starting clay extraction.

Clay products, particularly bricks and tiles, are mostly produced and fired in-situ without taking raw material over long distance and then used to construct nearby houses. Therefore, extraction and processing activities take place in the same area. In this case, there are many micro-value chains rather than one large value chain as described above. The key actors described in table below are involved in the ideal large clay value chain.

Table 3: Key actors in clay value chain and their roles in Rwanda

CLUSTERS	Name	REPRESENTATIVES	ROLE
1. Policy and Law makers	Government of Rwanda (GoR)	• Ministry of Justice, • Ministry of Environment, Rwanda Mining Petroleum and Gas Board, • Rwanda Environment Management Authority, • Ministry of Industry and Commerce, • Ministry of Infrastructure, Ministry of Local Government etc.....	**Regulation** ✓ Setting up sound environment policies that are conducive to private sector investment in mining; ✓ Administering the mining laws and attendant regulations; ✓ Issuing and administering all types of licences taking into considerations related rights and obligations; ✓ Establishing environmental, health, safety and security guidelines and ensuring compliance; ✓ Collecting taxes, duties, royalties, fees and rental payments arising from mining development **Role of Promotion**

			✓ Establishing and Coordinating consultation mechanisms within the public sector, the private sector and other agencies for smooth development of the mineral sector; ✓ Carrying out basic geological mapping of the country and maintaining up-to-date information on mineral resource potential for promotional and development purposes; ✓ Promoting the development of Rwanda's mineral potential by preparing and disseminating promotional materials; ✓ Providing guidance to investors and facilitating contracts and communication with relevant institutions; ✓ Promoting and facilitating linkages with important partners.
			<u>Role of Services Provider</u> ✓ Creating and managing an efficient mineral licensing system; ✓ Providing or encouraging others to provide technical advice and services relating to the mineral sector; ✓ Establishing, supporting and coordinating technical assistance programmes to the artisanal and small-

			scale mining sub-sector etc.
2. Exploration groups	GoR	Rwanda Mining , Petroleum and Gas Board	Large Scale clay exploration
	RMA	Rwanda Mining Association	
	Private Companies	National and overseas Companies	
	ASM	FECOMIRWA and associated Cooperatives	Artisanal and Small Scale Mineral Exploration
	Individuals	-	
3. Extractive industry	Miners, private companies	Large Scale Mining	Clay extraction
		Medium size Mining	
		Small Scale Mining	
		Artisanal Mining	
4. Processing groups	Private companies	Private companies	Clay processing
5. Packing	Private companies	Private companies	Packing of end products
6. Haulage groups	Private companies	Private companies	Transport of raw materials to be mixed with clay and firing materials (viz., firewood, sawdust, coffee husk and rice husk) and final products.
7. Traders	Private companies	Private companies	International and local trade of end products
8. Retailers	Individuals	Individuals	Domestic selling business
9. End users	Constructors	Constructors	End users of end products

Source: Kanzira *et al.*, 2018

1.6. The objectives of the study

The main objective of this consultancy is to conduct a value chain analysis including a technology audit of the clay value chain for construction materials by assessing the following:

1. Evaluate each value chain in terms of efficiency:
   - ✓ Identify the products offered in the value chain and its producers;
   - ✓ Determine the degree to which supply meets demand for each product identified;
   - ✓ Identify production efficiency in terms of the ratio of costs versus benefits (inputs versus outputs);

- ✓ Assess available technology and technological capabilities that is used for the development of products; is this suitable for production processes? What are gaps, challenges?
- ✓ Research on other kind of technologies from other countries that can be imported from other countries and adopted in Rwanda.

2. Assess each value chain in terms of existing quality:
   - ✓ Are customers satisfied with the quality of the product including design?
   - ✓ Are customers satisfied with the value for money?
   - ✓ Do the products meet market requirements?
   - ✓ Is the product presentation (e.g. marketing, packaging) up to standard?
   - ✓ How to improve existing quality? How to improve the perception of the existing quality? f. Which are best practice examples in other countries?
3. Assess each value chain in terms of product differentiation:
   - Identify the competition (Competitive advantage/disadvantage) of local products on the market;
   - Evaluate the main competitors;
   - Assess the available new technology, gaps in existing technology, green, and climate resilient strategies.
4. Assess each value chain in terms of social and environmental standards:
   - ✓ Do producers take any social (including workplace security) and environmental standards into account? If so which ones (RSB, RHA, ILO, MIFOTRA, other)
   - ✓ What are the labour costs/standards?
   - ✓ Are any trainings offered to employees?
   - ✓ Do producers work together with TVET schools?
   - ✓ Do they take interns or apprentices?
   - ✓ Which are the main impacts in the environment of this value chain? Which synergies can be implemented?
   - ✓ How each technique will be valuable in the Green Building Minimum Compliance system developed by RHA with GGGI?
   - ✓ Which standards have still to be developed
5. Assess each value chain in terms of business environment:

- Evaluate the immediate business environment (e.g. market conditions, regulations and administrative procedures, etc.) and wider business environment (e.g. interest from the business, infrastructure, access to labour, etc),

6. Assess the carbon impact (CO^2) of these materials:
   - ✓ What is the expected total CO^2 emission of the production and transport processes of clay construction materials?
   - ✓ What is the difference in CO^2 emissions between the proposed clay construction materials and the usual construction materials (e.g. industrial bricks and local handmade burned bricks)?
7. Assess the technological capabilities of companies in the clay value chain:
   - ✓ Analyze the existing technology and technological capabilities that are available in the value chain versus what is available outside of Rwanda to increase the efficiency of products developed in the value chain including indicating new products that could be developed if the relevant technology/technological capability would be available;
   - ✓ Use SWOT analysis of the clay value chain and individual players and recommendations on which strengths and weaknesses to focus on;
   - ✓ Analyze an upgrading (collaboration between different producers to move to a higher value added component of the chain), extending (actions to broaden existing value chain to increase its job creation and value impact potential) and optimizing (actions to improve operation of certain links of the value chain to achieve greater value added) the value chain;
   - ✓ Make recommendations on the above.

2. DESCRIPTION OF USED APPROACHES AND METHODOLOGY

An integrated methodology combining the literature review, quantitative and qualitative methods was used in this study. While the quantitative methods are free from personal biases and thus help ensure objectivity of findings, the qualitative methods reflect better the interviewees' perceptions and experiences and they uphold humanistic values essential to understand perceptions. The main components of the methodology are the following:

2.1. Desk review

A desk review of all relevant documents related to the aspects of the study, including but not limited to national development plans and strategies, legislation, market data and other studies related to clay have been collected prior to the field data collection. Through the initial desk review, key stakeholders and the clay key actors were identified. Furthermore, clay product markets were assessed as well as end-users to have general view of Rwandan clay value chain including technology audit of clay value chain for construction materials.

2.2. Field data collection tools

Both quantitative and qualitative approaches were used. The quantitative approach involves the use of digital questionnaire and photo taking while the qualitative approach combined desk review, Focus Group Discussions (FGD) and Key Informant Interviews (KII). It is observed that mixed methods studies promote an understanding of chosen phenomena in a manner that would not be possible using a single approach and identified 4 main aspects that must be taken into consideration when planning a mixed method research study: time distribution, weight attribution, combination and theorization (Dos Santos, et al., 2017[6]).

2.2.1. Quantitative research and sample size

The value chain analysis including technology audit of clay value chain for construction materials were undertaken in all the 29 Districts of the country expect Rusizi district due to the Covid-19 restrictions (97% of total districts). Purposive/judgemental sampling and simple random sampling techniques were used to determine the sample size. The sample were selected in two stages: The first stage focused on the key stakeholders who will respond to the individual questionnaire. The list included all actors involved in the clay value chain from the producers up to the end-users (e.g. extractors, processors, haulers, retailers and users/constructors).

The table 4 shows the planned and empirical sample whereby, the field data collection exceeded the planned sample (109%) which increase the quality and thereof validity of the research.

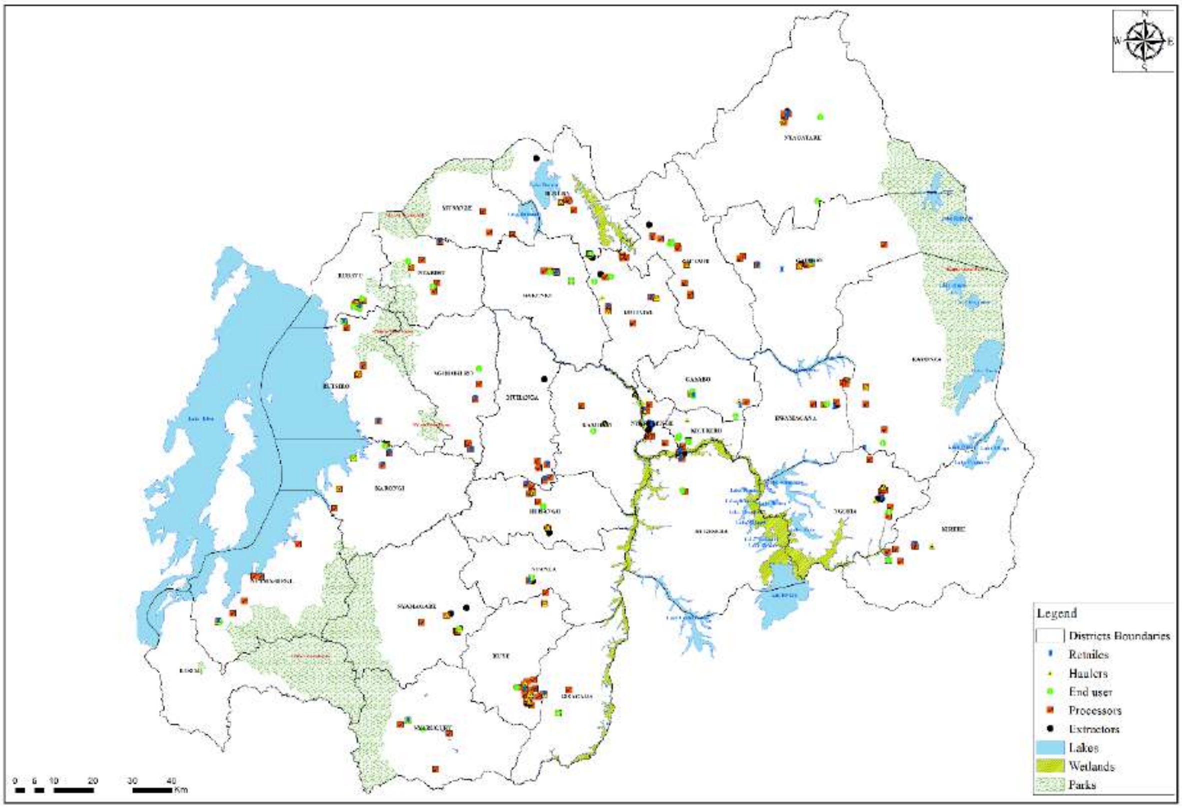
[6] Dos Santos, J. L., Erdmann, A. L., Meirelles, B. H., Lanzoni, G. M., da Cunha, V. P., & Ross, R. (2017). Integrating Quantitative Data in Mixed Method Research. *Texto Contexto Enferm, 26*(3), 1-9

Table 4: Planned and interviewed sample size to be given an individual questionnaire

Methodology	Tool	actors	planned sample size	Empirica l field	Percentage
Quantitative methods	Digital individual questionnaire	**Extractors**	100	123	123
		Processors	200	195	98
		Users/ constructors	48	42	88
		Haulers	30	44	147
		Retailers	30	39	130
Sub-total			**408**	**443**	**109%**

It is with noting that the research used Open Data tool kit (ODK) which helped capturing the GPS data and visualizing location of the respondents as per the following map.

Figure 4: Locational map of respondents



The Computer-Assisted Personal Interviewing (CAPI) comprising of tablets with appropriate software were used to collect necessary data which was finally submitted to the client. This system has proved to be more effective and efficient than the usual Paper and Pencil Interviewing (PAP) system. The process involved uploading of the final questionnaire in both languages (English and Kinyarwanda) on the tablets using Open Data Kit software (ODK). The latter helps to collect field data on a mobile device (tablet) and transmit it to a server from where they are later extracted for analysis. In addition, the GPS incorporated in ODK helped to regularly monitor geographical location and progress of the interviews.

2.2.2. Qualitative research and sample size

At the second stage, qualitative data were collected using interview guides used during the Focus Group Discussions (FGD) and Key Informant Interviews (KII). The latter include non-profit and governmental agencies along with researchers and academia who are interested to studies related to clay. The following stakeholders were planned to be involved in the study through interviews as Key Informants when conducting technology audit of clay value chain in Rwanda.

Table 5: List of planned Key informants

SN	Institution/informants	Location of head office
1	Ministry of Justice (MINIJUST)	Kigali
2	Ministry of Environment (MOE)	Kigali
3	Ministry of Trade and Industry	Kigali
	Ministry of Infrastructure (MININFRA)	Kigali
4	Ministry of Local Government (MINALOC)	Kigali
5	Ministry of Finance and Economic Planning (MINECOFIN)	Kigali
6	Enabel	Kigali
7	Rwanda Environment Management Authority (REMA)	Kigali
8	Rwanda Mining Petroleum and Gas Board (RBM)	Kigali
9	National Industrial Research and Development Agency (NIRDA)	Kigali
10	Rwanda Housing Authority (RHA)	Kigali
11	Rwanda Land Management and Use Authority	Kigali
12	Vice Mayor of Economic Affairs/Maire of district (4)	District level
13	Director of One Stop Center (4)	District level
14	Infrastructure officer at district level/other officials(4)	District level
15	IPRC	District level

Notwithstanding that the above mentioned stakeholders were planned to be interviewed across the country; in total, 10 and 12 FGDs were undertaken with extractors and processors respectively were conducted as collective views of the key stakeholders (see annex 5.2), while 62 KIIs were met to inform the study(see annex 5.3). The list was expanded in order to capture views of different stakeholders involved in clay sector.

2.3. Secondary data collection

The secondary data were collected to complement the primary field data. Key documents were sourced from NIRDA, Enabel, Ministry of Environment, Rwanda Mining Petroleum and Gas Board, Rwanda Environment Management Authority, Ministry of Industry and Commerce, Ministry of Infrastructure, Ministry of Local Government, the National Institute of Statistics of Rwanda (NISR) and other relevant governmental and non-governmental institutions which host a comprehensive and complete dataset needed to perform this assignment. Furthermore, the secondary data were also obtained from published articles, books, reports and official gazettes of the Republic of Rwanda.

2.4. Research quality assurance and ethics

The research was subject to ethical approval. It was underpinned by a commitment to integrity, honesty and competence. Participation to the research was voluntary; all informants were asked to give informed consent to their participation. All interviews were carried out in private and confidentiality as well as anonymity were assured. All survey data were stored to ensure that there was no possibility of data leakage. Participants in KII and FGDs were asked to respect the confidentiality of what members of the group said. The Enumerators were trained on ethics, questionnaire contents and well as handling the gadgets. A pre-test was conducted to ensure the appropriateness of the data collecting tools as well as the statistical outputs.

2.5. Data analysis and report writing

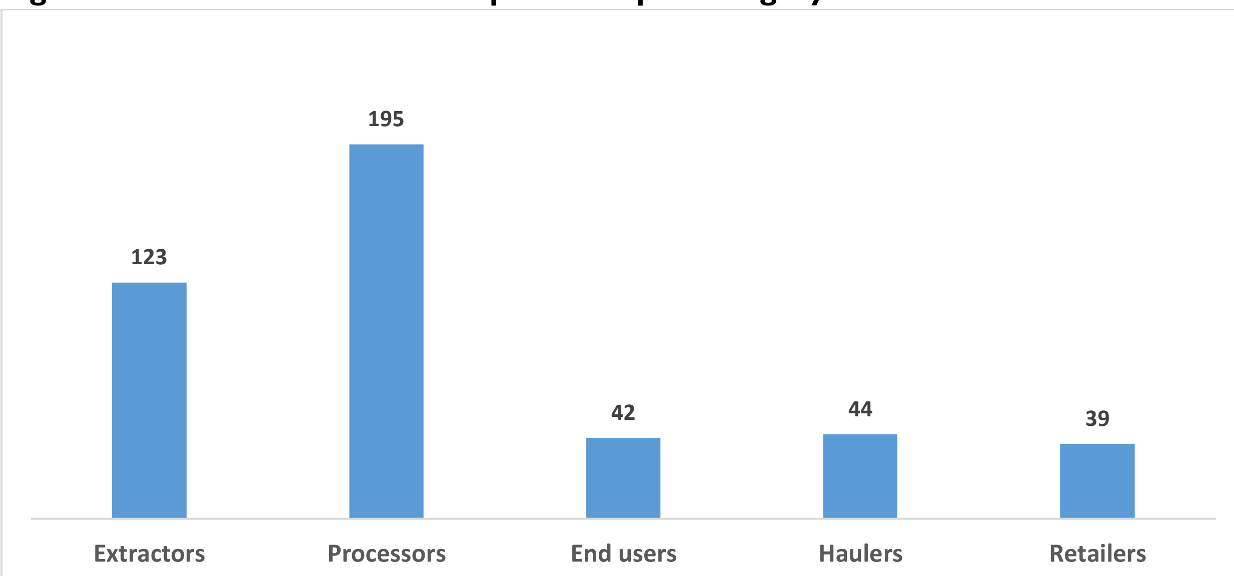
During analysis, descriptive statistics using SPSS were employed to analyse the findings of the survey and a comprehensive analysis of each stratum of value chain was undertaken. ArcMap software were used to prepare maps for geo-locating and identifying clay sites, as well as stratifying the number of different categorizations.

Triangulation of data was made with focus on the existing technology and technological capabilities that are available in the value chain versus what is available outside of Rwanda to increase the efficiency of products developed in the value chain including new products that could be developed if the relevant technology/technological capability would be available;
Furthermore, the analytical and comparative approaches were used to assess the local value chain technology audit versus what is available outside the country as well as the internationally competitive value chain.

3. ANALYSIS OF DATA AND PRESENTATION OF RESULTS

The section below provides the findings of the survey from the field on a number of indicators, which include demographic characteristics of respondents, description of firms, working conditions of employees, productivity and financial assets, infrastructure and technology in place, quality control and standards status assessment and environmental issues resulting from the used clay. It is important to mention that 29/30 districts were covered (97%) while the planned sample size was exceeded up to 109%. Basing on table 4 above, the following figure shows the distribution of respondents per categories of actors.

Figure 5: Distribution of data/respondents per category

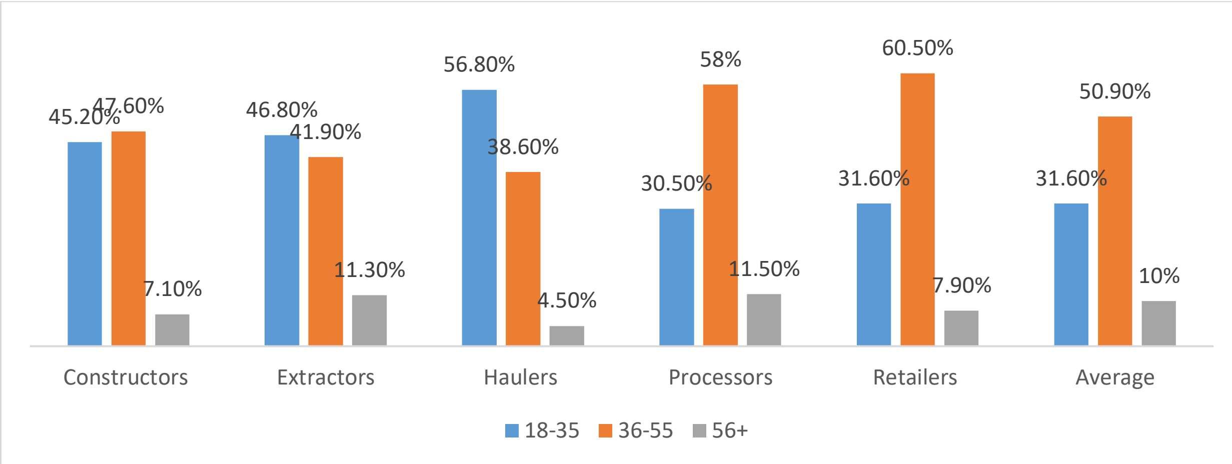


The figure above depicts that more processors (195) contributed to this study by responding to the individual questionnaire followed by extractors (123). Furthermore, haulers (44), End-users (42) and retailers (39) gave also their point of view by responding the questions addressed individually to them.

3.1. Demographic characteristics of respondents

It is worth noting that all interviewed respondents are included in extractors, constructors, processors and traders for both female and male. Therefore, the distribution of respondents by age has been presented below.

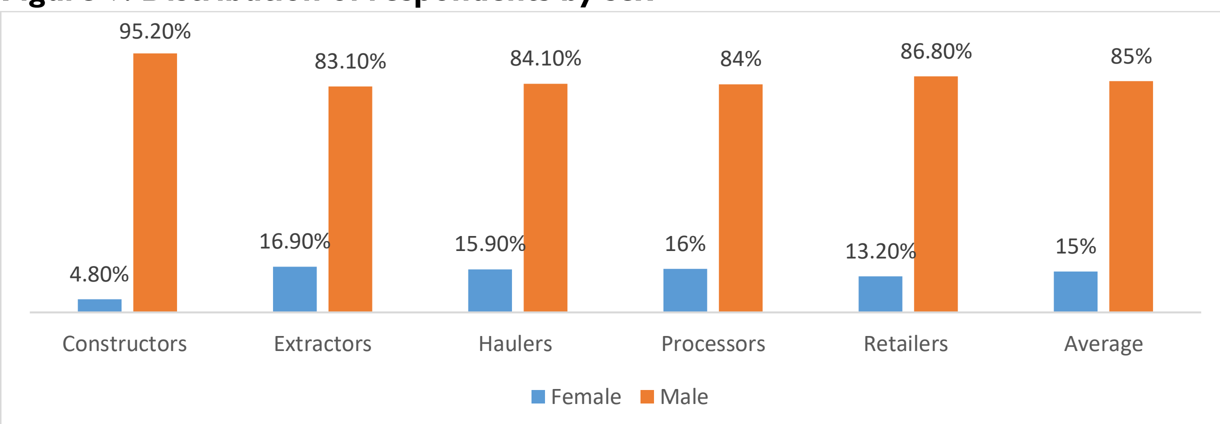
Figure 6: Distribution of respondents by age



Source: *Clay Tech Audit survey, 2020*

It was revealed that retailers (60.5%), processors (58%) and constructors (47.6%) are aged between 36 and 55 year while the majority of haulers (56.8%) and extractors (46.8%) are between 18 and 35 years old. The value chain actors with more than 56 years old are representing less than 12% in all categories. This implies that more than 85% of clay value chain actors are in the age group varying between 18 and 55 years. The distribution of respondents by sex is reported in figure below.

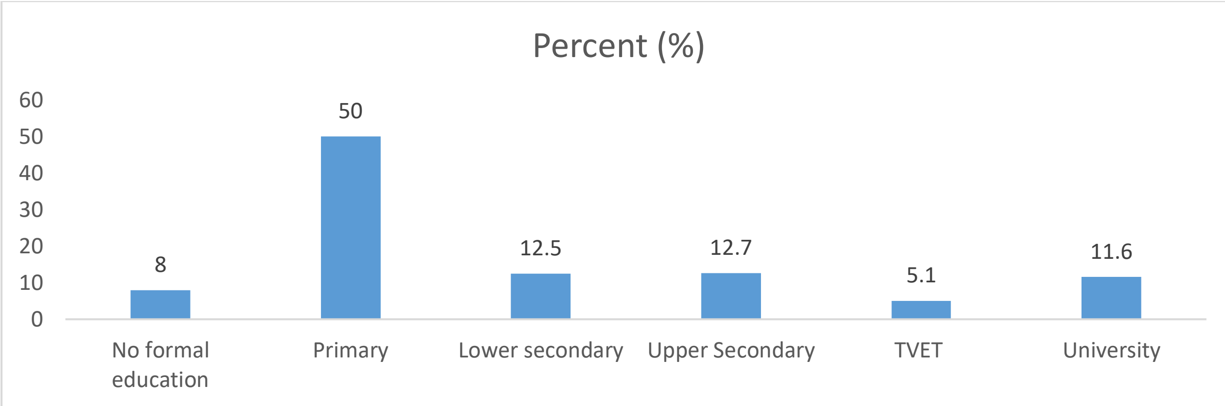
Figure 7: Distribution of respondents by sex



Source: *Clay Tech Audit survey, 2020*

The figure above depicts that more males (greater than 83%) were interviewed compared to the females (less than 17%) and very few in construction works/stage (only 4.8%). The highest number of interviewed males (95.2%) belongs to the constructors. This implies that males are much more engaged in activities linked to all stages of the clay value chain especially for the production of clay-based construction materials.

Figure 8: Education attainment by respondents



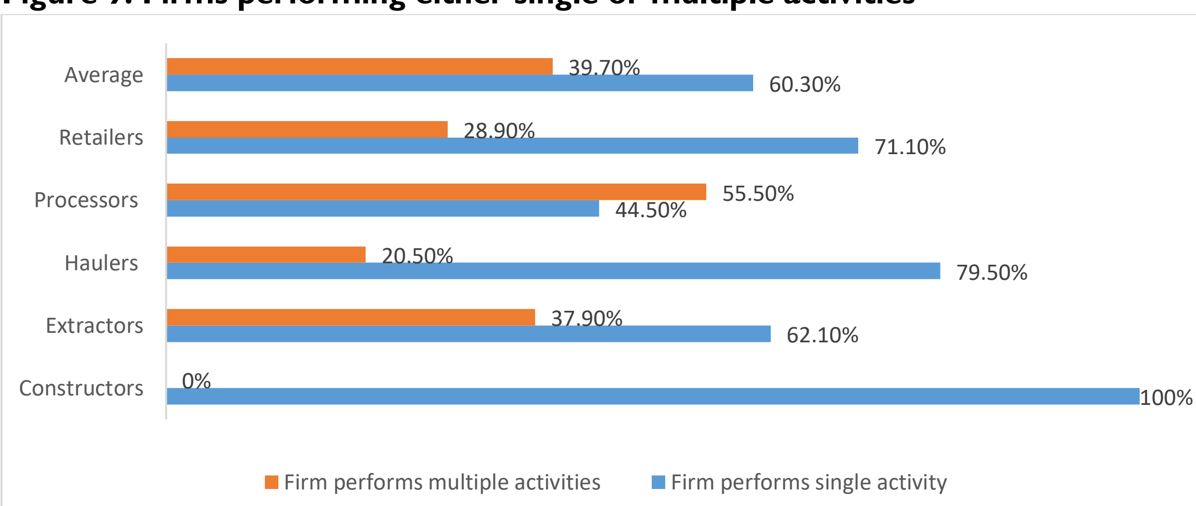
Source: *Clay Tech Audit survey, 2020*

Among the respondents, the majority (50) have at least primary education while only 8% did not go for formal education. That is to say that the data were collected from knowledgeable people in the sector who were all literate. The following figure shows details. The high number of staff who completed lower and upper secondary schools and TVETs are much more seen as constructors as reported by the members of FGDs and KII across visited districts. This shows that the clay sector is still using unqualified staff who implies traditional methods resulting into production of less competitive clay products. SKAT revealed to have conducted a good number of training to the employees from different clay based construction materials' firms. The feedback on the working hours per day are presented here below.

3.2. Description of firms

The information on the main activity of a firm engaged in clay value chain for construction materials informs on the expected products from such firm. Therefore, the information on whether visited firmed are performing either single or multiple activities are presented in figure below.

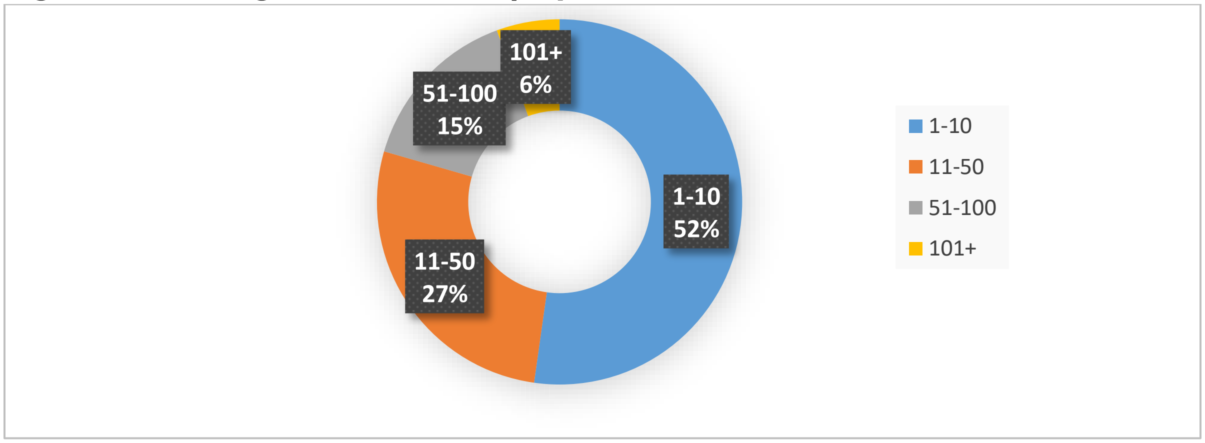
Figure 9: Firms performing either single or multiple activities



Source: *Clay Tech Audit survey, 2020*

The figure above reveals that 100% of constructors as well as the majority of haulers (79.5%) and retailers (71.1%) are performing a single activity while 20.5% of haulers and 28.9% of retailers are engaged in multiple activities of value chain. Moreover, the dominant percentage of processors (55.5%) are engaged in multiple activities especially extraction and processing as confirmed by the respondents in Focus Group Discussions (FGD).

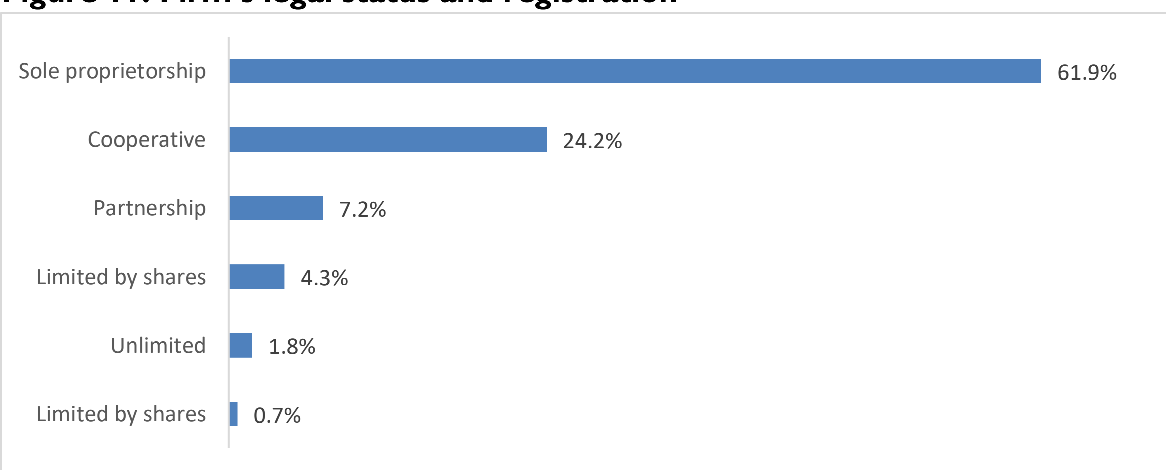
Figure 10: Average number of employees of the firms



Source: *Clay Tech Audit survey, 2020*

The figure reveals that the majority of firms possess less than 50 employees where 52% of visited firms use between 1 and 10 employees while 27% have between 11 and 50 employees. There are also 15% and 6% of firms who have employees ranged between 51 and 100, and above 100 respectively. The later include the industries like Ruliba located in Nyarugenge district. When the respondents were asked about the firm's legal status and registration what they reported has been captured in figure below.

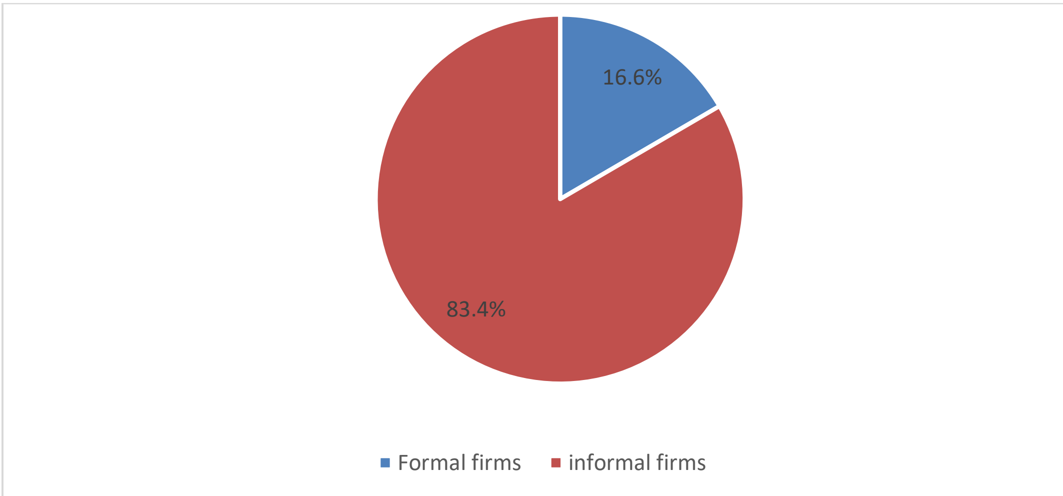
Figure 11: Firm's legal status and registration



Source: *Clay Tech Audit survey, 2020*

It has been declared that 64.9% of the visited firms belongs to sole proprietorship against 24.2% which are the properties of cooperatives while 7.2% are owned by different people working in partnership. Moreover, 4.3% of firms belong to different stakeholders in form of limited by shares and a negligible equal percentage of 1.8% and 0.8% of firms are registered as unlimited and limited by shares and guarantee respectively. This shows that there is still a need to sensitize the investors in clay products on the importance of investing by putting together shares to improve the competitiveness of Rwandan clay products. Additional data on origin of the firm's owners was presented in figure below.

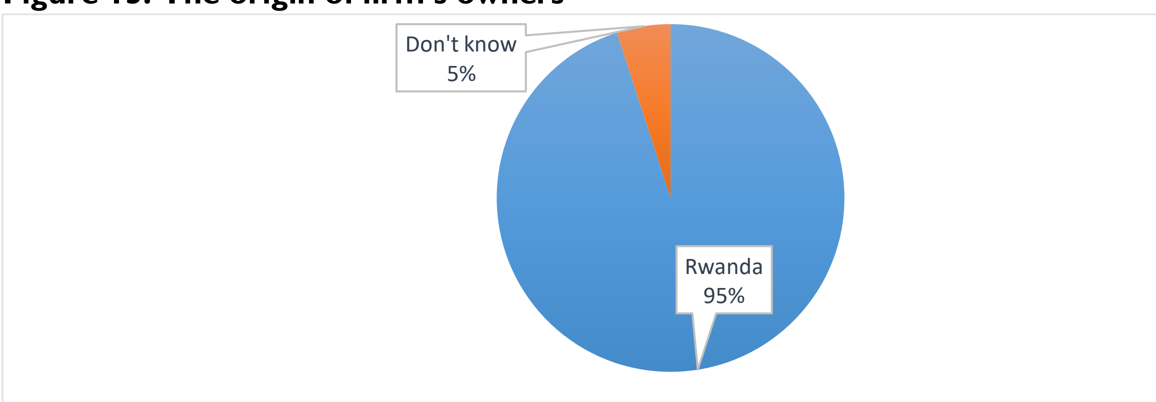
Figure 12: Firm's formality status



Source: *Clay Tech Audit survey, 2020*

The study revealed that majority (83.4%) of firms are informally operating across the country with only 16.6% are operating formally. The members of FGDs said that the process and requirements to get trading and quarrying licenses are very complicated; the reason why the majority of clay operators prefer to work under few firms/cooperative/individual which hold them. The origin of firm's owners are shown in figure below.

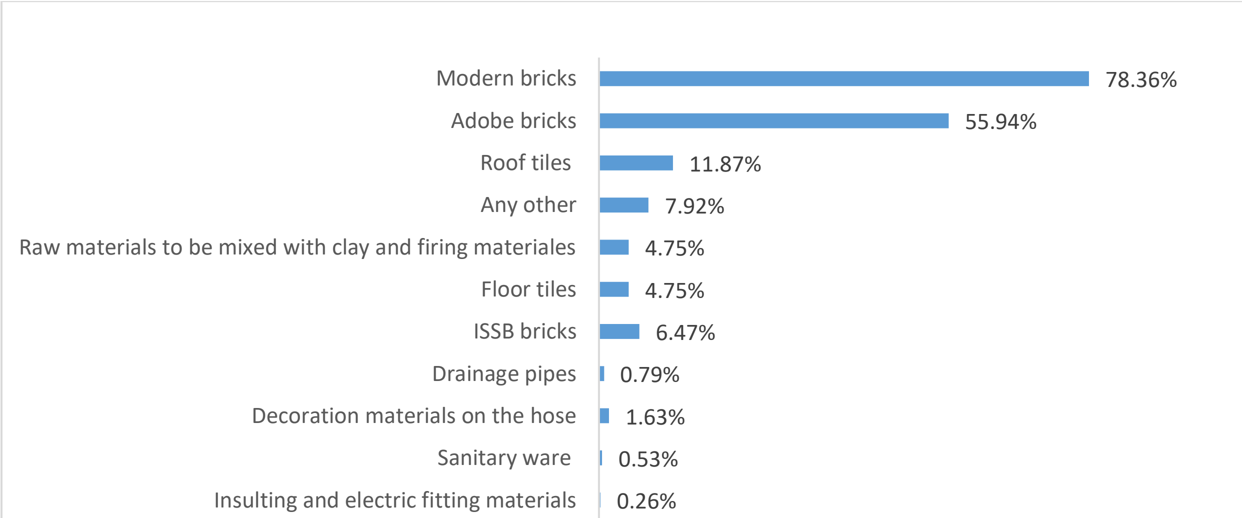
Figure 13: The origin of firm's owners



Source: *Clay Tech Audit survey, 2020*

It has been reported that the majority (95%) of visited clay firms are owned by Rwandans while the country of origin of the owners of 5% of firms were not given. This means that the foreigners are almost absent in the clay industry for construction materials. Hence, there is a need to sensitize and attract the foreigners' investors to come exploring the business opportunities existing in clay industry for construction materials to respond to the high demand on market in construction sector. These foreigners' investors would bring their experience and technologies in making clay-based construction materials to upgrade this sector in Rwanda. With regard to main activity of the firms, the feedback from the respondents was reported in figure below.

Figure 14: The main activity of the firms



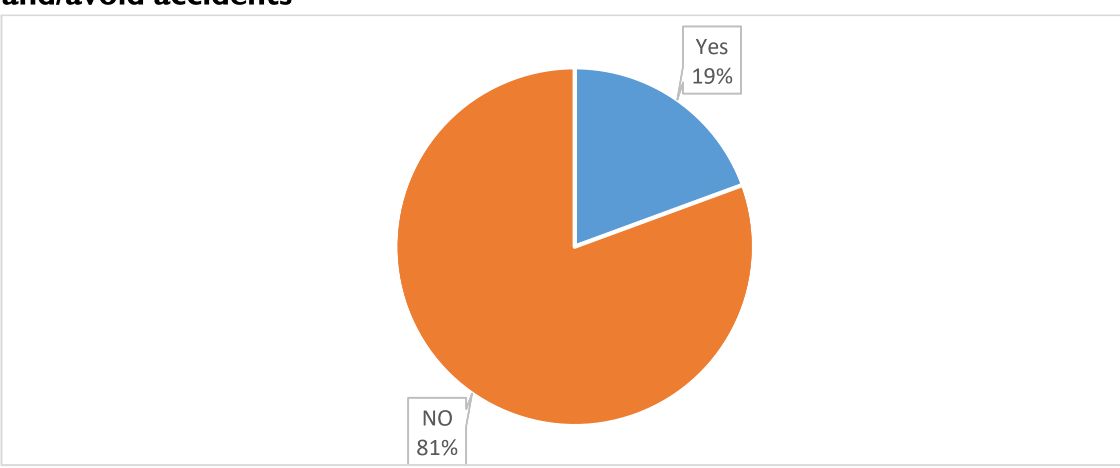
Source: *Clay Tech Audit survey, 2020*

The majority of clay firms (78.36%) are engaged in production of modern bricks compared to 55.9% who are engaged in production of adobe bricks and 11.8% are in production of roof tiles. It was seen that the adobe bricks are generally used for construction in rural areas while the modern bricks are dominantly used in urban areas as confirmed by the members of FGDs in various districts. Moreover, floor tiles are rarely produced because the existing clay deposits across the country are not of the good quality to make floor tiles as confirmed by the experts working with SKAT Ltd.

3.3. Working conditions of employees

Working conditions of the employees contribute to his/her productivity in the firm. Motivated employees contribute much more compared to the discouraged ones but there are different ways of motivating the employees. Therefore, this aspect was explored to assess whether the working conditions in place may facilitate the employees to be very productive or not.

Figure 15: Possession of clothes and other form of protection to reduce or and/avoid accidents



Source: *Clay Tech Audit survey, 2020*

It has been revealed that only 19% of firms' employees have appropriate clothes and other protection tools to reduce or/and avoid accidents at the work place. This percentage is still very low. Therefore, there is a need to sensitize the firm' managers to avail to their staff needed protection clothes and tools to avoid and reduce accidents at the working place.

Figure 16: Clay value chain actors at working place without appropriate clothes and other protection materials

Huye District, Tumba Sector, Mpare Cell, Kigarama Village

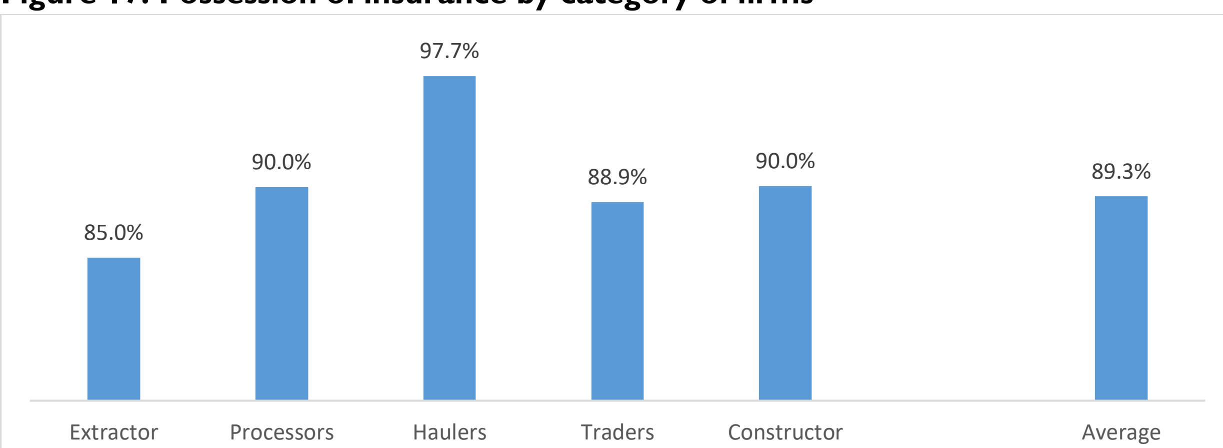
Nyanza District, Busasamana Sector, Nyanza Cell, Nyarunyinya Village

Gasabo District, Rusororo Sector, Nyagahinga Cell, Rusororo Village

Source: *Clay Tech Audit survey, 2020*

The figure above shows that working conditions of different clay value chain actors are unsafe which may result to potential accidents. Therefore, there is a need to avail to these workers appropriate clothes, shoes and other protection materials such as helmets and gloves. The possession of a health insurance scheme by households under investigation is presented in the figure below.

Figure 17: Possession of insurance by category of firms



Source: *Clay Tech Audit survey, 2020*

The GoR has promoted different health insurance schemes. The most affordable health insurance known as "Mutuelle de Santé" has had a significant impact in improving the standards of living and community

health in Rwanda. It has enabled the largest segment of the population to gain access to preventive, curative, rehabilitative and palliative health services.
This "Mutuelle de Santé" scheme has also been credited with mitigating the catastrophic out-of-pocket expenses on health care and promoted the culture of seeking early treatment, consequently reducing the burden of health bills on households and minimizing the use of unorthodox treatment respectively. Therefore, the study revealed that more than 85% of investigated clay value chain actors possess an activated "Mutuelle de Santé" with the remaining having access to another health insurance scheme (e.g., RSSB, MMI, CORAR, MEDIPLAN) possessed by household heads or spouse although the details about other schemes were not provided at satisfactory level. It is worth mentioning that in 2015, GoR moved the management of "Mutuelle de Santé" to Rwanda Social Security Board to improve its efficiency and augment access across the country. The clay value chain actors are very happy with this health insurance scheme as it was scaled up to cover any type of needed medical treatment including accidents at the work place (EICV 5, 2018).

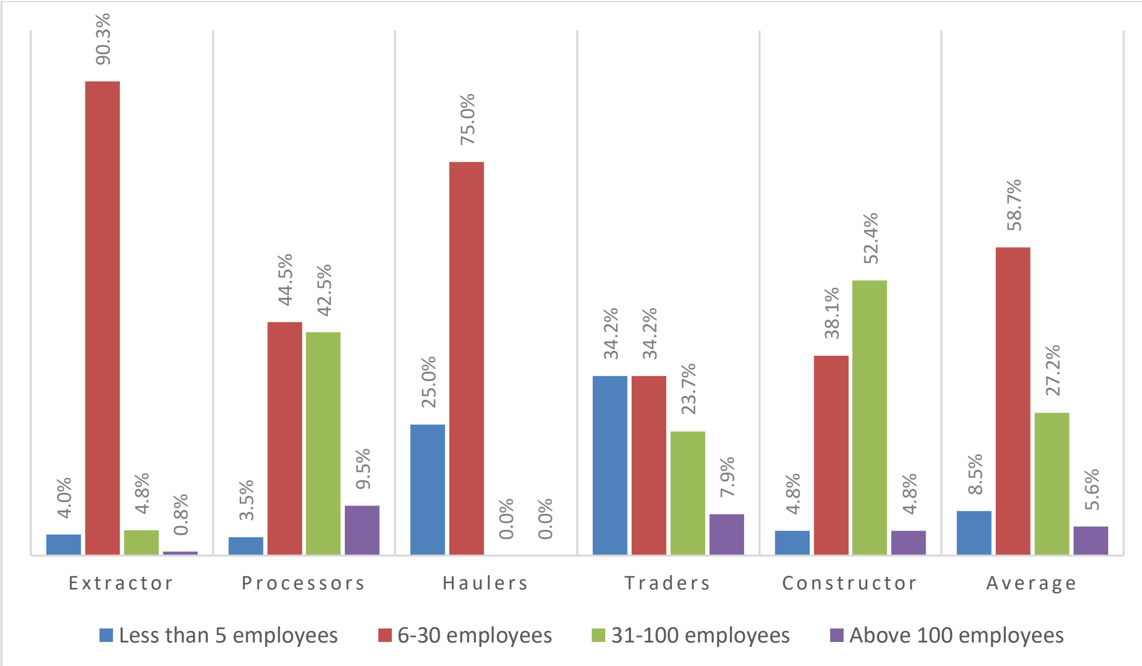
Table 6: Working schedule by category

	Extractor	**Processors**	**Traders**	**Constructor**	**Average**
Full time	56.1%	58.6%	50.3%	77.1%	63.70%
Part-time	34.6%	26.8%	33.0%	5.4%	19.20%
Occasional workers	9.3%	13.8%	16.7%	14.5%	15.60%
Professional Intern	0.0%	0.9%	0.0%	3.0%	1.50%
Total	100%	100%	100%	100%	100.00%

Source: *Clay Tech Audit survey, 2020*

The table above shows that the highest number of firm's employees by category are full time employees working as either extractors (56.1%), processors (58.6%), traders (50.3%) or constructor (77.1%). Moreover, it was highlighted in FGD that the constructors are only fully engaged to complete specific houses and at specific stage. A good percentage of extractors (34.6%), processors (26.8%), and traders (33%) are working as part-time employees. It is necessary mentioning that a negligible percentage of professional interns were seen among processors (0.9%) and constructors (3%) while they were absent in extraction and trading of clay products. This gives an indication that extraction of clay is still traditional in nature. Therefore, the suggestion comes to integrate teaching and learning programs related to the processing of clay based construction materials in TVET and technical schools to improve the sector. The average number of firm's workers is presented in figure below.

Figure 18: Average number of firm's workers



Source: *Clay Tech Audit survey, 2020*

The majority of firms investigated revealed that the highest number of firms have between 6 and 30 employees especially in clay extraction (90.3%) and transporting clay products (75%). A high number of employees was also found in construction and processing stages where 52.4% and 42.5% of respondents respectively confirmed that their firms/companies have between 31 and 100 employees. Moreover, 34% of traders and 25% of haulers reported to have less than 5 employees engaged clay related activities. The highest number of firms with employees above 100 were 9.5% and majority were processors while 7.9% were traders. There were no firms employing more than 30 employees as haulers. The feedback on the working hours per day are presented here below.

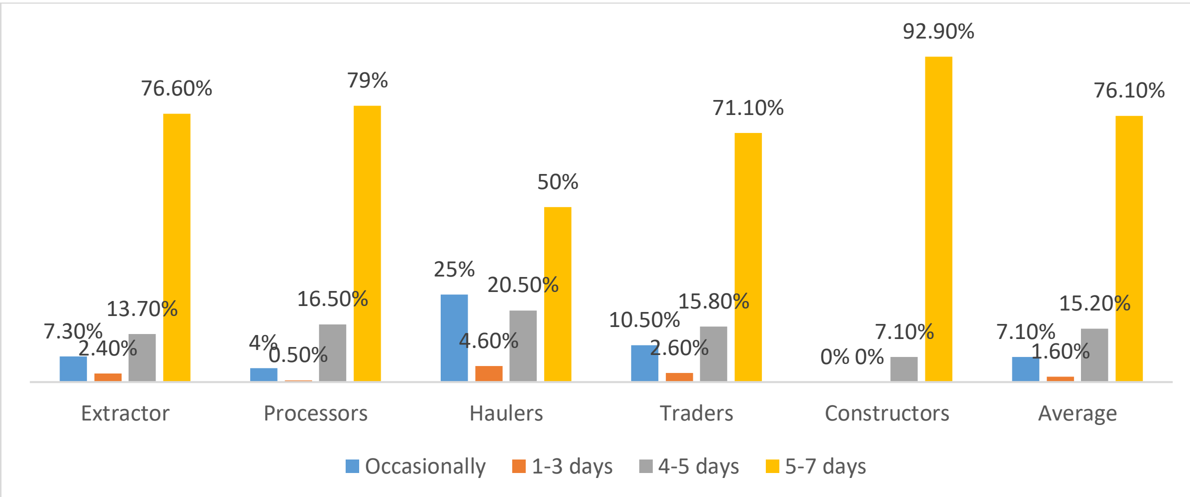
Table 7: Working hours of firm's staff per day

	Extractors	Processors	Haulers	Traders	Constructors	Average
Occasionally	12.1%	5.0%	9.1%	10.5%	0.0%	7.4%
Less than 4 hours	0.8%	0.0%	0.0%	0.0%	0.0%	0.2%
4-8 hours	33.9%	45.0%	43.2%	23.7%	28.6%	38.4%
8-12 hours	53.2%	48.5%	47.7%	63.2%	71.4%	53.1%
More than 12 hours	0.0%	1.5%	0.0%	2.6%	0.0%	0.9%
Total	100%	100%	100%	100%	100%	100%

Source: *Clay Tech Audit survey, 2020*

The table above informs that the highest number of firm's staff work between 8 and 12 hours per day in each category. This includes extractors (53.2%), processors (48.5%), haulers (47.7%), traders (63.2%), and constructors (71.4%). This is followed by a group of extractors (33.9%), processors (45%), haulers (43.2%), traders (23.7%), and constructors (28.6%) are working between 4 and 8 hours a day. This shows that the majority of firms' staff are spending between 4 and 12 hours at work. This working time is reasonable if the employees are given a good salary and also an annual paid leave. Moreover, there is a very low percentage of firm's staff (less than 1%) working less than 4 hours and others (less than 3%) who are working more than 12 hours. When respondents were asked about the working days per week, the feedback given was reported in figure below.

Figure 19: Working days per week



Source: *Clay Tech Audit survey, 2020*

It was reported that between 70% and 80% of extractors, processors and traders spend between 5 and 7 days per week at work compared with 92.9% of constructors who are at work in the same period with only 50% of haulers working the same days per week. Apart from 25% of haulers who are occasionally engaged in clay related activities during a week, there are very few clay actors (less than 10%) who are working less than 3 days per week. This a good indication that most of clay actors are dedicated to their activities as they spend most of their days of a week at work implying that their livelihood depend on income generated from the clay related activities. The information on the received incentive by employees of the firms is presented in table below.

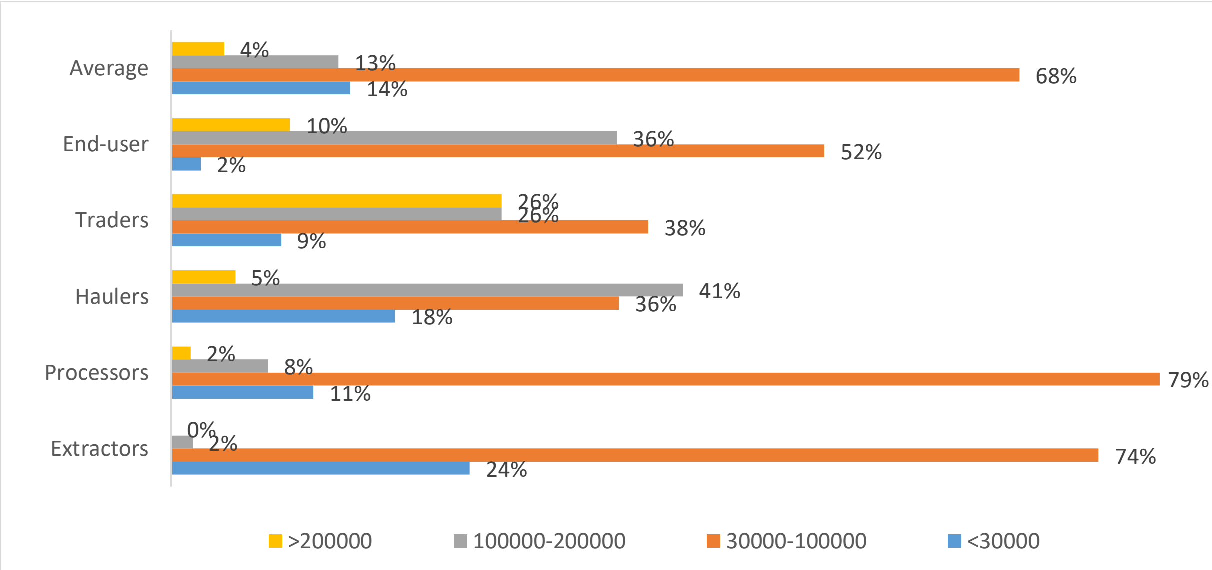
Table 8: Received incentive by employees of the firm in past 12 months

	Extractors	Processors	Haulers	Traders	Constructors	Average
Fixed monthly bonus	0.8%	4.0%	11.4%	5.3%	4.8%	4.0%
Bonus on done activity	4.0%	14.0%	11.4%	10.5%	7.1%	10.0%
Trainings	1.6%	1.0%	0.0%	0.0%	2.4%	1.1%
Irregular bonus	23.4%	35.5%	18.2%	34.2%	16.7%	28.6%
No incentive received	70.2%	45.5%	59.1%	50.0%	69.1%	56.3%
Total	100%	100%	100%	100%	100%	100%

Source: *Clay Tech Audit survey, 2020*

This study explored the incentive given to the employees by the firms and it was found that the majority of the clay actors did not receive any incentive as declared by the highest number of extractors (70.2%), processors (45.5%), haulers (59.1%), traders (50%) and constructors (69.1%) respectively. However, there are a good number (varying between 16% and 36%) of clay actors who reported to have received irregular bonus in past twelve months. The percentage of staff who benefited from trainings is very low which implies a poor capacity building strategies in clay sector. The average monthly income of firm's employees is presented in figure below.

Figure 20: Average monthly income of firm's employees



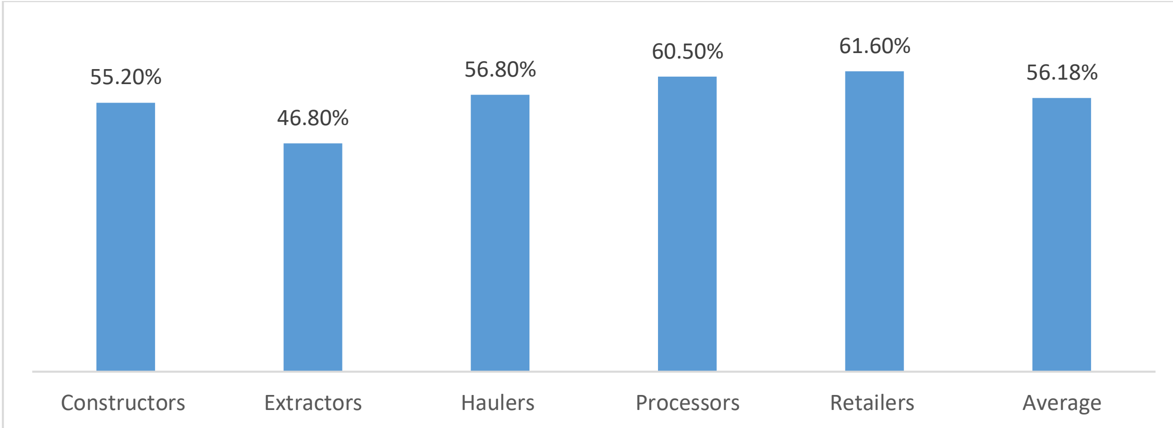
Source: *Clay Tech Audit survey, 2020*

The figure above reveals that more than 70% of extractors and processors earn between 30,000 Rwf and 100,000 Rwf on average per month while the remaining proportion in these groups get less than 30,000 Rwf per month during the past 12 months with exception of 8% who are paid a salary varying between 100,000 Rwf and 200,000 Rwf and 2% of processors who are paid above 200,000 Rwf. This means that the extractors are the least paid among other clay value chain actors while traders are the most well paid than any other clay actors whereby 52% of them get more than 200,000 Rwf and between 100,000 Rwf and 200,000 Rwf per month.
Though 52% of constructors are getting a salary of less than 30,000 Rwf, there is 36% of them who are paid a salary ranging between 100,000 Rwf and 200,000 Rwf. Another 10% of them receive a monthly salary of above 200,000 Rwf and only 2% of this group of constructors are paid less than 30,000 Rwf. This shows 18% of the extractors, processors and haulers get paid less than 30,000 Rwf and 36% receive a monthly salary ranging between 30,000 Rwf and 100,000 Rwf.

The findings presented in the figure above reveals that the majority of clay value chain actors are getting a monthly salary of less than 100,000 Rwf. This salary is probably linked with the low qualification of clay value chain actors as it was shown in figure 18. In all cases, these salaries are very low to sustain a family.

With this regard, clay operators were asked on the level of satisfaction with the value of money the clay value chain actors get from clay-based activities, what they said was summarized in figure below.

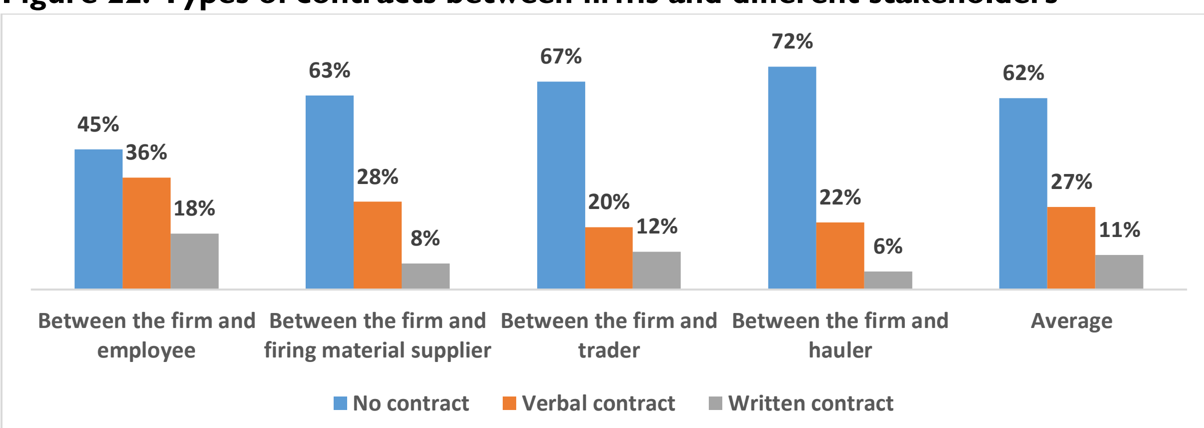
Figure 21: The level of satisfaction of clay value chain actors in terms of income



Source: *Clay Tech Audit survey, 2020*

The study revealed that only between 55% and 62% of clay value chain actors are satisfied with the income they gain from clay based activities with only 46.8% of extractors who showed such satisfaction. Reference to the feedbacks from FGDs which took place with extractors and processors, the majority of participants in the discussions were not happy with the income they get from clay based activities but they confirmed to have a hand on cash regularly compared to others who are engaged in farming activities. They wish to see their income increased as they claimed that the big portion of income from their activities goes to the firm's owners rather than being well paid. When respondents asked about the types of contracts existing between firms and different stakeholders, the provided feedback was presented in figure below.

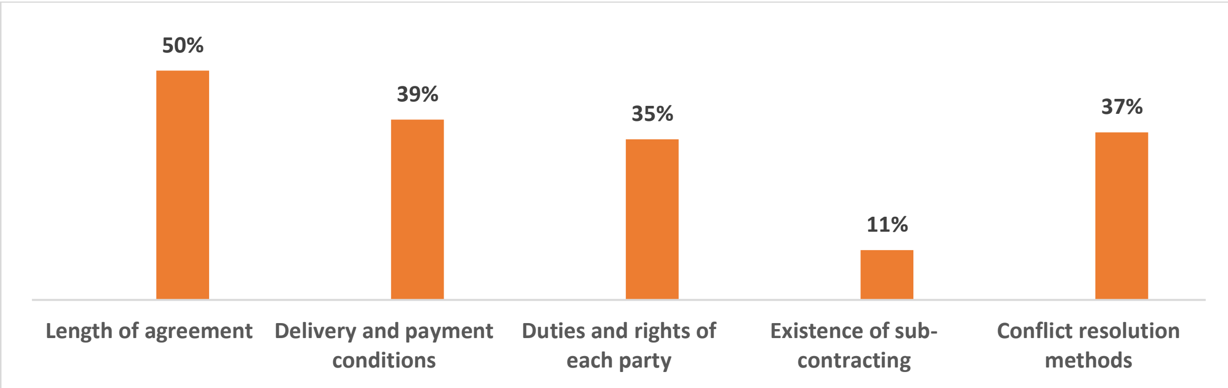
Figure 22: Types of contracts between firms and different stakeholders



Source: *Clay Tech Audit survey, 2020*

The study revealed that the majority of firms do not have any contract between the firm and various stakeholders as only 18% of firms have confirmed to have written contracts with employee and 12% with traders while only 8% and 6% of the firms have contracts with firing material suppliers and with haulers respectively. Furthermore 36 % of employees, 28% of firing material suppliers, 22% of haulers and 20% of traders have confirmed to have verbal contracts with the firms. Absence of contracts between firms and employees, traders, raw material suppliers, haulers makes them unsafe at rendering their services as they can be stopped any time. Additionally, the existence of contracts would help the employees, raw material suppliers, traders and haulers to take loans from the banks to extend their businesses or develop new projects otherwise it is very hard to depend only on monthly salary to extend clay related business or to undertake new projects.

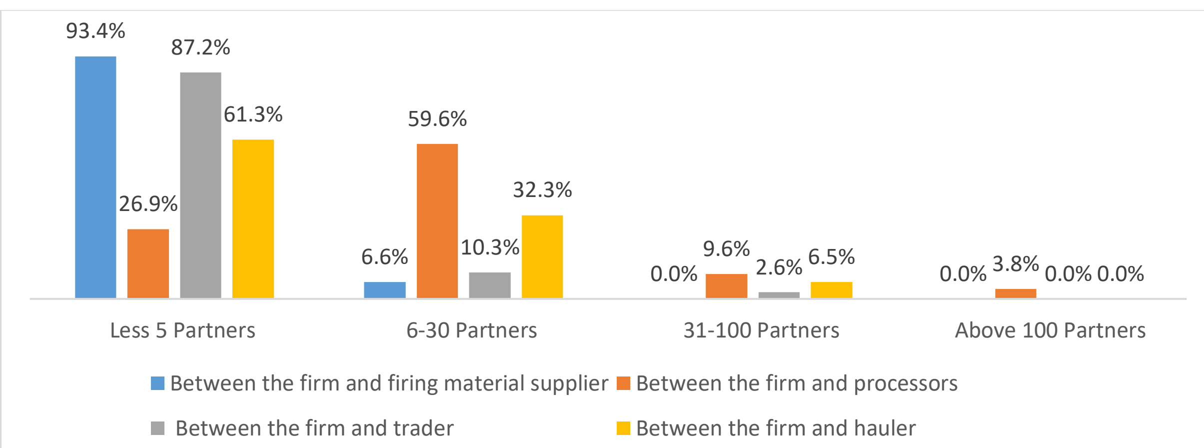
Figure 23: Key aspects highlighted in contract



Source: *Clay Tech Audit survey, 2020*

When the respondents who have confirmed to have written contracts with firms involved in clay value chain for construction materials, they confirmed that their contracts highlight the length of agreement (50%), delivery and payment modalities (39%), duties and rights of each party (35%) and conflict resolution methods (37%) with 11% of firms who have confirmed to have included the existence of sub-contracting in the contract. When the respondents were asked whether they have consulted the lawyers about signing the contracts, the answer was 'no' for the majority of the respondents. This means that the contracts are not prepared by professionals in the domain which might results into inconsistence in different articles of the contract.

Figure 24: Existing partnership involved in stages of the clay value chain



Source: *Clay Tech Audit survey, 2020*

Based on the information gathered from the field, the most partnerships were seen between the firm and firing material suppliers because there are different types of materials to fire bricks and tiles other partnerships in clay value chain activities were seen between the firm and traders followed by the existing partnerships between firm and processors. Moreover, most of firms have less than 5 permanent partners in the business with except in partnership between firm and processors where 59.6% and 9.6% of respondents confirmed to have between 6 and 30 and between 31 and 100 partners respectively in their business. It can be depicted from the figure above that the dominant partnership is between the firm and firing materials suppliers. Moreover, it is necessary to highlight that the partnership rate of the firm with other stakeholders is linked with its productivity and financial assets. Thus, this aspect was analyzed below.

3.4. Productivity and market analysis

The study revealed that there are a variety of clay products manufactured across the country as presented in the table below.

Types of products	Technical description	Manufacturing characteristics	Examples
Modern bricks	***First class bricks (Grade A):*** First-class bricks are fine-looking, well-burnt in kilns, table-moulded, rectangular with sharp edges. Its surface is clean, smooth and it has no cracks, these bricks are very hard bricks. First-class bricks are mostly used for face work structure or superior work.	***First Class Bricks:*** These are 19 x 9 x 9 cm in size. They are made from good quality of clay, free from saline deposits. They should be thoroughly burnt. They should be of good color. They should be of regular shape with square edges and parallel faces. These bricks are free from flaws, cracks, chips, stones, etc. They should give a ringing sound when two bricks are struck together. Its compressive strength shall not be less than 140 kg/cm2. And they shall not absorb more than 20% of water when immersed in water for 24 hours. *USE:* Excellent for all types of construction in the exterior walls. They are also suitable for flooring.	

Traditional fired/burnt bricks	***Second class bricks (Grade B):*** Second class bricks are burnt in clamps and ground-moulds but with a slight irregularity in shape. Its surface is rough and has spots, these bricks are tough. These bricks are used in ordinary structures and places where the brick coat provided with a plaster coat. Advertisement ***Third class bricks (Grade C):*** The third class clay bricks are moulded to the ground and burnt in a clamp.	***Second Class Bricks:*** Second class bricks are also fully burnt and give a clear ringing sound when struck together. Slightly irregularities in shape, size or color are accepted. Its compressive strength shall not be less than 70 kg/cm^2, and absorption value should not be greater than 22% when soaked for 24 hours in water. Slight difference in the structure on fractured surfaces is admissible. *Use:* For exterior work when plastering is to be done. And can also be used for interior works but they may not be used for flooring.	  

	Its surface is rough and has distorted edges, these bricks are slightly soft. These bricks are used in irrelevant and temporary structures, especially places where rainfall is not heavy. ***Fourth class bricks (Grade D):*** Fourth class bricks are over burnt bricks. Its surface is irregular and its colour is dark, these bricks are very hard. These bricks are used in foundations, floors, roads, etc.		
Traditional unburnt bricks (Adobe)	These are not burnt but are generally of uniform reddish yellow or black color. Defects in uniformity or shape are tolerated. On striking together, they produce a dull thud sound.	Its compressive strength lies between 35 – 70 kg/cm2 and absorption between 22 – 25 percent.	
Tiles	Traditional "U" and "S" shape tiles	This tile has a "U" or "S" shape that creates a distinctive interlocking design. These tiles are made from two components, including a rounded top section and a flat bottom piece. The bottom unit is laid flat on the roof and uses	

		flanges to keep water off the roof surface. The rounded top portion overlaps the flanges to mimic the look of Mission tile. Flat clay tiles are known as Mangalorean or interlocking units.	
	Modern tiles	Modern tiles have different designs and shapes,	

Source: https://constructionor.com[7]

The production of each firm informs on the potential financial profit which can be made by specific firms. The analysis of Hydraform sub-sector was specifically analyzed in following paragraphs as it was seen as the best alternative of traditional burn bricks if the need to reduce firing bricks arise.

The hydraform blocks, also known Interlocking Stabilised Soil Blocks (ISSB), are made of a mixture of soil (with clay content less than 13%), cement, coarse sand / stone dust (if required), water (potable quality) The term soil stabilization implies improved in strength and durability of soil i.e a less stable soil after treatment improves the strength and resistance to erosion and water absorption with purpose for which it is adopted whether it is for roads, buildings, embankments etc.

The use of hydraform building blocks produced by hydraform machines helps to boost the construction of affordable housing because a structure constructed with hydraform blocks is cheaper than one with conventional bricks and is believed to be more durable. These blocks do not necessitate cement between them. They just interlock them until the house gets complete. A hydraform block costs Rwf 130 and it can take up the space of ***four*** conventional bricks compared with one clay mpunyu (less durable) and one modern brick selling at an average price of Rwf 31 and Rwf 117.5 respectively.

A hydraform machine has capacity to produce one block per nine to 14 seconds or 2,200 hydraform blocks per day, and consumes 13 litres of diesel to perform the work with each machine worth $34,000 (about 33 million Rwf).

A 50-kilogramme bag of cement can help produce 45 hydraform blocks, each weighing between 10 to 12 kilogrammes. The quantity of soil would be 12 times the quantity of cement and the soil should have not more than 13 per cent of clay in it. The activities take place on the construction site thus elimination the transportation costs and wastage of materials and time.

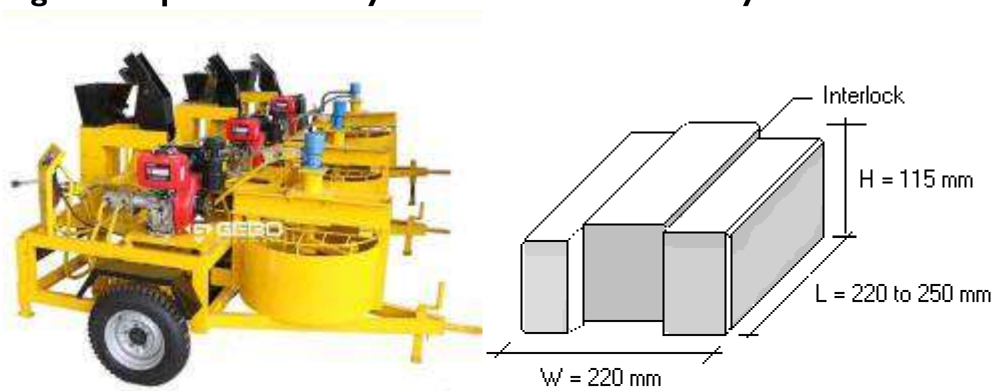
It is therefore very important to recommend the use of Hydraform ISSB for construction purposes because of their advantages over the other bricks.

[7] https://constructionor.com, retrieved on 10 November 2020

Their advantages are that they are:

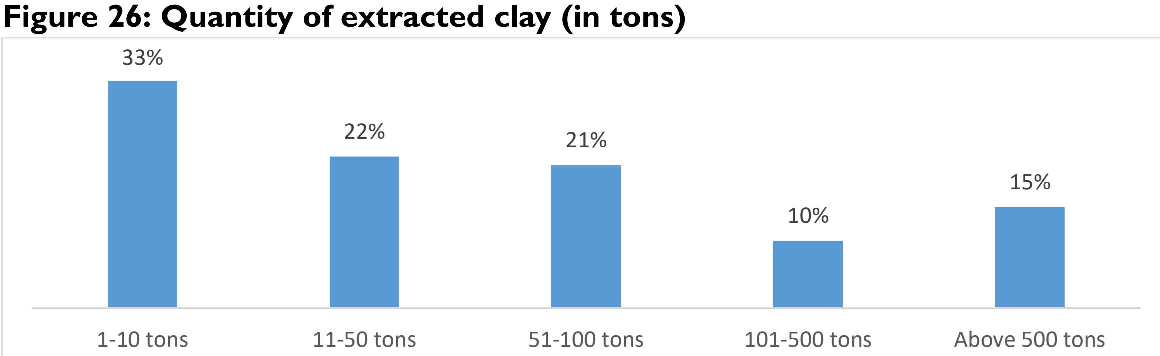
- much stronger than hollow cement blocks, bricks or other locally available alternatives;
- considerably less expensive than hollow/solid concrete blocks ;
- made on site, so transport costs are eliminated;
- environmentally friendly – low energy input and no depletion of trees for burning, does not use top soil meant for agriculture purpose, uses waste like fly ash and other materials;
- most attractive, with a face-brick appearance in the natural colours of different soil/fly ash, with beveled edges;
- as interlocked to facilitate fast construction because the blocks can be largely dry stacked (built without mortar).

Figure 25: picture of a Hydraform machine and Hydraform ISSB brick



It is in this regard that the average quantity of extracted clay was analyzed and presented in figure below.

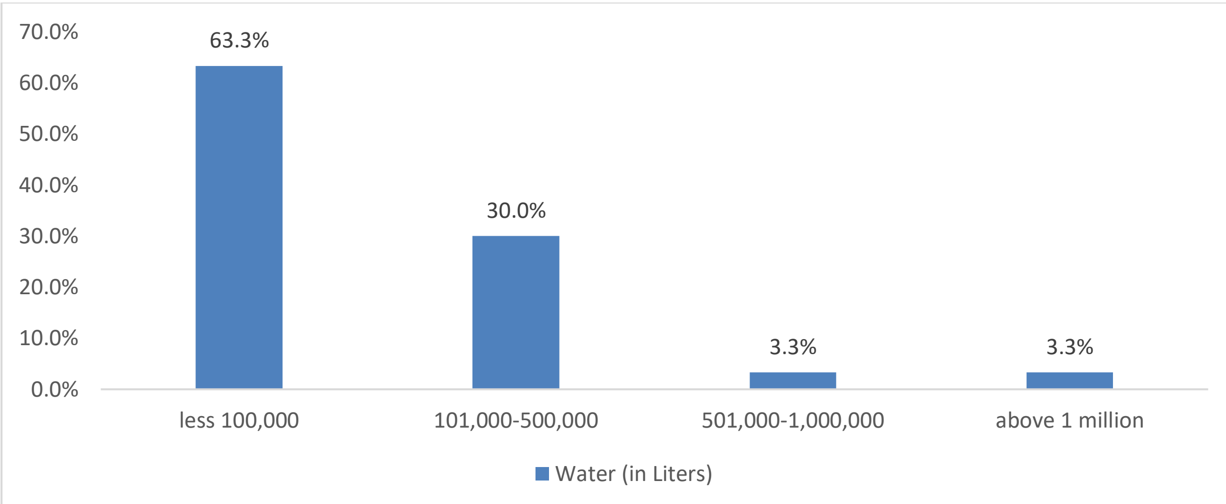
Figure 26: Quantity of extracted clay (in tons)



Source: *Clay Tech Audit survey, 2020*

Based on the information gathered from respondents, 33% confirmed to have used between 1and 10 tons, 22% have used between 11and 50 tons, 21% have used between 51 and 100 tons, while 10% have used between 101 and 500 tons and 15% used above 500 tons respectively. The quantity of extracted clay was estimated by taking the quantity of clay used to produce one brick or tile multiplied by the total number of produced items. This quantity informed about the needed land for reclamation of extracted area. Additionally, further studies can be undertaken to assess the total amount of clay soils taken out from the environment for construction purpose. The average processed bricks and tiles per year is presented in figure below.

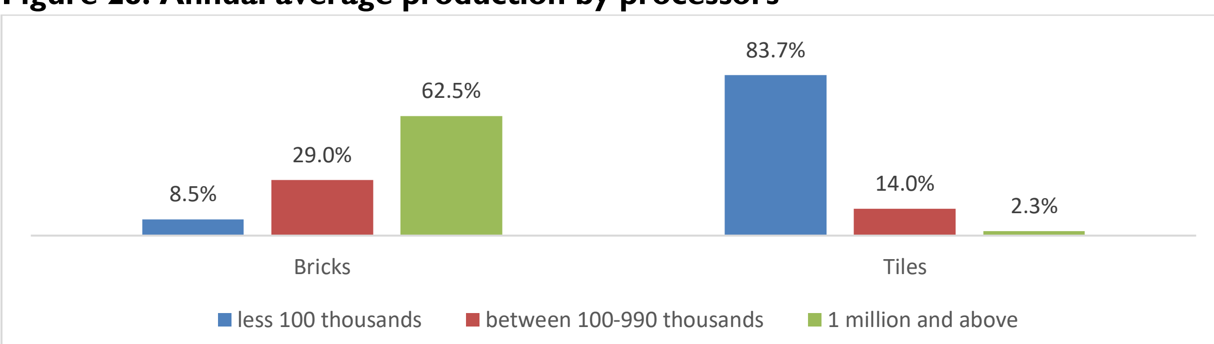
Figure 27: The quantity of water used in the past 12 months in processing stage



Source: *Clay Tech Audit survey, 2020*

The study revealed that 63.3% of firms have used less than 100,000 litres while 30% used between 101,000-500,000 litres with a negligible percentage of firms which used more than 500,000 litres in past 12 months. Moreover, it is difficult to estimate the quantity of water used when all activities are taking place in marshlands where the water is used and flows as waste back in swamps and marshlands. The average production of processors per year was presented in figure below.

Figure 28: Annual average production by processors

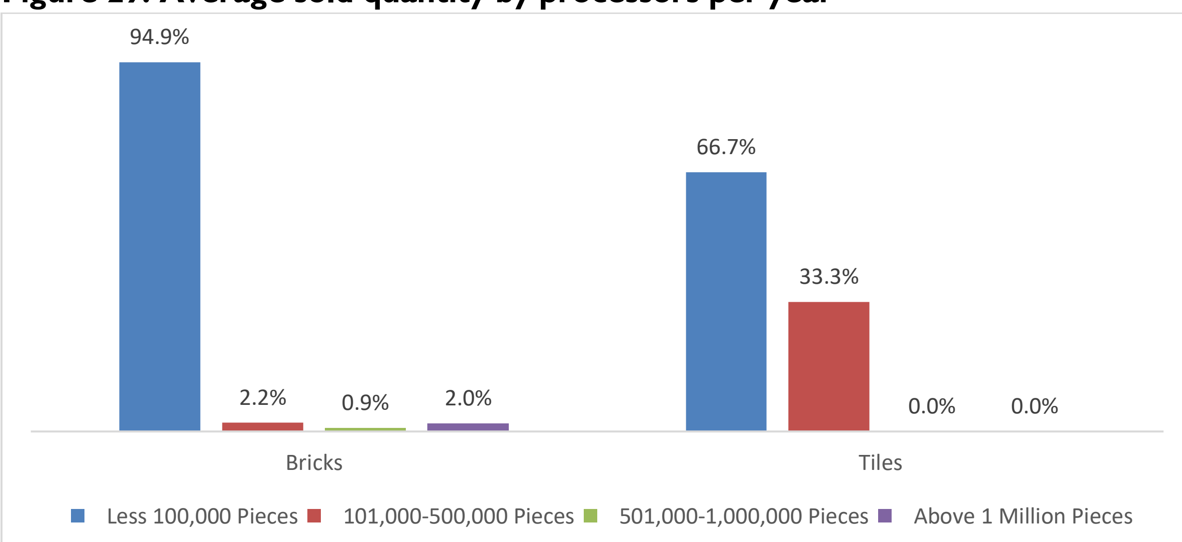


Source: *Clay Tech Audit survey, 2020*

The figure above shows that more bricks are produced compared to the tiles. For instance 62.5% of firms have declared to have produced more than a million bricks compared to 2.3% which produced the tiles in the same range. Furthermore, 29% of firms produced between 100 and 990 thousands bricks in past 12 months compared to 14% of firms that produced the same quantity of tiles. On the contrary, 83.7% of firms produced less than 100 thousands tiles compared to 8.5% that produced the same quantity of bricks. This implies that the bricks are highly needed on the market compare to the tiles. Moreover, further investigation should be undertaken to investigate the reason behind of the low preference of tiles compared to the iron sheets in Rwanda.

Additionally, Rwanda's construction sector has grown steadily over the years despite the high cost of raw materials. GoR envisions that by 2020 approximately 30% of the population will live in urban areas. To date, only about 5% of residents in Kigali own modern-style houses In Kigali alone, there is fast growing population (3%- 5% year average) combined with urban growth currently at more than 4% per annum. The demand for housing is (8,000 - 10,000) units per annum. The combined demand for housing countrywide was estimated to be more than 25,000 units per annum. With clay materials construction already representing a large part of housing construction, its demand can only rise. Moreover, supply of clay construction products was restricted to few industries despite the high demand. Local production was estimated to be around 50,000 T annually for clay bricks and tiles (Rwanda Mining Policy, 2009[8]), which was barely enough to meet demand at that time so this quantity cannot satisfy the current market. (Ministry of Trade and Industry, industrial sub-sector Master Plan for construction materials, 2015).

Figure 29: Average sold quantity by processors per year

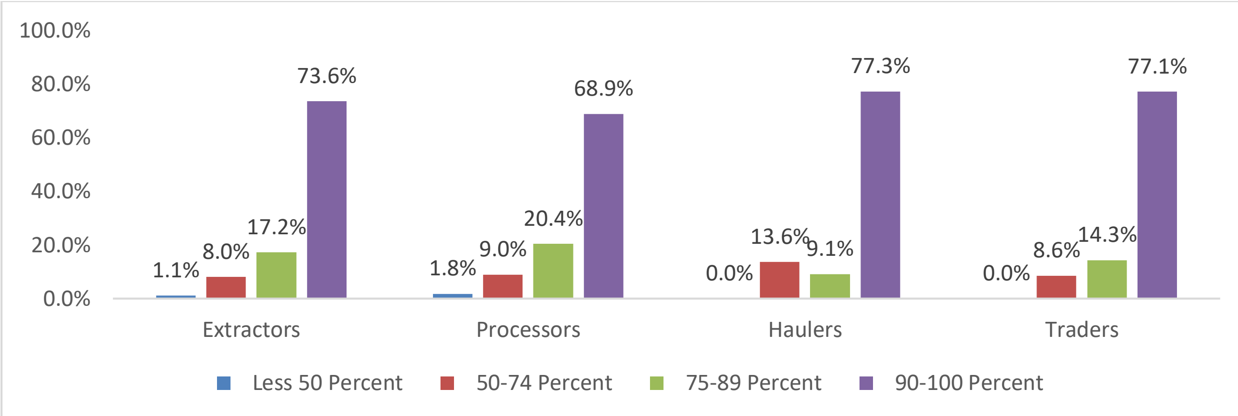


Source: *Clay Tech Audit survey, 2020*

The figure above depicts that modern bricks dominated on the market compared to the tiles in past 12 months as 94.9% and 66.7% have declared to have sold less than 100,000 bricks and tiles respectively. Furthermore, there is 0.9% and 2% of firms which sold between 501,000 and 1,000,000 and above one million bricks respectively while no single firm has managed to sell such quantity of tiles. This shows that bricks are much more needed on the market compared to tiles. The delivery ratio to the production was also analyzed and findings presented in figure below.

[8] Rwanda Mining Policy, 2009

Figure 30: Delivery ratio to the production

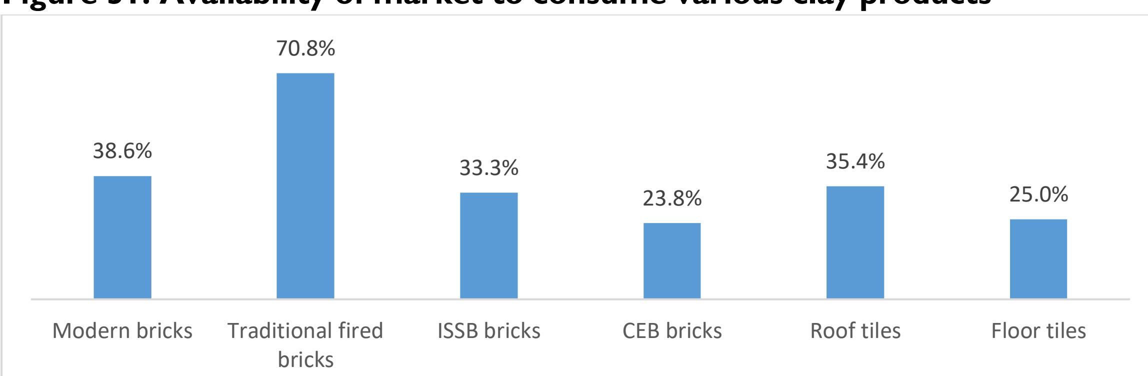


Source: *Clay Tech Audit survey, 2020*

The figure above shows that more than 70% of respondents confirmed that between 90-100% of production is delivery, they said also that between 75-89% of the production is delivery to the ratio of between 10 and 20% in different categories of clay value chain operators. This shows a big loss of more than 20% of production during delivery process from one stage of value chain to the next one. This may result from various reasons like poor delivery tools, poor quality of product or long distance taken to deliver clay product. Therefore, there is a need to develop appropriate mechanisms which will help to reduce the losses occurred in delivery processes.

The study also explored the profitability of clay products by comparing production cost and selling cost, then the findings revealed that most of clay value chain actors get profit from what they produce but they confirmed that the price per unit varies depending on climatic season, the quality of clay used, and type of products. Although, it was hard to compute the earned profit on each type of brick, tile or any other clay product but the average annual total firm's turnover was analyzed and presented in table 11. The availability of the market was analyzed and the findings were summarized in the following figure.

Figure 31: Availability of market to consume various clay products



Source: *Clay Tech Audit survey, 2020*

The figure informs that modern bricks are much more needed at the market followed by adobe bricks as reported by 70.8% and 38.6% of the respondents respectively. The market for ISSB and CEB bricks are also still available as confirmed by 33.3% and 23.8% of respondents respectively while 35.4% and 25% of respondents declared to have a market for roof and floor tiles respectively. When clay value chain actors were asked about strategies in place to increase the number of consumers of various clay products especially tiles which are less commercialized, the respondents said that they have started to improve marketing and promotion of their products. The producer companies have increased investment in advertisement (through posters, television and radio advertisements) but this is only done by the large companies like Ruliba clay Ltd.

Figure 32: High demand for construction primary schools in 2020

Gisagara District, Kibirizi Sector, Kibirizi Cell, Kibirizi site	Huye District, Ngoma Sector, Kaburemera Cell, Runda primary school	Nyanza District, Busasamana Sector, Kavumu Cell, Hanika site

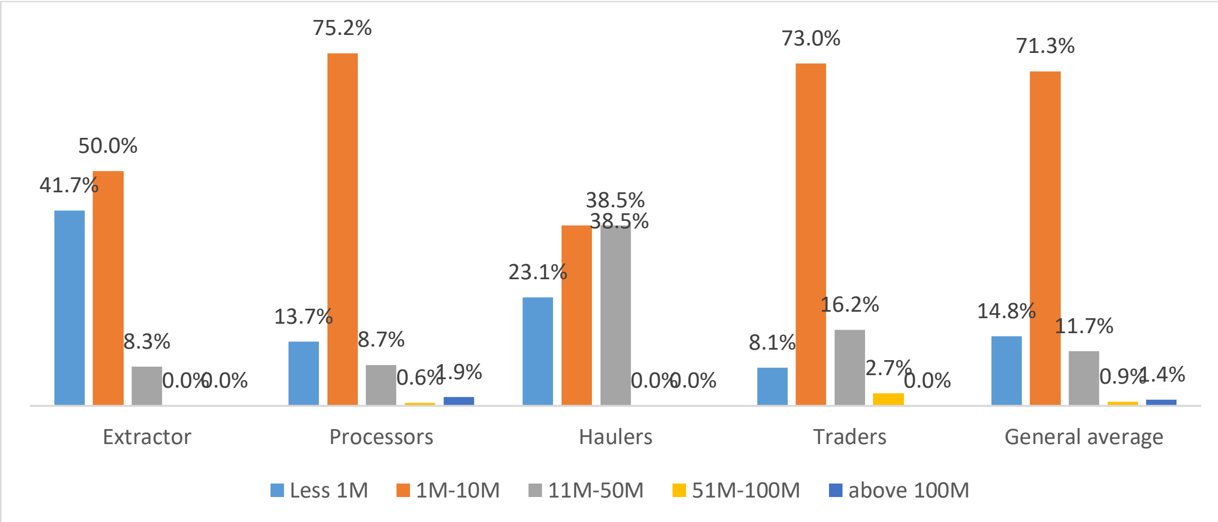
Source: *Clay Tech Audit survey, 2020*

Many primary schools were constructed during 2020 which increased the demand of bricks on the market. Based FGD and KII information, it was revealed that the demand is higher compared to the available bricks on the market. Furthermore, the constructors of the primary schools under construction were complaining to have delayed to handover schools due to limited bricks on the market. This high demand for bricks gives a good indication that not much of the forest trees are cleared for construction of classroom walls. Furthermore, the study conducted by MINICOM, 2015 informed that In Kigali alone, there is a fast growing population (3% in average of 5 years) combined with urban growth currently at more than 4% per annum, the demand for housing became (8,000 - 10,000) units per annum since 2015. The combined demand for housing countrywide is estimated to be more than 25,000 units per annum. With clay construction already representing a large part of housing construction, its demand is still increasing every day. However, the total clay deposits available in Rwanda is not yet well known to estimate its capacity to respond to the above mentioned demand in coming years.

3.5. Source of capital/investments and financial capacity

This section presents findings on investments and financial capacity of the assessed actors.

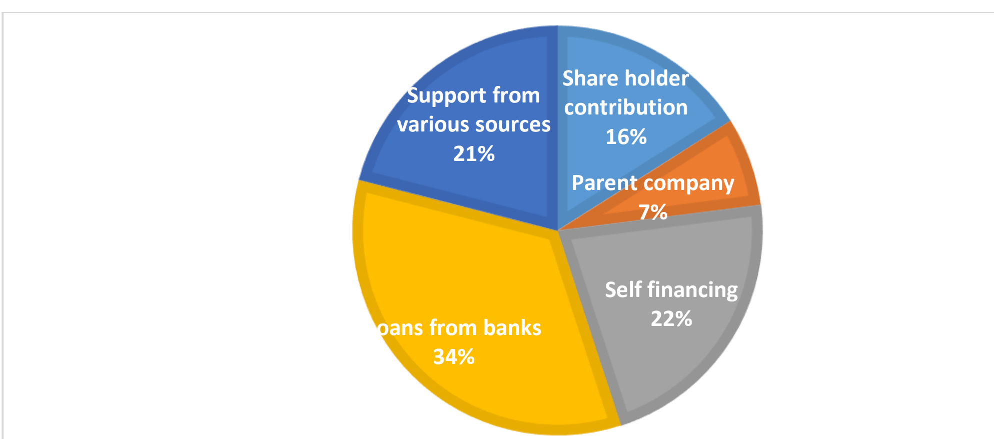
Figure 33: Invested capital (Rwf) by key value chain actors



Source: *Clay Tech Audit survey, 2020*

The figure above reveals that the majority of actors in clay sector have invested between one million and 10 million. These includes the processors, traders, and extractors. Only the haulers seem to have invested more, with 38.5% of them reporting to have invested between 11 and 50 million RwF. This is understandable because involvement in the transport of clay products requires large vehicles which are more expensive. Moreover, the extractors have invested low amount of money compared to other actors to start operating in clay sector as 41.7% of respondents reported to have started working with the investment of less than one million. The information on financial sources to start a business of producing clay-based construction materials was depicted in figure below.

Figure 34: Source of finances to start a business linked with clay based construction materials



Source: *Clay Tech Audit survey, 2020*

Financial resources act as enablers of any business. The figure above summarizes the major source of finances, the largest being bank loans.

The biggest challenge in sourcing finances is the high interest rates and the inaccessibility to these bank loans. Clay operators present during FGDs in particular cited high interest rates on bank loans and a general lack of adequate capital to finance and invest within the companies as the main challenges that bog down this sector. Therefore, the "Open Call" planned by NIRDA and Enabel to come after this study will help many clay value chain actors to upgrade their business to the higher level rather than relying on bank loans. The winners of supports from this "Open Call" by NIRDA in collaboration with Enabel should make their products to be more competitive not only on East Africa market but also worldwide. The information of the firm's annual turnover was captured in figure below.

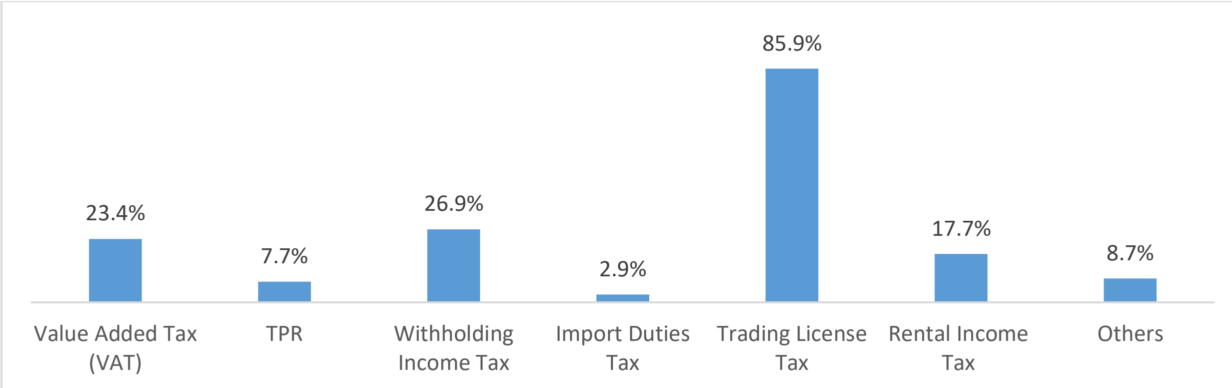
Table 9: Firm's annual turn over

category	Extractor	Processors	Haulers	Traders	Constructors
Less than one million	36.4%	15.2%	0.0%	2.8%	13.3%
Between one million and ten	36.4%	76.0%	92.3%	63.9%	72.9%
Between 10 million and fifty million	27.3%	7.6%	7.7%	27.8%	11.9%
Between fifty million and one hundred million	0.0%	0.0%	0.0%	5.6%	0.9%
Above one hundred million	0.0%	1.3%	0.0%	0.0%	0.9%

Source: *Clay Tech Audit survey, 2020*

Regardless of the profit made by firms in past 12 months, majority of the respondents reported to have an annual turnover varying between one million and 10 million which is still in the same range like the investment. Surprisingly the percentage (92.3%) of haulers who have annual turnover varying between one million and ten has increased compared to the invested amount. A good percentage of extractors (27.3%) and traders (27.8%) declared to have a turnover ranged between 10 million and fifty million. This shows that extractors and processors got more profit compared to other clay actors. When clay firms asked about the payment of taxes, 89.1% of them confirmed to have paid taxes as specified in figure below.

Figure 35: Payment of taxes



Source: *Clay Tech Audit survey, 2020*

The majority of respondents (85.9%) report to have paid the trading license tax while reports of payment of VAT (26.9%), with holding Income Tax (23.4%) and Rental Income Tax (17.7%) are less prevalent. The other taxes like TPR, import duties tax have been paid by less than 10% of firms as confirmed by the respondents.

3.6. Competitiveness of clay based construction materials on internal and external market

According to the Porter's theory[9] the competitiveness of clay sector can be assessed by analysing the interaction of the following aspects; firstly, the availability of labour and skills they possess and raw materials. Secondly, the status of domestic demand in pressuring companies into making their products more competitive. Thirdly, the received supports from various stakeholders and inputs that are advantageous for internationalization and innovation and lastly, the factors regards how companies are managed and organized. The unit price and quality of the clay based construction materials were mentioned in KIIs and FGDs as the main factors determining the competitiveness of clay products.

With regard to the labour engaged in clay sector, it was seen that the majority of clay actors have at least completed primary school education level (figure 8) where they have not been taught about the use of clay to make construction materials. This shows that the majority of clay actors are using especially working experience rather than skills gained from the schools. Thus, it becomes harder to the numerous clay companies to adopt the new technologies helping to produce the most competitive products. The lack of training in this sector coupled with unimproved raw materials are the basis of lack of competitiveness of clay products on the construction market. This affects both rural and semi-urban areas where most of the production activities take place.

On domestic demand: The results from FGDs and KIIs confirmed that the majority of the end users in rural areas prefer to use adobe bricks as they are much more affordable in terms of

[9] Porter, M. E, Argyres, N. & McGahan, A. M. (2002). p. 43

prices compared to the remaining types. Moreover, the modern bricks are much used in urban areas like Kigali city while the traditional fired bricks the most commonly used across the country.

It is worth noting that To produce a brick for the market, costs related to clay mining, transport, storage, molding, drying and firing are necessary and often are not taken into consideration by artisans and small scale miners. We got information from personal informal contacts in Burundi, Uganda, Tanzania and DRC only for the selling prices. Hereunder we present the different prices collected in neighboring countries.

Table 10: Adobe brick comparative prices in Rwf

Country	Production cost	Average production price	Selling price	Average selling price	Ratio
Rwanda	14-20	17	22-26	24	1.41
Burundi	12-15	13.5	20-25	**22.5**	1.66
Uganda	**10-15**	**12.5**	**18-22**	20	1.66
Tanzania	**15-20**	**17.5**	**25-30**	27.5	1.61
DRC	**15-20**	**17.5**	**25-30**	27.5	1.57
Kenya	**20-25**	**22.5**	**30-35**	32.5	1.44

Table 11: Traditional burnt (Mpunyu) brick comparative prices in Rwf

Country	Production cost	Average production price	Selling price	Average selling price	Ratio
Rwanda	22-25	**23.5**	30-35	32.5	1.38
Burundi	20-25	22.5	30-34	**32**	1.42
Uganda	**18-22**	**20**	**25-30**	27.5	1.37
Tanzania	**25-30**	**27.5**	**35-40**	37.5	1.36
DRC	**25-32**	**28.5**	**35-42**	38.5	1.35
Kenya	**28-35**	**31.5**	**40-45**	42.5	1.35

Table 12: Modern bricks (Row-lock with 3 holes) brick comparative prices in Rwf

Country	Production cost	Average production price	Selling price	Average selling price	Ratio
Rwanda	70-75	**72.5**	100-150	125	1.72
Burundi	80-85	82.5	150-250	**200**	2.42
Uganda	**50-70**	**60**	**85-120**	102.5	1.7
Tanzania	**70-80**	**75**	**90-150**	120	1.33
DRC	**100-150**	**125**	**200-250**	225	1.8
Kenya	**100-150**	**125**	**200-250**	225	1.8

The tables above reveals that the modern bricks are the most expensive in all five countries of the region including Rwanda while adobe bricks are the cheapest in the same countries. The highest ratio price (2.42) on production cost to the selling cost was seen in modern bricks in

Burundi while the lowest (1.33) was seen in Tanzania. Moreover, the highest prices was seen in modern bricks (Row-lock with 3 holes) in DRC and Kenya where the average price was 225 Rwf. Therefore, clay products are still competitive on regional market in terms of price if the transport costs is not taken into account.

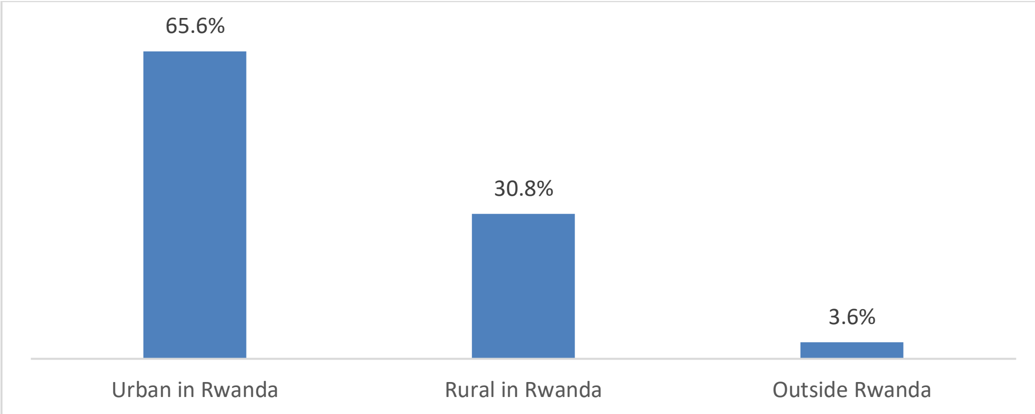
The market of industrial minerals and construction materials is open as regional integration provides an outlet for the country. Rwanda is a member of regional alliances: African Union (AU), and The Common Market for East and Southern Africa (COMESA), East African Community (EAC), Communauté Economique des Pays des Grands Lacs (CEPGL) / Economic Community for Great Lakes Region. The opportunities become available with the right infrastructure for increased connectivity and sharing.

It is with this in mind that Rwandan products could be sold beyond the country's borders, especially in border regions with the Congo (DRC) where bricks, tiles, tiles and other construction products will be sold in cities as Goma (North Kivu), Bukavu, Kamanyola, Uvira and Fizi (South Kivu), border regions with Burundi namely the provinces of Cibitoke, Kayanza, Gitega and Kirundo, as well as a very large part of western Tanzania bringing together the districts of the Akagera Province.

The production cost is calculated by following several parameters relating to: technology used in extraction and processing clay, cost of transport, availability of storage and drying facilities, molding, used technology and materials in firing, supply of sources of energy used, various taxes, etc. Therefore, reducing the cost of production requires to minimize the costs of all these factors. It would be advisable to test clay in laboratory to avoid any impurities. This will help to use the clay of high quality in preparation of clay based construction materials. Hence, it will require to take into account the following: moisture content in clay (quantity of water contained in a material), mineralogical composition (MC), Chemical composition (CC), particle size distribution PSD, plasticity, fusibility, etc.

Additional, the brick makers should be endowed with enough skills and technology to produce a clay based construction material which is very competitive not only on local market but also at outside the country market. However, the technology in use at different stages of clay value chain (extraction, processing, firing, transport) plays a determinant role for price variations. Thus, the use of advanced technology in extraction, processing and firing is susceptible to lessen the costs of clay based construction materials. It is worth pointing out that the sells outside the country are still limited as depicted in figure below.

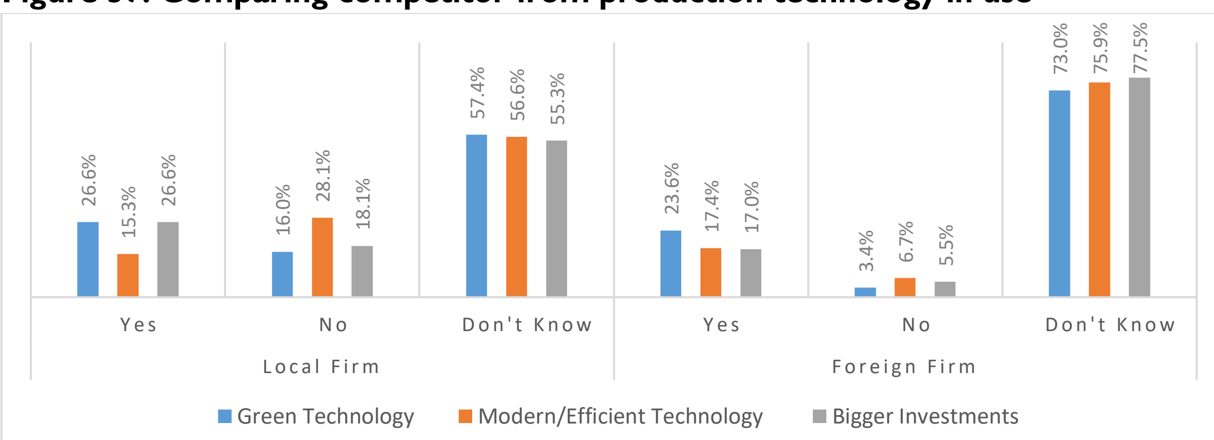
Figure 36: Destination of clay products



Source: *Clay Tech Audit survey, 2020*

Based on the information gathered from the field, it was revealed that the highest percentage of clay based construction materials are used in urban areas as declared by 65.6% of respondents with 30.8% being used in rural areas. Additionally, the Key Informants from SKAT Ltd and Focus Group Discussions confirmed that the highest portion of modern, ISSB and CEB bricks are taken to be used in urban areas due to their prices which are higher compared to the traditional and adobe bricks. It was mentioned by 3.6% of respondents that there are a small portion of bricks which are exported outside the country especially in Goma and Bukavu which are the urban areas of Democratic Republic of Congo (DRC) neighboring to Rwanda. This was also confirmed by SKAT Ltd staff and members of FGD which took place in districts neighboring to DRC. The preference between local and clay based products from outside the country was made and the findings were summarized in table below.

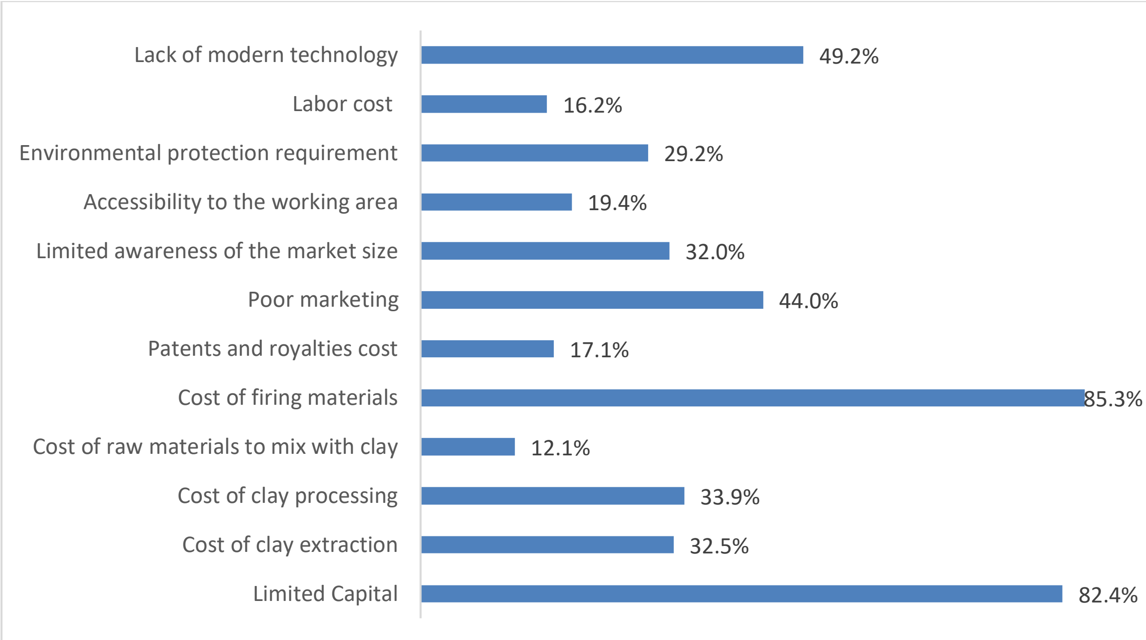
Figure 37: Comparing competitor from production technology in use



Source: *Clay Tech Audit survey, 2020*

The figure above revealed that most of respondents do not have a clear strategies to assess their competitors in the business related to clay. However, they are aware that in order to be competitive they need bigger investments and adopt green and modern technologies. These technologies will help in improving the productivity in terms of quality and quantity by responding at the same time to the environmental protection requirements. Below there are the main challenges faced by the firms to be more competitive on both internal and external market.

Figure 38: Main challenges hindering the competitiveness of clay products



Source: *Clay Tech Audit survey, 2020*

The majority of respondents (85.3% and 82.4%) highlighted the cost of firing materials and limited capital respectively as the main problems hindering the competitiveness of clay products. The lack of modern technology comes to the third position among the others main challenges facing clay sector. The same has been confirmed also during FGDs and by KIIs in different districts. Therefore, the firms should adopt modern kilns consuming less energy to reduce high cost spent on firing materials. Additionally, working in cooperatives or/and put together shares can be also one of the solutions of limited capital faced by clay value chain actors. Respondents cited poor marketing (44%), cost of clay processing (33.9%) and clay extraction (32.5%) being among the problems that also hinder the competitiveness of clay products.

Other challenges to the clay value chain actors include: environmental protection requirement (29.2%), limited awareness of the market size (32%), patents and royalties cost ((17.1%), accessibility to the working area (19.4%), labor cost (16.2%), and cost of raw materials to mix with clay (12.1%), among others. Some participants of the FGDs in most of visited districts highlighted that the issue of poor quality of infrastructure and limited access to finance are very serious problems hindering the competitiveness of clay based construction materials. Therefore, the relevant governmental and non-government authorities should intervene to get sustainable solutions to the above mentioned challenges hindering the smooth operation of clay value chain actors and making substantial profit from this sector. When clay value chain actors were asked about the invested capital, the feedback they gave was compiled and reported in the following figure.

3.7. Analysis of value for money to the clay-based products

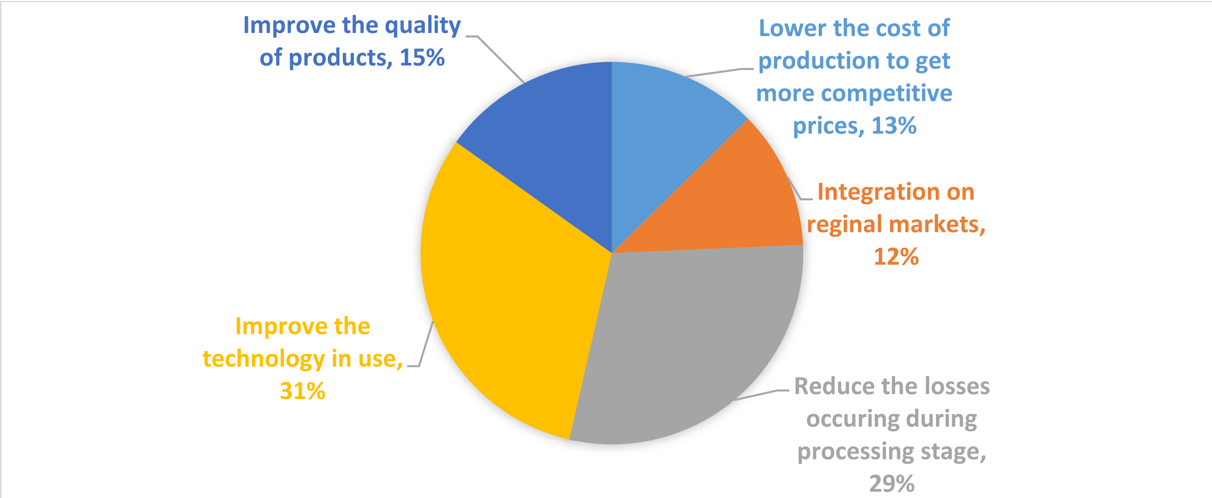
Rwandan clay tiles are less preferred especially in urban areas because they are fairly expensive compared with many other roofing materials, and they are difficult to install as declared by FGDs in urban areas. They added that the roofers cannot walk on these tiles without damaging them, which makes installation and repair challenging. Furthermore, most types of clay roof tiles are also relatively heavy and may require a reinforced or enhanced roofing system to support their weight as they require a reinforced framing and sheathing system to support their added weight. They also require an enhanced water proofing membrane to keep water away from the roof structure. All these reasons push the majority of Rwandans to make a roof with iron sheets rather than using tiles roofing. The response from FGD is that people are happy with the durability of the tiles but not with their enormous weight. It is common to find those who can afford the new light roofing materials using them instead of the clay tiles.
On the issue of prices, the clay tiles are more expensive than the common iron sheets but cheaper than the modern iron sheets most of which are imported and used in high residential areas of towns. Such as those manufactured by SAFINTRA and other companies.

It is with this regard, various stakeholders like SKAT Ltd, NIRDA as governmental institution in charge of promotion of industries of different scales, Enabel among others have contributed substantially in improving the competitiveness of this sector through provision of training of clay value chain actors and modern machineries, construction of modern warehouses and energy efficient kilns to firms/companies operating formally.

The study are still on-going for mapping clay of high quality across the country. This should help the investors to be engaged in the sector knowing what they may gain from it. Therefore, this sector will be fully competitive , if its status quo is fully understood and set into Rwandan context. On one hand, a business's performance in a certain environment should be evaluated. On the other hand, the market environment should be well assessed based on its suitability to promote businesses. Business and market intelligence are technical terms that describe these perspectives. Moreover, leaders of businesses, government, and various institutions all should have a stake—and play correctly their roles in the economics of competition. This task will require fully engagement of concerned leaders and the willingness of firms/companies leaders to modernize their clay based industries, to adopt the updated new technologies in processing and firing clay based products being innovative in their business. All this requires substantial investment to get a long term profit.

The following are additional solutions to improve the competitiveness on the market as suggested by the respondents.

Figure 39: Solutions to the market competition



Source: *Clay Tech Audit survey, 2020*

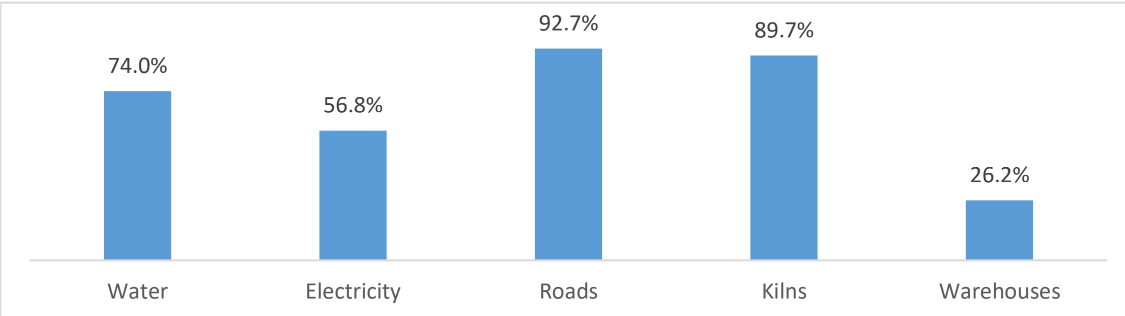
The improvement of technology in use (31%) and reduction of losses occurring during processing stage (29%) were suggested to be the best solutions to the market competition. The improvement of the products quality (15%) and Lower the cost of production to get more competitive prices (13%) along with integration on regional markets were also mentioned as appropriate solutions to deal with market competitions. The processors in FGDs emphasized on the improvement of the quality of products and lowering the prices as the best strategy to deal with the internal market competition. However, they highlighted that the prices may be lowered if the modern technology is integrated in processing clay-based construction materials. Furthermore, the exportation of clay based construction materials especially on the East Africa countries market. Thus, the competition in term of the use of technology was studied and reported in figure below.

3.8. Infrastructure and technology in place

3.8.1. Infrastructure in Rwanda

The infrastructure and technology in place may give the idea on the development level of a given firm. The firm with a very good road access, enough water and electricity is potentially well positioned to be developed faster than the ones without such facilities. On the other hand, the firms with modern and automated technologies are in good position to become competitive on national and international market compared to those which use only traditional methods of production. The availability of infrastructure at processing place was analyzed and presented in figure below.

Figure 40: Availability of infrastructure at processing place



Source: *Clay Tech Audit survey, 2020*

It is very encouraging to see that 92.7% of respondents confirmed to have roads reaching the processing place, 74% confirmed the availability of water, and 56.8% had access to electricity but only 26.2% declared to have warehouses. 89.7% of respondents who confirmed to have kilns implying that they are producing either bricks or tiles. Therefore, it is assumed that bricks are the most produced among other construction materials delivered from clay. In FGDs and KII in up country areas, when the respondents asked about the level of satisfaction with regard to the available infrastructure, the majority of respondents were complaining about the poor quality of roads reaching to the processing place of clay based construction materials. "The issue of poor roads is a serious one given that during the rainy season our roads become impassable" declared the majority of participants in the FGDs.

3.8.2. Assessing the clay technology in Rwanda

A-Technology on working sites/Kilns type

Apart from the public infrastructure, the actors complained about the losses experienced especially during rainy season due to the poor quality or absence of warehouses and use of traditional kilns.

It is worth noting that the current operational brick kilns in Rwanda could be divided in two main groups, namely permanent and traditional kilns. Below there are some examples.

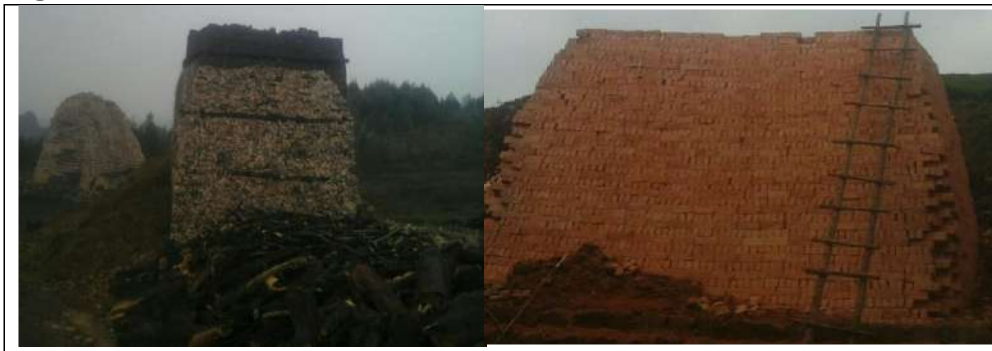
Figure 41: Permanent kilns in Rwanda

Huye District, Tumbe Sector, Cyarwa Cell, Mukoni site

Huye District, Tumba Sector, Cyarwa Cell, Brique nouvelle Ltd

Ngororero district supported by SKAT Ltd

Figure 42: Traditional kilns



Nyanza District, Nyabicuma Sector, Mushirarungu, Rushaya site

Nyaruguru District, Muganza Sector, Samiyonga Cell Nyirakareshya site

Source: *Clay Tech Audit survey, 2020*

The permanent kilns require very limited firing materials and emit less Greenhouse gases emissions in atmosphere compared to the traditional kilns. Furthermore, it takes between 27 hours to 30 hours to fire bricks in permanent kilns while it takes 7 to 8 days in traditional kilns. This is the additional advantage of using permanent kilns on the top of the good quality of bricks they provide. The study conducted by the Ministry of Environment in 2018 classified brick kilns in the following groups:

Table 13: Cumulative number of brick kilns in Rwanda

Location	Permanent kiln	Traditional kiln	Total
City of Kigali	13	55	68
Southern Province	13	179	192
Western Province	54	302	356
Eastern Province	2	49	51
Northern Province	22	124	146
Total	**104**	**709**	**813**

Source: MoE, 2020

The traditional brick kilns have a dominant fraction of 87.21% of the existing kilns in Rwanda. Moreover, it was observed on the field during data collection in September, 2020 that there are some permanent kilns which are covered while other are not. It is worth noting that SKAT supported a number of firms to build permanent kilns which are energy efficient. These include the modern kiln seen in Ngororero district and shown in figure 40. Therefore, they may also classified as follows:

Table 14: Firms/companies with modern and energy efficient kilns

SN	NAME OF THE FIRM	Products	Province	District
1	COOPERATIVE TURANEZA	Bricks	North	Musanze
2	MAHANO Alexis	Bricks	North	Musanze
3	COOPERATIVE ABADAHEZA	Bricks	North	Musanze
4	HABUMUREMYI	Bricks	North	Musanze
5	COOPERATIVE TWIBATURE	Bricks	North	Musanze
6	HITIMANA Joseph	Bricks and Tiles	West	Rutsiro
7	BAPFAKWITA Francois	Bricks	West	Rutsiro

8	NTEZIYAMBERE Jean Piere	Tiles	West	Nyamasheke
9	MUSABYIMANA Andre	Bricks	West	Nyamasheke
10	NSENGIYUMVA Salathiel	Bricks	West	Nyamasheke
11	HABIYAMBERE Viateur	Bricks	West	Nyamasheke
12	NATHANAIRE	Tiles	West	Nyamasheke
13	MUKANDAHINDURWA Jeannette	Bricks	West	Nyamasheke
14	NDUWAMUNGU Athanase	Bricks	West	Nyamasheke
15	COOPERATIVE	Tiles	West	Nyamasheke
16	COOPERATIVE TURAHEZA	Bricks and Tiles	West	Nyamasheke
17	COOPERATIVE TURAHEZA	Bricks	West	Nyamasheke
18	TEBUKA MUTUNTU	Bricks and Tiles	West	KARONGI
19	APAFBR	Bricks and Tiles	West	KARONGI
20	TWITEKUBUZIMA	Bricks and Tiles	West	KARONGI
21	UBAKUSAKARE RUGANDA	Bricks and Tiles	West	KARONGI
22	KIGOGWE Cell	Bricks	West	KARONGI
23	UWIFASHIJE Pelecie	Tiles	West	KARONGI
24	DUKOMEZINKUTA	Bricks and Tiles	West	KARONGI
25	COOPERATIVE COOPENYARU	Bricks and Tiles	East	BUGESERA
26	BIZIMUNGU Oswald	Bricks and Tiles	East	NGOMA
27	NTAGANDA		North	Rulindo
28	KARIMBA Jean Paul	Tiles	Kigali City	Nyarugenge
29	COOPDEM	Bricks	North	Rulindo
30	COOPERATIVE TWUZUZANYE GICUMBI	Bricks	North	GICUMBI
31	UBUDEHE(Sector)	Bricks	North	Rulindo
32	SINA Gerard	Tiles	North	Rulindo
33	C00PABIC(NIZEYIMANA)	Bricks and Tiles	North	Rulindo
34	COOPERATIVE TABARA(KABENGERA)	Bricks and Tiles	North	Rulindo
35	KAMARI Elisaphan	Bricks	Kigali City	Nyarugenge
36	COOPERATIVE TUZAMURANE	Bricks	West	Rusizi

Source: Clay Tech Audit survey, 2020, http://madeingreatlakes.com/

B-Technology on working sites/Drying & warehouse facilities

The existence of warehouses at firm operating place was also looked at and below are some of sampled warehouses among others.

Figure 43: Sample of warehouses in use for clay products

Musanze district, Rubabi sector, Nturo cell, Rwaza village | *Gicumbi district, Nyamiyaga sector, Gahumuriza cell, Majyambere site* | *Rulindo district, Nyirangarama clay warehouse*

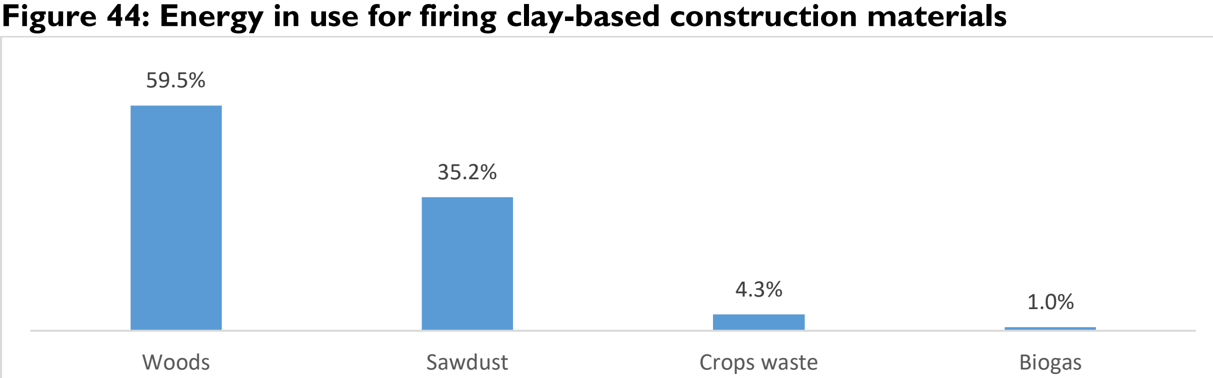
Source: *Clay Tech Audit survey, 2020*

As mentioned in figure above, only 26.2% of the visited clay firms have warehouses, others store processed clay products outside in open areas. Though some clay value chain operators claimed to have constructed warehouses, they look like temporal shelters to be used especially during the raining period as it a case for a warehouse seen in Musanze district, Rubabi sector, Nturo cell, Rwaza village presented in figure above. However there are few clay industries like Ruliba in Nyarugenge, Nyirangarama in Rulindo, OBRIKA Ltd in Gatsibo among others which have permanent strong warehouses.

C-Technology on working sites/products firing technology

The technology used in firing clay based construction materials contribute in getting a product with a certain quality. The figure below depicts different source of energy used for firing clay-based construction materials.

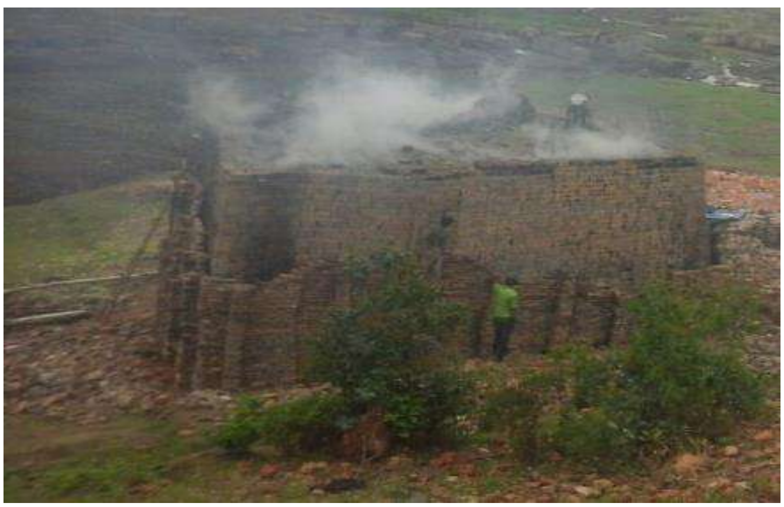
Figure 44: Energy in use for firing clay-based construction materials



Source: *Clay Tech Audit survey, 2020*

The figure above shows that woods are the most used firing materials for the clay construction materials production as declared by 59.5% of respondents followed by sawdust (35.2%) while crops waste and biogas are rarely used as said by 4.3% and 1% of respondents respectively. It is worth noting that provided that the afforestation and re-afforestation has been taken into account wherever there is a tree cut for various uses including firing bricks and/or tiles, the emissions of GHG due to brick firing is nearly zero as it is a carbon neutral process. Moreover, the quantities of fuels to be used in firing bricks and/or tiles depend on the efficiency of the kiln (type of the kiln), the quantity of bricks and the type of fuels used. Ministry of Environment reported in 2018 that in Rwanda, four main fuels are used in the bricks industries, viz., firewood, sawdust, coffee husk and rice husk. Some fuels used in firing clay construction materials contain a considerable amount of moisture, which could increase the quantity of the fuels consumed during the combustion process. The increase of moisture in the fuel could hinder the firing process resulting in the increase of the specific energy consumption of the kiln. Therefore, these firing materials should be dried enough before being used in firing bricks and/or tiles.

Figure 45: Sample of smokes from kiln



Nyaruguru District, Munini Sector, Ngeri Cell, Ruseke Village

Source: *Clay Tech Audit survey, 2020*

Bricks are manufactured in brick kilns that emit very harmful gases which in turn affect the human health, environment. The smokes released from kilns may cause the diseases related to skin, and respiratory system. Therefore, it is very important to identify the brick kilns and estimate the emissions that are extremely harmful for the environment and human health. According to REMA, 2018, kilns release CO_2, CO and SO_2 which have harmful effects on the environment. Similarly, carcinogenic dioxin, SO_2 have adverse effects on the human health. In the light of the results, it was recommended to the government of Rwanda to formulate and implement the rules and regulations for minimizing the emissions from bricks and tiles kilns (MoE, 2018). Moreover, the best solutions is to adopt the new technologies for bricks making like automated system used by Ruliba clay Ltd.

Alternatively, a number of key informants suggested to replace fired bricks by unfired bricks. The past experience, demonstrated the success in durability of compacted bricks made in selected soils mixed with a low quantity of cement and water to make a solution with some grasses. The houses constructed in such materials were seen for instance in Gasabo district, Kimironko sector and in Kicukiro district, Gatenga sector. However, these bricks need to be made with appropriate machine to be compacted enough. Different firing materials are shown in figure below.

Figure 46: Different firing materials across the country

Firewood in use Ngoma district, Gatore sector, Gashubi cell, Kibaya village

Firewood in use in Rulindo district, Buyoga sector, Ndarage cell, Rukono site

Sawdust to be used in firing bricks and tiles

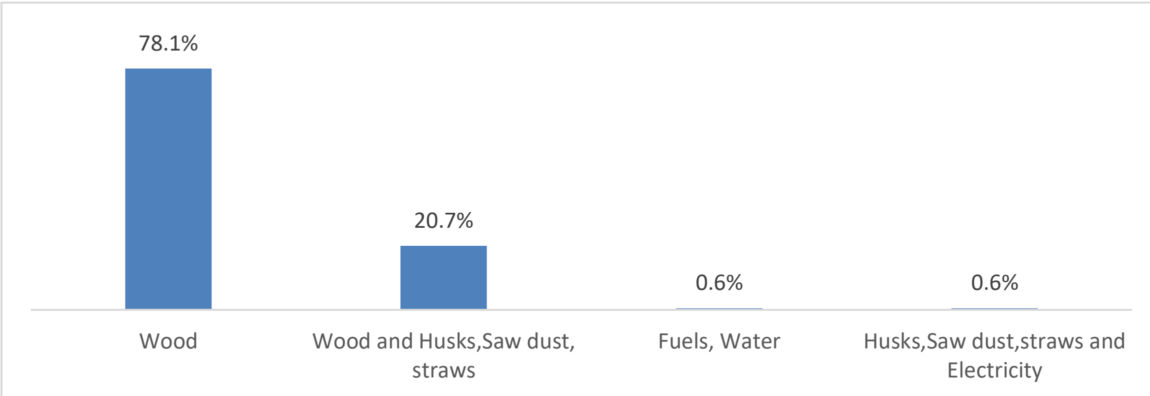
Rice husk to be used in firing bricks and tiles

Coffee husk to be used in firing bricks and tiles

Source: *Clay Tech Audit survey, 2020*

The figure above shows that the forests have been cut off to get firewood to make bricks. Such practices if not stopped or reduced would exuberate the adverse impacts of climate change and variability across Rwanda. To deal with that issue Rwanda has introduced the use of sawdust, rice and coffee husks. Moreover, the promotion of technology to produce unburned bricks (ex. Hydrofoarm) will be among the best alternative to reduce environmental degradation resulting from clay extraction and processing.

Figure 47: Firing materials in use by different firms



Source: *Clay Tech Audit survey, 2020*

The figure above shows that only wood is used predominantly (78.1%) as firing materials followed by the use of a combination of wood, husks, saw dust and straws (20.7%). A negligible percentage of firms uses fuels and water (0.6%) especially at Nyirangarama sites and the combination of husks, saw dust, straws and electricity (0.6%).

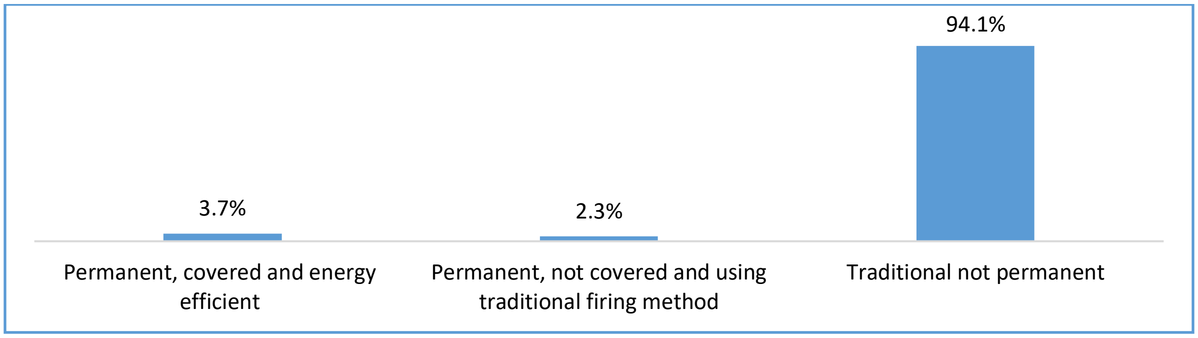
Table 15: Estimation of firing materials to be used for specific number of bricks

Materials	Number	Clay's quality	Number of mature trees (1)	Production price	Saw dust / Rice & Coffee husks (tons)_ (2)	Production price	Combination (1+2)		Production price
							1. Trees	2. Saw dust / Rice & Coffee husks (tons)	
Firing bricks	100,000	High	400	2,000,000	30	2,150,000	20	10	2,100,000
Firing bricks	100,000	Medium	440	2,100,000	35	2,300,000	25	10	2,150,000
Firing bricks	100,000	Poor	460	2,150,000	40	2,450,000	30	10	2,200,000

The table above shows that fire wood is dominantly used compared to the saw dust/Rice & coffee husks. This may lead to the reduction of forest cover if afforestation and re-afforestation programs are not reinforced across the country. The study revealed that the use of trees on high quality of clay seems to be the cheapest though it is hard to trees regularly as the forests are well protected by the Government of Rwanda. It is important mentioning that modern kilns use between 27 hours to 30 hours to fire bricks in permanent kilns while it takes 7 to 8 days in traditional kilns. This is the additional advantage of using permanent kilns on the top of the good quality of bricks they provide. Moreover, it is very hard to compare traditional kilns with modern ones as the latter are used to fire modern bricks while the earlier are used to burn traditional bricks known as "Mpunyu".

Furthermore, firing bricks and/or tiles may contribute to the global warming specifically and to the climate change generally. In return the climate change has an adverse effect on not only the physical environment but also on human activities. This study explored whether the clay value chain actors are aware of adverse impacts of climate change and variability, the information gathered on this aspect was gathered and presented in figure below.

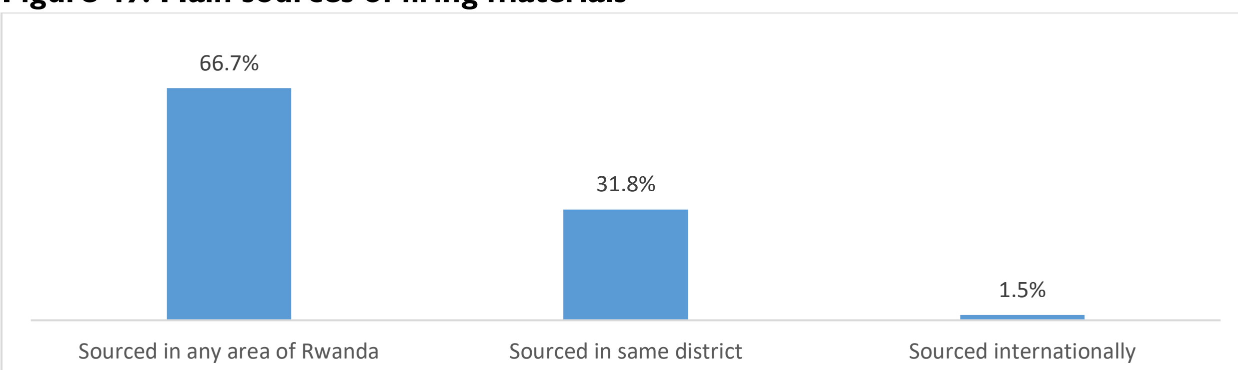
Figure 48: Classification of kilns based on the ways are constructed and firing method



Source: *Clay Tech Audit survey, 2020*

Based on the information gathered from respondents, 94.1% of brick kilns use traditional firing methods and are not permanent while only 3.7% are permanent, covered and use limited energy compared to traditional kilns with 2.3% which are permanent but are not covered and still using traditional firing methods. Based on collected primary field data and data sourced from SKAT Ltd website the following 36 firms/companies were considered to have modern and energy efficient kilns

Figure 49: Main sources of firing materials



Source: *Clay Tech Audit survey, 2020*

A considerable percentage of respondents (66.7%) have confirmed that they sourced firing materials in various parts of the country while 31.8% of respondents revealed that they get them from same district in which their firms are located. A small fraction (1.5%) imports its firing materials from abroad especially DRC as reported by the interviewees during FGD and KIIs. This means that most of firing materials are

D-Technology on working sites/level of automation in processing stage

The technology in processing stage places a determinant role on the quality and cost of the product. The main method used to produce bricks and tiles across the country are presented in figures below.

Figure 50: Traditional methods in use for producing bricks

Ruhango District, Ruhango Sector, Bunyogombe Cell, Karehe site

Muhanga District, Shyogwe Sector, Mbari Cell, Nyakiburiri site

Kamonyi District, Runda Sector, Ruyenzi Cell, Kibaya site

Figure 51: Semi-automated machines in use for producing bricks

Gatsibo district, Kageyo sector, Busetsa cell, Gitebwe village for COBRIKA Ltd

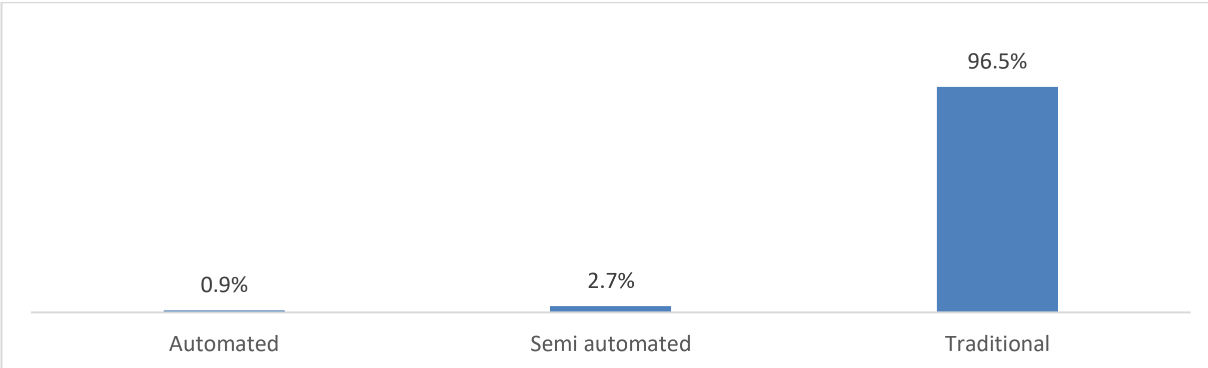
Figure 52: Automated machines in use for producing bricks

Nyarugenge district, Kigali, Nyabugogo, Kamenge, Ruliba Clay

Source: *Clay Tech Audit survey, 2020*

The figure above shows that in Rwanda, there a range of technologies in use in clay industry. However, the traditional methods with simple tools as it can be seen on the following graph are still dominating the sector.

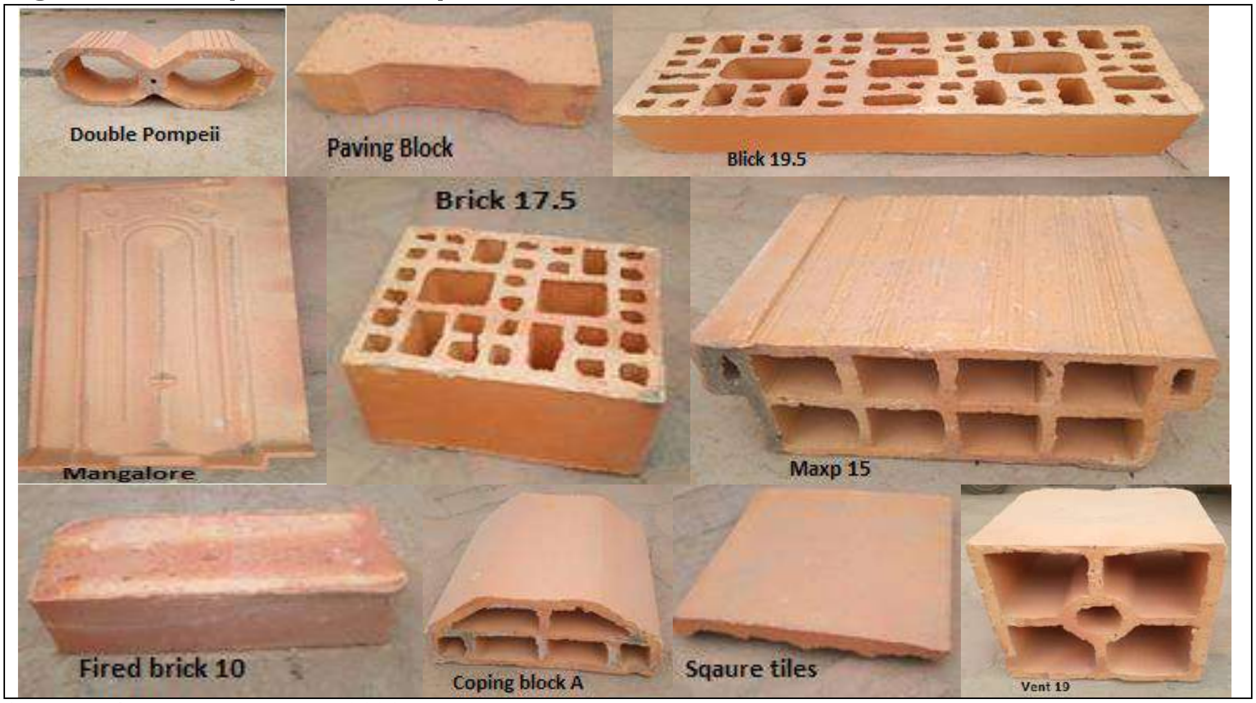
Figure 53: Types of technology in use by firms



Source: *Clay Tech Audit survey, 2020*

The figure above shows that only 0.9% and 2.7% of firms use automated (powered equipment) and semi-automated (partially manually operated) technology respectively while the remaining 96.5% are still using traditional and manual technology. The latter method requires a lot of time to make one brick, a lot of firing materials. Furthermore, the firms which use traditional technology are still constructing traditional kilns. The use of traditional technology results into low quality brick and tile production in terms of durability and external appearance. To overcome these weaknesses of this traditional technology, KOBRIKA Ltd, Briks Development Company Ltd located in Mataba Cell and bricks company operating in Mageragere Sector Nyarugenge District have been supported by SKAT to upgrade their technology and they managed to adopt a semi-automated method to produce various type of bricks. Moreover, Ruliba industry Ltd is still on the top of other clay firms with regard to technology in use (Figure 44) across the country. This technology helps Ruliba to produce different type of bricks of good quality as shown below.

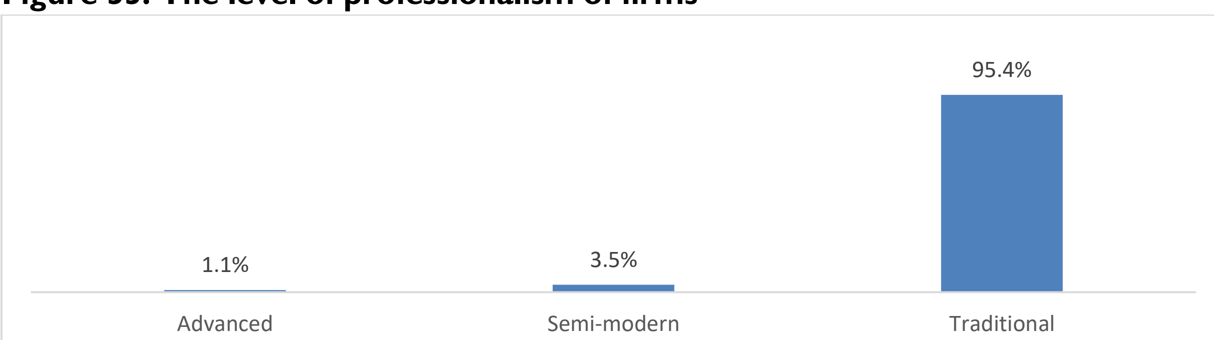
Figure 54: Samples of Ruliba products



Source: *Clay Tech Audit survey, 2020*

Automated technology can give bricks with various shapes which are also stronger than those prepared using traditional methods. Furthermore, they are fired in modern and permanent kilns which make them to be available in 27 to 28 hours as reported by Ruliba staff in FGD. Despite the production of high quantities in short periods, this technology is also energy efficient. Moreover, Ruliba clay Ltd informed that is not yet able to satisfy the demand on market. By considering the type of technology, availability of warehouse and possessed kilns, the firms were classified in the following categories:

Figure 55: The level of professionalism of firms



Source: *Clay Tech Audit survey, 2020*

The study revealed that 95.4% of firms are still traditional in nature against only 1.1% and 3.5% which were classified as advanced and semi-modern firm respectively. With this regard, a call is made to different investors and stakeholders to invest in modern technology for clay related materials to contribute to the national ambitions of having households with suitable and environmentally sustainable houses by 2050. Based on the technology in use the following table shows the modern brickyards.

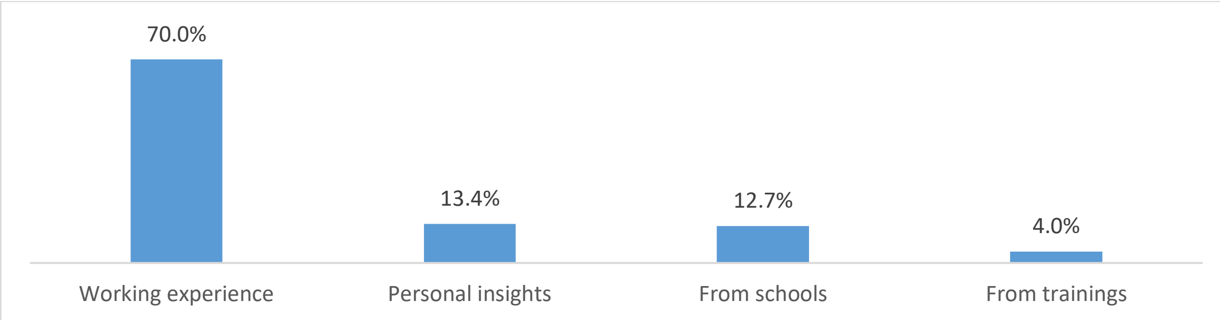
Table 16: Operational modern brickyard in Rwanda

SN	NAME OF THE FIRM	Province	DISTRICT
1	COBRIKA Ltd	Eastern	Gatsibo
2	BRIQUETERIE DE GATI LTD	Eastern	Rwamagana
3	MCECO LTD	Eastern	Rwamagana
4	IN-SITU KANOMBE	City of Kigali	Kicukiro
5	PYRAMID	City of Kigali	Gasabo
6	MUNYANKINDI Francois	City of Kigali	Gasabo
7	AMEGERWA	City of Kigali	Gasabo
8	PJK TRADERS	City of Kigali	Nyarugenge
9	RULIBA CLAYS	City of Kigali	Nyarugenge
10	DUSABEYEZU Emmanuel	City of Kigali	Nyarugenge
11	CLAY'S FACTORY	Eastern	Bugesera
12	DESOTECH	Eastern	Bugesera
13	BRIQUETERIE INDUSTRIELLE	Eastern	Bugesera
14	ECO CLAYS	Eastern	Bugesera
15	MUTOKAMBARI Jacques	City of Kigali	Kicukiro
16	MAX7 COMPANY LTD	City of Kigali	Nyarugenge
17	Cooperative INTARUSHWA za Rusiga	Northern	Rulindo
18	KAVUBI Elise	Northern	Burera
19	COOPERATIVE COMIVA	Northern	Musanze
20	COOPERATIVE MFASHANGUFASHE	Northern	Gakenke
21	BRIQUETERIE NOUVELLE	Southern	Huye
22	COOPERATIVE DUKUNDUMURIMO	Southern	Nyamagabe
23	COOPERATIVE NEW BWEYEYE	Western	Rusizi
24	NGIRINSHUTI Theobald	Western	Rusizi
25	BRIQUETERIE KAMONYI	Western	Nyamasheke
26	COOPERATIVE TUNOZE UMURIMO	Western	Nyamasheke
27	COJETRACO	Southern	Karongi
28	TUGOBOKANE	Southern	Karongi
29	COOPERATIVE TWIYUBAKIRE	Western	Rutsiro
30	COOPERATIVE KOPTKA	Western	Ngororero
31	SKAT VSBK	Western	Ngororero
32	ABAHARANIRA KWIGIRA	Southern	Ruhango
33	OPTIMAL CLAYS LTD	Southern	Muhanga
34	ABISHYIZEHAMWE	Western	Ngororero
35	Ngororero District Clay Resources	Western	Ngororero
36	RULIBA Ltd	City of Kigali	Nyarugenge

E-Source of technical skills

The information on the source of skills and knowledge used in performing daily duties by clay value chain actors is presented in figure below.

Figure 56: Source of skills and knowledge used in performing daily duties



Source: *Clay Tech Audit survey, 2020*

Based on the information gathered from respondents, the majority of the clay value chain actors (70%) make use of their working experience to perform daily duties. Only 12.7% and 4% are applying what they have learnt from the schools and trainings respectively. These percentages are still very low to make clay value chain for construction materials skills and knowledge based sector. Therefore, there is a call to develop short course programs and trainings which would be delivered in collaboration with Technical and vocational education and training (TVETs) and other stakeholders to help various clay value chain actors to gain required practical skills to be used in clay related activities. Additionally, The Integrated Polytechnic Regional College (IPRC) schools should integrate in their programs a component regarding clay value chain activities. These will help to apply modern technologies in each stage of clay value chain and make sector more competitive

3.8.3. Elsewhere technologies that can inspire Rwanda model

(i) Technologies in construction of kilns

The study conducted by Nkurikiyimfura, 2016[10] showed different technologies which may be used in construction of permanent kilns that are energy efficient

Table 17: Various technology which may be applied while constructing permanent kilns

Technology	Features	Approx. Capital Cost (in US $)	Production capacity (million bricks/year)	Typical simple payback period under normal conditions
FCBTK	Chimney height 27 to 30 m; kiln circuit capacity 0.5 to 1 million bricks.	40,000 - 60,000	4-8	< 2 years
Zig-Zag	Natural draft kiln with a chimney height of 30 m.	40,000 - 60,000	4-6	< 2 years
	Kiln of 24-36 chambers; induced draft fan operated by a 15-20 hp motor; valve system in the flue ducts	60,000 - 80,000	4-6	< 2 years

[10] Innocent Nkurikiyimfura, (2016). Energy Consumption measurement of clamp and climbing Kilns. Kigali, Rwanda.

VSBK	Two-shaft Indian VSBK with a conveyor system for lifting the brick.	60,000	1.0 -1.5	2-3 years
	Four-shaft Vietnamese VSBK: higher height; electrical lift; extruder for making internal fuel bricks; drying shade; hydraulic jack and fork-lift truck for unloading bricks	400,000	3.5-4.5	3-4 years
Tunnel	Vietnamese tunnel kiln plant; daily production capacity: 40,000 to 50,000 bricks per day; tunnel kiln, tunnel dryer, drying shed, extruder for firing bricks	1-2 million	15-20	> 3 years

Source: *MINICOM, 2015*

From the above data, Zig-zag kilns appear to be the almost preferable, because of low capital investment and environmental friendliness. The zig-zag kiln performance strongly depends on the kiln operation practices. Moreover, at least 2.5 ha of land is required to set up a brick-making factory and this type of kiln can use both peat and fuel as source of energy. Such type of kiln was constructed in Ngororero district with support from SKAT Ltd (figure 38).

The study conducted by Katabarwa in 2018 revealed that Rwanda was producing annually 70 million fired clay bricks; 60 million are produced by cottage industries that are not mechanized, have no financing, and make inefficient use of materials and energy. Their workers have no training, so the quality and size of the bricks varies. Losses of up to 40% could occur using primitive ovens and their supply is irregular. With the cooperation of researchers from the University of Sherbrooke, Canada, researchers at the National University of Rwanda have developed methods for improving local production of fired bricks. These methods reduce losses, improve the quality of the bricks (they are stronger and of a standard size), reduce energy needs, protect the environment, and create new jobs (Katabarwa, 2018).

The methods comprise of the use of (i*) an improved oven that optimizes firing. It gives an even temperature and uses peat as well as wood for fuel; (ii) additives to the clay, such as rice husks and sand; (iii) the locally manufactured manual presses; (iv) drying bricks in the sun or the fresh air in sheds; and (v) Locally manufactured insulation bricks* (for oven construction and other purposes). This improved oven is made from bricks. The walls are three bricks thick, two of them being insulation bricks. The vault is a semi-circle covered with a grill onto which a Portland cement purging is fixed. A metal clamp collar surrounds the oven. For the construction of the oven and fittings requires RWF 300 000; ancillary costs (moulding, handling, fuel, and heater) are RWF 1.768 per brick compared with RWF 2.5 per brick using the traditional method. This method should be introduced to replace the existing traditional method.

The *Hoffman kiln* consisting of a main fire passage surrounded on each side by several small rooms which is in use in different East Africa country like Uganda and Kenya has been approved to be energy efficient. This kiln is constructed in such way that each room contains a pallet of bricks.

In the main fire, passage there is a fire wagon that holds a fire that burns continuously. Each room is fired for specific time, until the bricks are vitrified properly, and thereafter the fire wagon is rolled to the next room to be fired as each room is connected to the next room by a passageway carrying hot gases from the fire. This method of firing bricks was seen to be very energy efficient. Therefore such method can be imported in Rwanda to reduce the quantity of trees cut for firing bricks (ADA[11]).

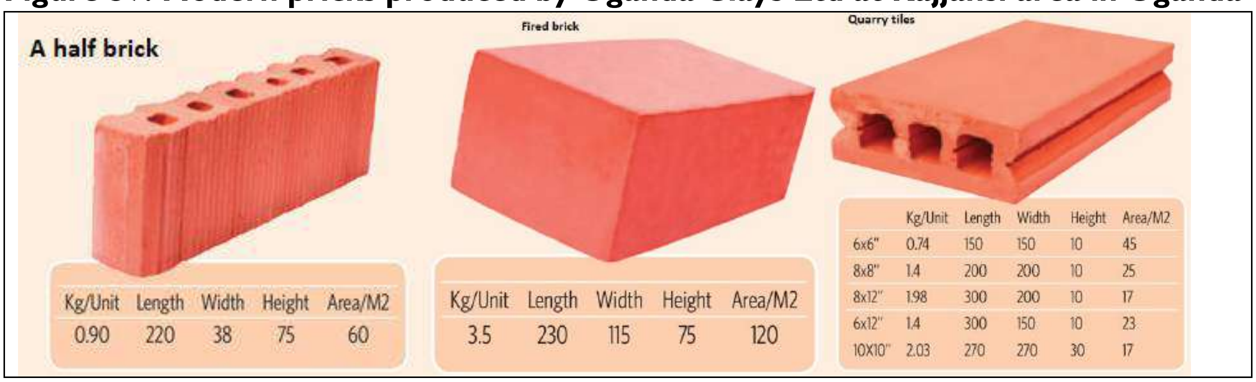
(ii) The use of machinery for production of clay-based materials

Rwanda's abundant clay deposits are of excellent quality and the massive demand of the countries fast-growing cities are fertile grounds for the construction industry to produce and build with modern brick technologies.

SKAT Consulting Limited is an independent Swiss consulting company and resource center working in the fields of development cooperation and humanitarian aid. For several years, Rwandan small and medium enterprises, with the support of the Ministry of Infrastructure and the Swiss Agency for Development and Cooperation, have started to produce machine-made modern bricks that allow for the construction of smart and cost-effective buildings.

The use of machinery helps to produce clay products of good quality and different shapes at a very low price as it has been a case at Kajjansi in Uganda (figure below).

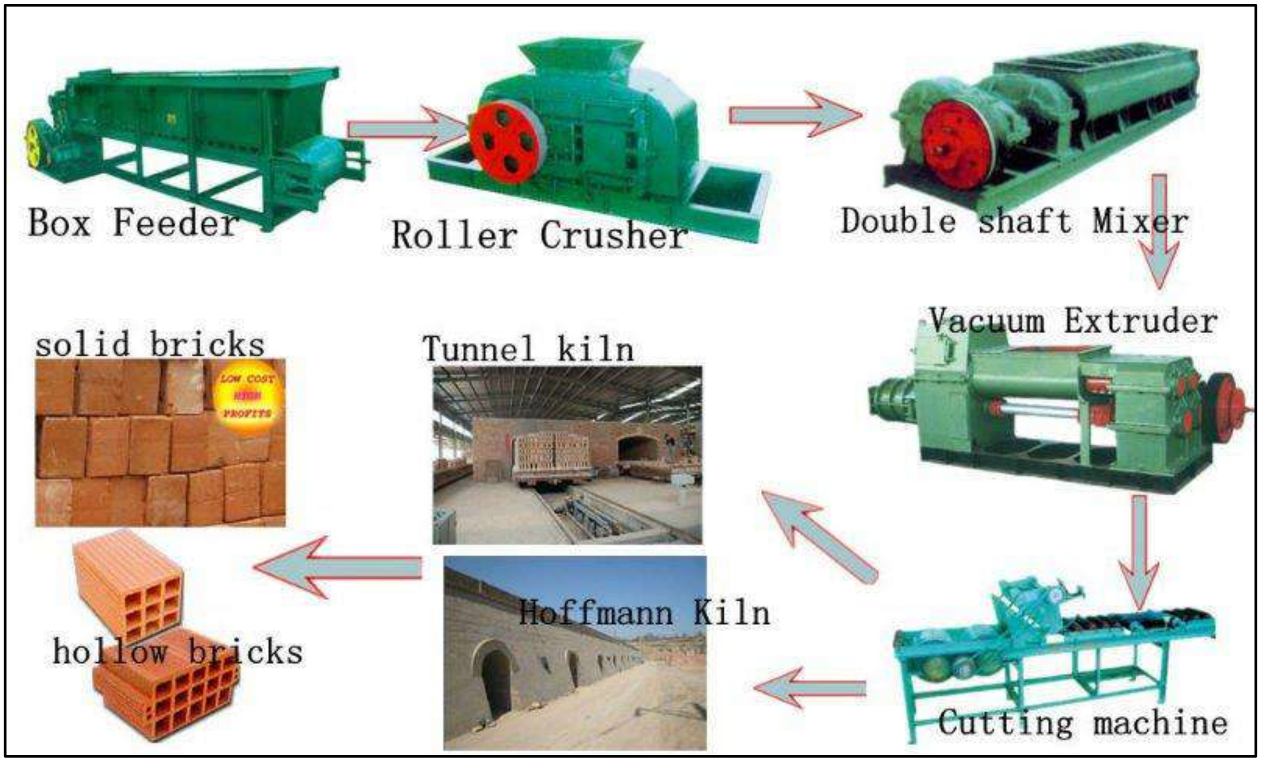
Figure 57: Modern pricks produced by Uganda Clays Ltd at Kajjansi area in Uganda



Source: https://ugandaclays.co.ug/products/

[11] Africa Development Associates, 2017. Study on Brick Cluster Development in Uganda

Figure 58: Example of technology in use by Uganda Clays Ltd



Moreover, Kenya Clay Products Ltd is leading manufacturer of quality baked clay building products not only in Kenya but also in East Africa. The company's products are categorized into roofing tiles, bricks, quarry floor tiles and others.

Figure 59: Samples of clay processing by Kenya Clay Products Ltd in Kenya

Source: https://www.skylarkconstructionkenya.com/our-services/kenya-clay-products/

Kenya Clay Products Ltd is using heavy clay processing machinery. The company prides in manufacturing over 42 different types of building materials from clay using sustainable production methods. Below are selected samples of clay products manufactured by Kenya Clay Products Ltd.

(iii) Promotion of Green building Technologies

It is commonly acknowledged that green building is an effective approach through which the need for implementing sustainability and sustainable development within the construction industry can be addressed12. Green building was defined as "the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's lifecycle"13.

Thus, the development of green buildings would result in substantial minimization of negative environmental effects and efficient utilization of resources. It should have a Minimum Compliance system developed by RHA with GGGI by promoting energy efficiency, use of renewable energy, ensuring water efficiency, using environmentally preferable building materials and specifications, using local materials, promoting waste reduction, promoting toxics reduction, ensuring indoor air quality, promoting smart growth and promoting sustainable development.

It is worth noting that Rwanda Housing Authority during KII stage, has informed about the existence of guidelines about minimum compliance with Green building technology in Rwanda, however, the informant confirmed that those guidelines are rarely followed. The RHA suggested to incorporate Green building Technologies (GBT) into building design to get construction permit but the informant declared that some time is not verified by competent staff before giving construction permit and when it is verified at this stage, there is no follow up made at implementation stage of the building design.

On the other hand, the processors of clay-based construction materials are requested to adapt their products to the requirement of GBTs to facilitate the end users (constructors) to implement them. Therefore, the use of machinery giving different shapes to the bricks would facilitate the implementation of GBTs by the end-users of clay-based construction materials.

[12] Sev, A. How can the construction industry contribute to sustainable development? A conceptual framework. Sustain. Dev. 2009, 17, 161–173.

[13] Son, H.; Kim, C.; Chong, W.K.; Chou, J.S. Implementing sustainable development in the construction industry: Constructors' perspectives in the US and Korea. Sustain. Dev. 2011, 19, 337–347.

3.9. Contribution of clay industry to the Greenhouse emissions

Transporting clay based construction materials and firing materials in use in clay industry have reported to contribute to the Greenhouse emissions as has been reported by the Ministry of environment in Rwanda. Default emission factors provided by IPCC 2006 Revised Guidelines were used to estimate specific physical characteristics (Net calorific values, densities) of emissions from various working sectors including clay industry. The study conducted by REMA in 2020 revealed that the biomass (i.e., firewood, charcoal, agricultural wastes, pellets, biogas and waste briquettes) is still the dominant source of cooking fuel and firing materials in Rwanda, followed by the liquid fuels (Liquefied Petroleum Gas and kerosene) while the electricity is the less used. The summary of the consumption per household and per capita are summarized in the table below.

Table 18: Annual average of cooking and firing fuels consumption

Type of firing material	Consumption in kg	Consumption per capita
Firing wood	1,778,6460.7	276.19
Agricultural wastes	4,276.82	258.09
Pellets	157.6	39.73
Briquettes	356.84	38.27

Source: *REMA, 2020*

The highest per capita annual cooking/firing energy consumption was observed for firewood 276.19 Kg followed by agricultural wastes 258.09 kg. The detailed consumption of firewood and agricultural wastes are presented in table below.

Table 19: Annual firewood and agricultural consumption per province

Province	Firewood consumption in Kg	Firewood consumption per capita	Agricultural wastes consumption in kg	Agricultural wastes consumption per capita
Eastern	624,967.42	298.74	11,992.86	499.7
Western	394,403.53	255.77	-	
City of Kigali	52,876.33	391.68	-	
Southern	409,727.66	245.49	5,193.74	370.98
Northern	296,671.13	307.43	4,197.5	419.17
Rwanda	1,778,646.07	276.19	-	

Source: *REMA, 2020*

The annual average firewood consumption per capita was 276.19 kg, while the total firewood consumption in Rwanda for cooking and firing is 1,778,646.07 kg per year. Moreover, it was hard to estimate the total f Greenhouse gases emissions from clay based activities. Moreover, emissions from mining and quarrying industries were estimated for a period of 2006 – 2019 and it was cumulatively estimated at 30.33 Gg CO2 eq.

Table 20: Summary of GHG emissions from mining and quarrying industries

Period	Consumption	CO_2	CH_4	N_2O	Total GHG
	(TJ)	(Gg)	CO_2 eq. (Gg)		
2006	94.77	6.77	0.0059	0.0175	6.79
2007	65.26	4.69	0.0041	0.0121	4.71
2008	41.83	3.01	0.0026	0.0078	3.02
2009	3.20	0.23	0.0002	0.0006	0.23
2010	19.89	1.43	0.0013	0.0037	1.43
2011	20.06	1.44	0.0013	0.0037	1.45
2012	39.95	2.87	0.0025	0.0074	2.88
2013	32.11	2.31	0.0020	0.0060	2.32
2014	25.19	1.81	0.0016	0.0047	1.82
2015	9.20	1.13	0.0010	0.0029	1.14
2016	10.6	1.24	0.0015	0.0034	1.86
2017	8.6	1.06	0.0014	0.0050	1.24
2018	9.2	1.16	0.0008	0.0036	1.72
2019	9.8	1.18	0.0008	0.0028	1.12
Totals	**389.66**	**30.33**	**0.027**	**0.0812**	**31.73**

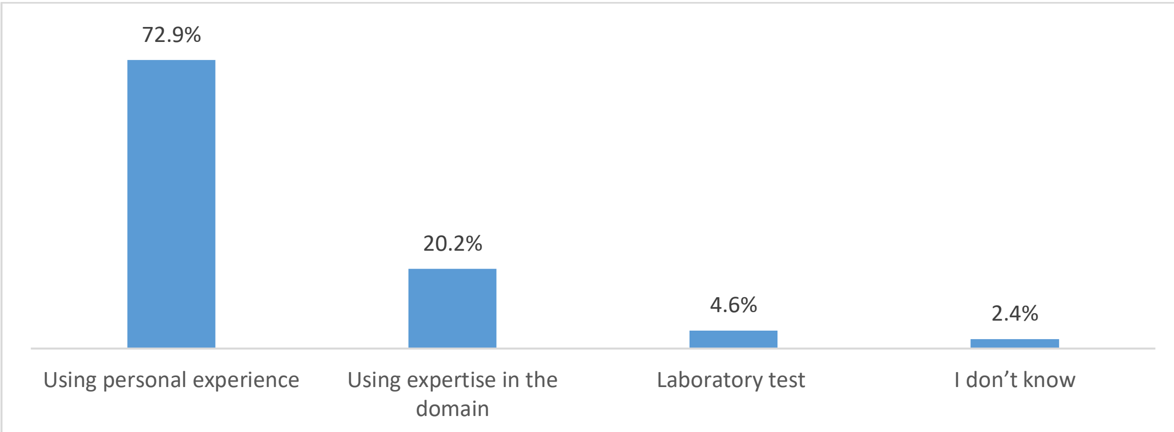
Source: *REMA, 2020*

The analysis of emissions gas per gas showed that CO_2 has the highest contribution of 95.58 % to the total GHG emissions. The contributions of CH_4 and N_2O are 0.027% and 0.08212%, respectively. Moreover, the contribution of 30.33 Gg CO_2 eq from mining and quarrying in which clay extraction and processing are included is still low compared to the total cumulative emission of 69,187.60 Gg CO_2 eq for the same period.

3.10. Quality control and standards status assessment

Rwanda's building and construction industry has rapidly grown in the past couple of years with both government and private sector engaged in the construction of buildings and roads triggering what is now dubbed as a "construction boom in Rwanda". The construction industry contributes immensely towards the GDP of the country mainly through direct income and massive employment opportunities generated from the construction of various infrastructure projects and their maintenance. It is estimated that the construction sub-sector of the larger industrial sector contributes the highest to the country's industrial GDP as it was shown in figure. However, this sector will be only sustainable if the used materials are of the high quality fulfilling international standards. With this regard investigation was made to assess the methods in use to identify clay with a good quality and findings were shown in figure below.

Figure 60: Identification of a clay with a good quality



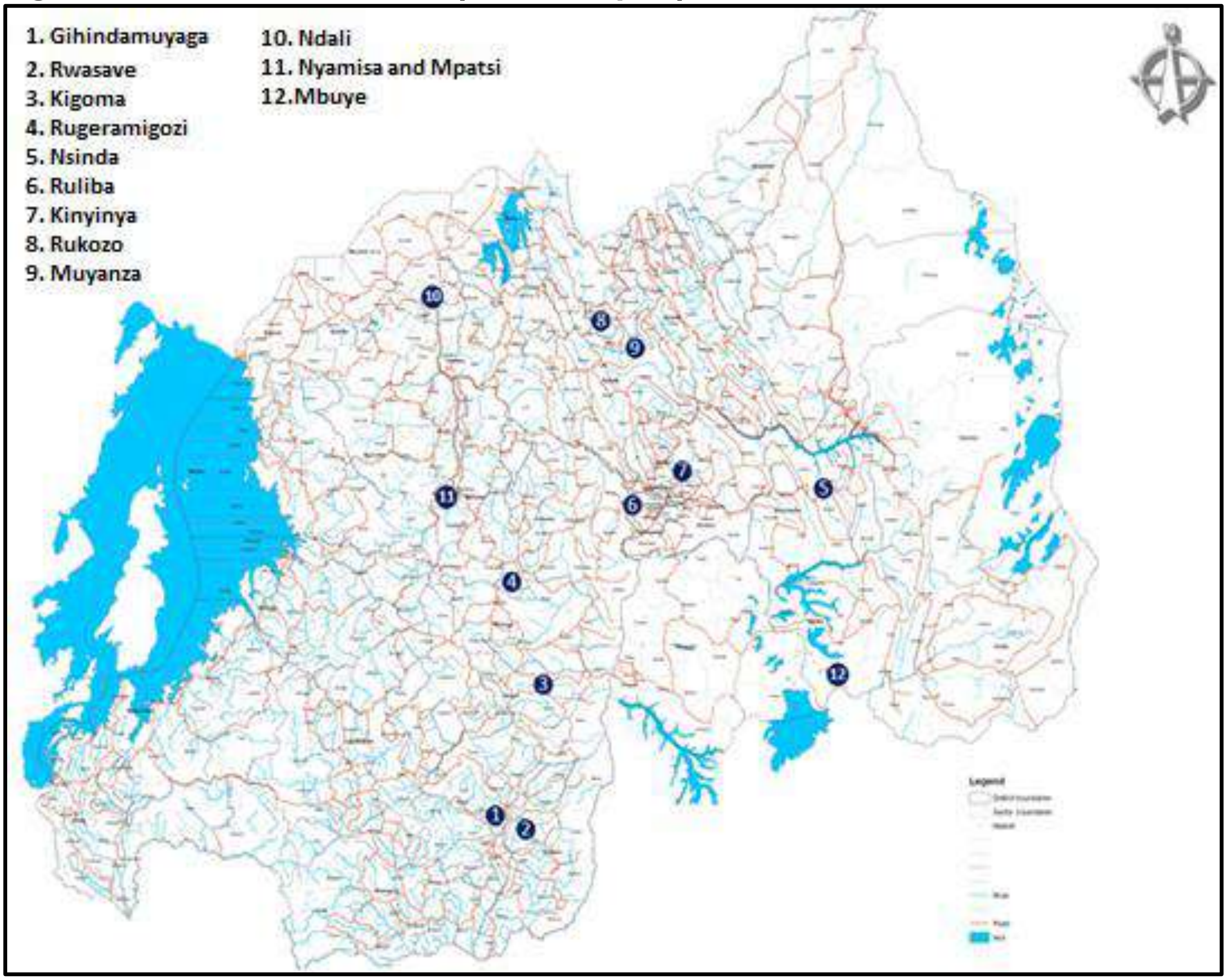
Source: *Clay Tech Audit survey, 2020*

The study revealed that the identification of a clay as raw material with good quality is done using personal experience as declared by 72.9% of respondents with 20.2% who use expertise they have in the domain. Only 4.6% of respondents confirmed that their firms are taking samples to be tested in laboratories to know the best quality of clay to be used in processing construction materials. Moreover, there is also possibility of making reference to the study already done previously in some areas across the country. For instance, there are studies of quality and quantity of clay deposits done by the Switzerland Cooperation and Rwanda Geological Survey in a joint project called "EGAR: Etude Globale de l'Argile au Rwanda". The following are key aspects to consider while assessing a clay of a good quality.

- **Sound and insulation:** The characteristic thickness and density of the mud-brick wall reduces noise transmission and prevents noise from outside for a peaceful and quiet home.
- **Durable:** Clay bricks do not warp, rust, wear, peel, or fade over time, they do not harbour termites and appear more beautiful when they are made.
- **Low Maintenance cost:** While these bricks may be expensive to acquire, their low maintenance and durability make these materials a cost-effective option for the exterior of your home.
- **High resale value:** Clay brick homes generally have a high resale value as homebuyers prefer the upscale appearance and easy care of a brick home.
- **Fire resistances:** These bricks do not burn and reduce the possibility of fire where they are used.

It is important to mention that there are a number of studies which contributed in identifying the most interesting clay deposits as presented in the figure below:

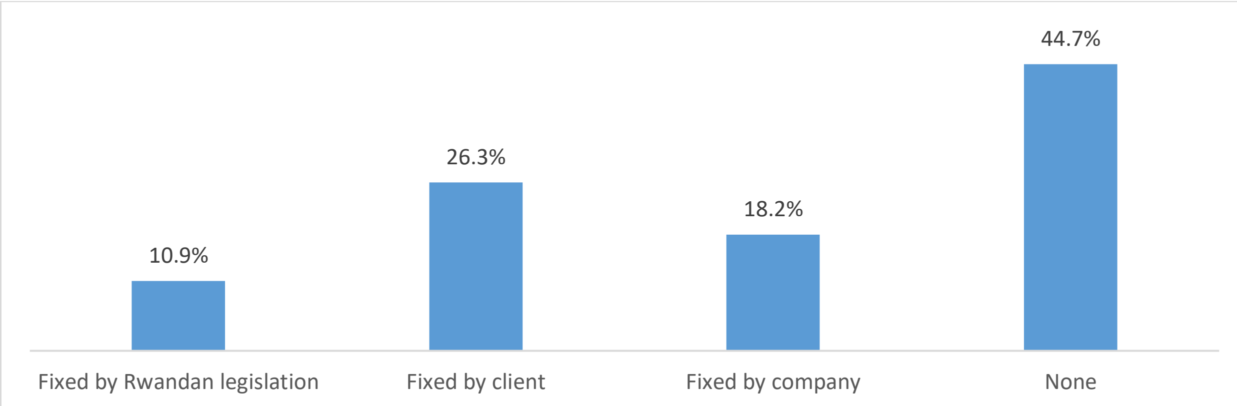
Figure 61: Some of the most important clay deposits identified in 2013



Source: *RNRA/GMD, 2013*

The study mentioned above have identified twelve most important clay deposits across the country and most of them were found in central part of the country. The same study identified operational small scale tile and brick making units which use the clay of high quality as presented below.

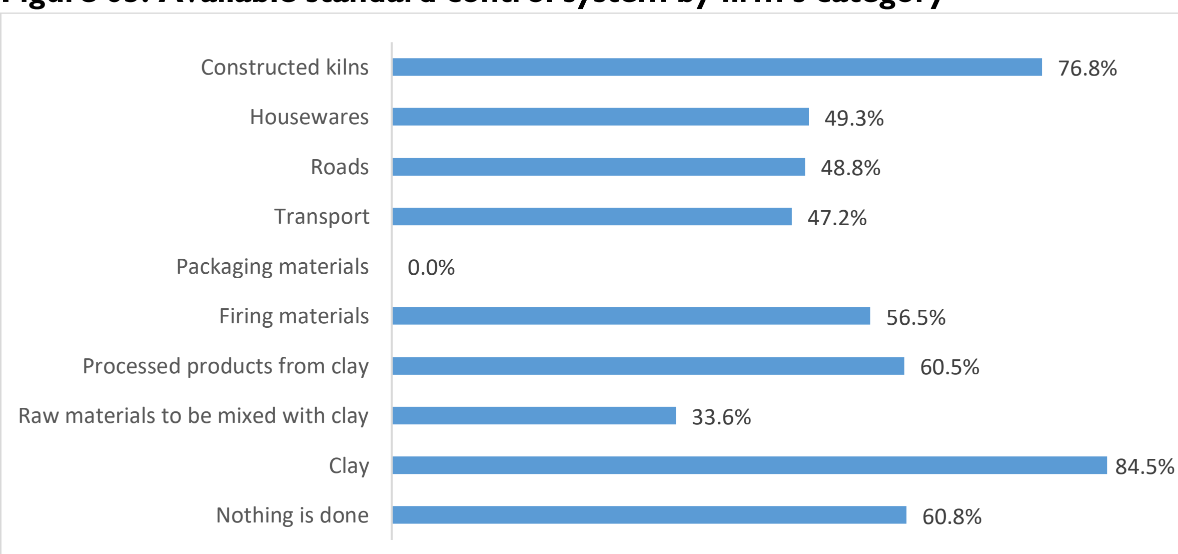
Figure 62: Standards followed by firms



Source: *Clay Tech Audit survey, 2020*

This study explored the standards followed by the firms and 44.7% of respondents revealed that they do not follow any standard in processing stages of clay product. 26.3% and 18.2% of respondents confirmed that their firms follow standards which were fixed by the client and company respectively while 10.9% that follow those fixed by Rwandan legislation. This implies that there is a poor follow up and check-up of clay products in terms of standards fixed by the government of Rwanda. This makes it difficult for the clients to select the best clay product in terms of durability, resistance to external shocks, and beauty among others. In this respect, a call is made to the governmental, non-governmental institutions (e.g. Rwanda Standards Bureau - RSB) and other stakeholders to put together their efforts to fix the standards which would be followed to produce competitive clay products delivered as construction materials.

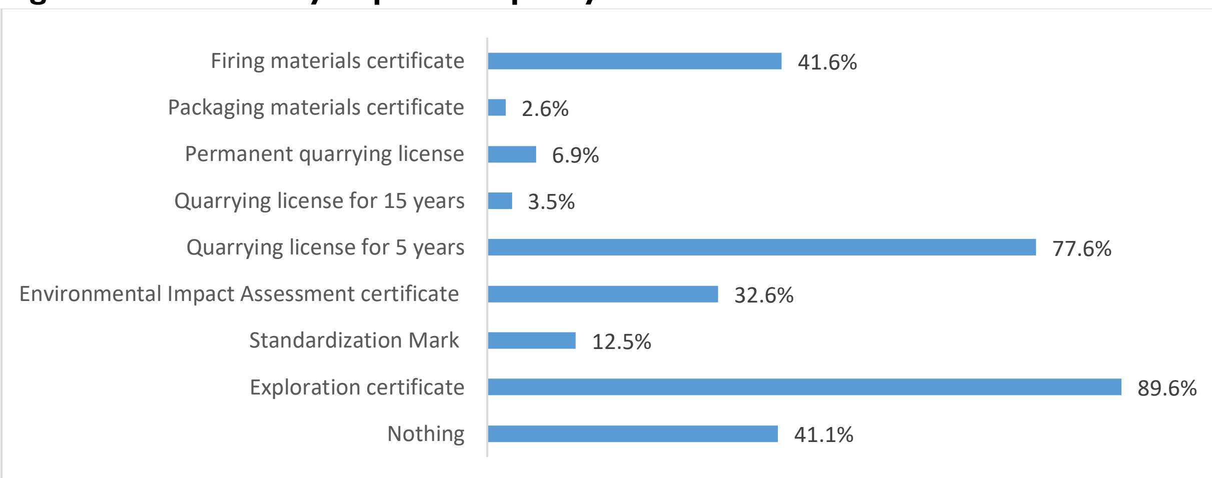
Figure 63: Available standard control system by firm's category



Source: *Clay Tech Audit survey, 2020*

It was reported by 84.5% of respondents that they have standard control system on extracted clay and constructed kilns as confirmed by 76.8% respondents while 60.5% of respondents testified to have standard control system on processed products from clay and 56.5% of respondents testified to have a control system on firing materials. Around 40% of respondents declared to have standard control system on housewares, roads, and means of transport and raw materials to be mixed with clay. Despite the confirmation of the existence of these standard control systems, it was revealed in FGDs that most of clay operators use working experience and personal insights to be followed in various clay related activities for construction materials production. When clay operators were asked about possession of product/quality certificates of their products the feedback provided was compiled in the following figure.

Figure 64: Availability of product/quality certificates



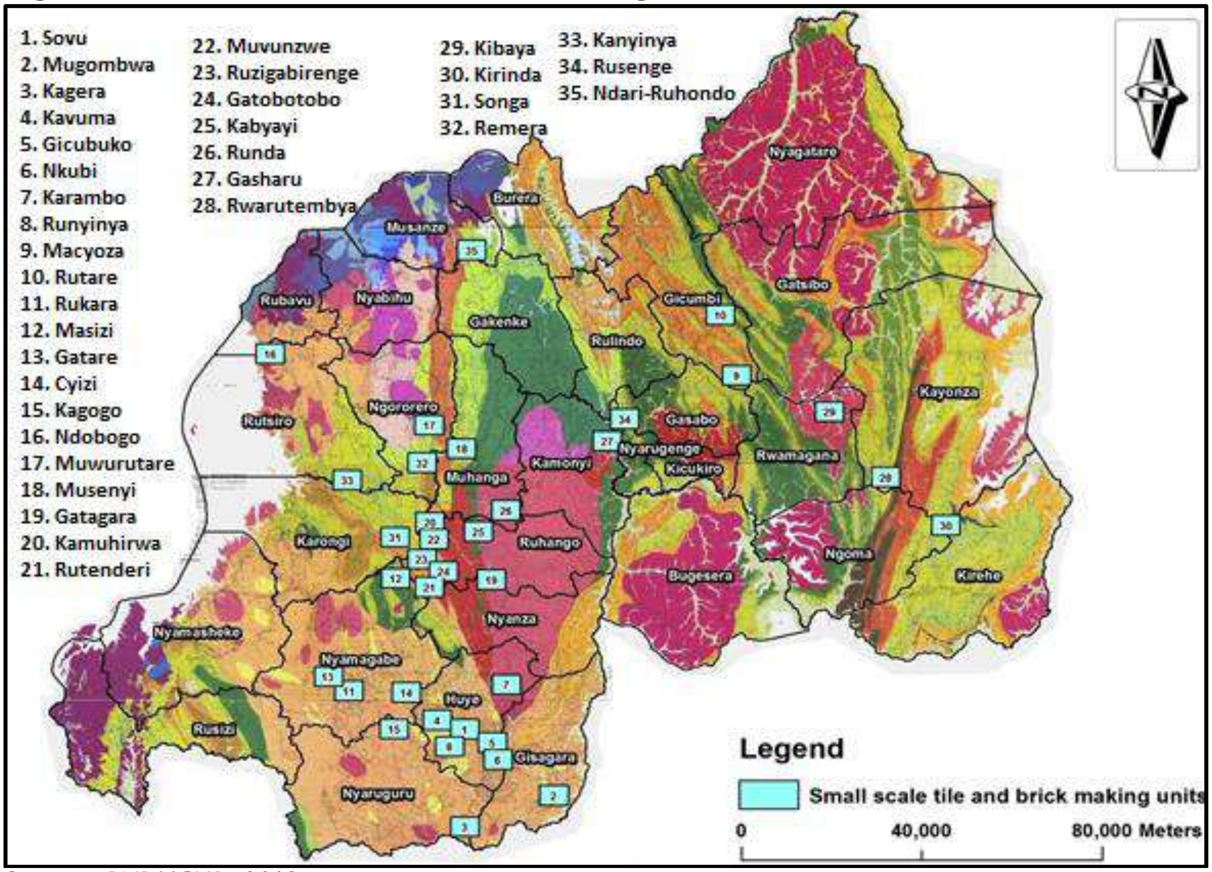
Source: *Clay Tech Audit survey, 2020*

It was declared by 89.6% of respondents that they possess exploration certificate while 77.6% have a quarrying licence for 5 years and. 41.6% of respondents confirmed to have firing materials certificate while 32.6% of respondents possess environmental impact assessment certificate. Only 12.5% of respondents confirmed to have Standardization Mark on their products but a negligible percentage (less than 7%) informed to have permanent quarrying licence, quarrying licence for 15 years and packaging materials certificates. Based on these findings it can be deducted that most of clay actors have short-term clay exploitation permit. This might discourage the investors to inject a lot of money in clay related businesses due to the uncertainty of having exploitation permit/certificate renewed which will have negative effects on productivity and competitiveness of clay sector.

3.11. Potential of clay raw material in Rwanda

Clay is readily available in Rwanda. These include clay that results from alteration of (a) granite rocks (b) volcanic rocks and (c) argillaceous rocks. Where the clay deposits exist, they are of good quality, but generally contain limonite. Some studies on quality and quantity of clay deposits were done through Swiss Cooperation with Rwanda Geological Survey as mentioned in introductory part. Below there are the key small scale tile and brick making units mapping in 2013.

Figure 65: Small scale tile and brick making units



Source: *RNRA/GMD, 2013*

The figure above presents 35 operational small scale tile and brick making units identified across the country in 2013 which were using clay of good quality. However, 104 and 709 modern and traditional kilns respectively were reported by REMA in 2018. This means that some of them are using clay of low quality to produce tiles and bricks. Furthermore, the study on the most extensive clay reserves were conducted as presented in annex 5.6. The table below shows the confirmed clay deports by MINICOM in 2015.

Table 21: Confirmed clay deposits

SN	District	Confirmed deposits (M^3)
1	Musanze	500,000
2	Rulindo	576,000
3	Gasabo	400,000
4	Nyarugenge	700,000
5	Rwamagana	30,000
6	Muhanga	310,000
7	Nyanza	80,000
8	Huye	600,000
9	Gisagara	1,000,000

Source: MINICOM in 2015

The clay value chain actors may make use of the above to project potential profitability of these confirmed deposits and then invest accordingly. Furthermore, the further research across the country should be conducted to have a national map of clay deposits.

3.12. Environmental issues resulting from the use of clay

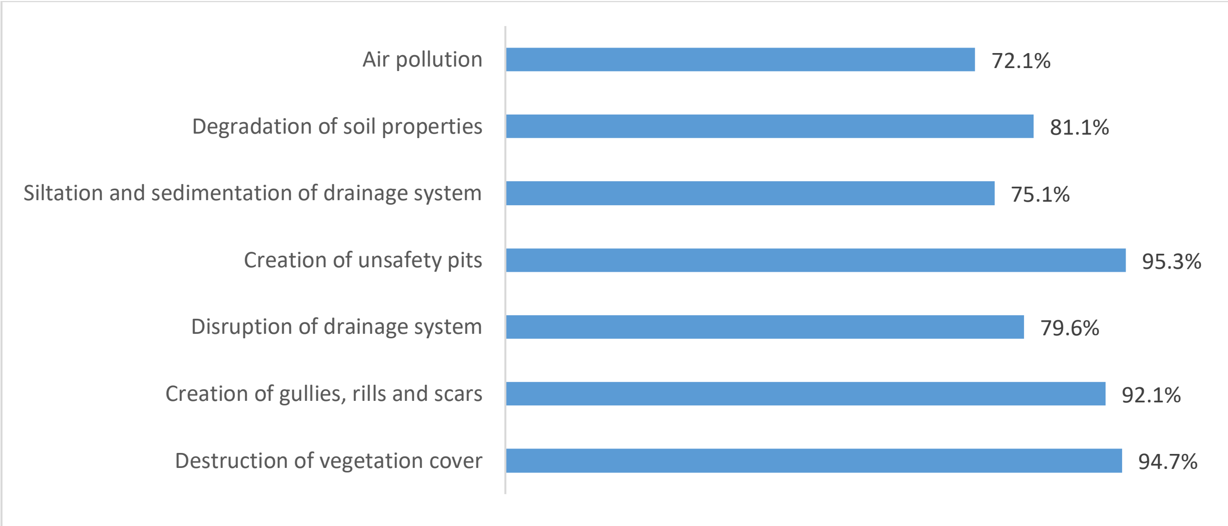
Environment encompasses physical and non-physical medium such as air, water, solid waste/land and also noise pollution. Therefore, processing clay-based construction materials exerts a negative effect on the landscape, water resources, soil and biodiversity. In this regard, environmental issues resulting from clay extraction and processing were studied and the results were presented in figures below.

Table 22: Environmental impacts of producing clay-based construction materials

Stage	Environmental issues	Possible impacts
Extraction impacts	• Removal of topsoil and overburden; • Clearing of Surface Vegetation; • Noise and vibration; • Competition for rich agricultural land; • Soil erosion; • Hydrological impacts.	✓ Loss of biodiversity and Ecosystem disturbance; ✓ Reduced vegetative cover; Water pollution and depletion; Contamination of Soil; ✓ Soil Degradation; ✓ Visual Impact.
Transportation	• Release of greenhouse gases emissions; • Road Accidents; • Increased pressure on infrastructure.	✓ Green houses gasses increase leading to global warming
Processing	• Material usage (Energy and Water use); • Release of greenhouse gases during the production; • Occupational Health and Safety issues; • Noise emissions; • Use of old technology.	✓ Accidents and injuries to workers. Solid waste generation High water and Energy consumption
Products End Use	• Waste Management and disposal • Release of greenhouse gases • Public health and occupational safety • Unsustainable products	✓ Solid Waste Generation

The study assessed whether clay value chain actors are aware of negative impacts from the extraction of clay and the feedback given was summarized in figure below.

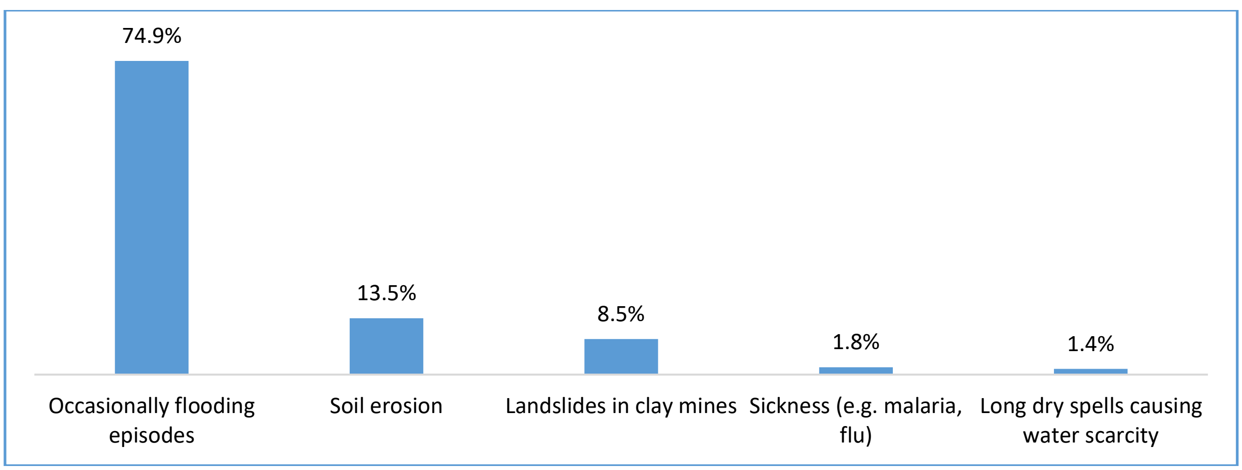
Figure 66: Awareness on negative impacts of clay extraction on the environment



Source: *Clay Tech Audit survey, 2020*

It was encouraging to hear that the majority of respondents (more than 70%) are aware of the negative impacts of clay extraction on the environment. The respondents are excellently aware that extraction and processing of clay may result into creation of unsafe pits, destroy vegetation cover, creation of gullies, rills and scars as reported by more than 90% of respondents. They are also aware that extraction and processing of clay may cause siltation and sedimentation of drainage system (70%), disruption of drainage systems (79.6%), degradation of soil properties (81.1%) and air pollution (72.1%). The energy in use for firing clay construction materials were analysed to estimate the potential Green House Gases emission and the feedback from the respondents was presented in figure below

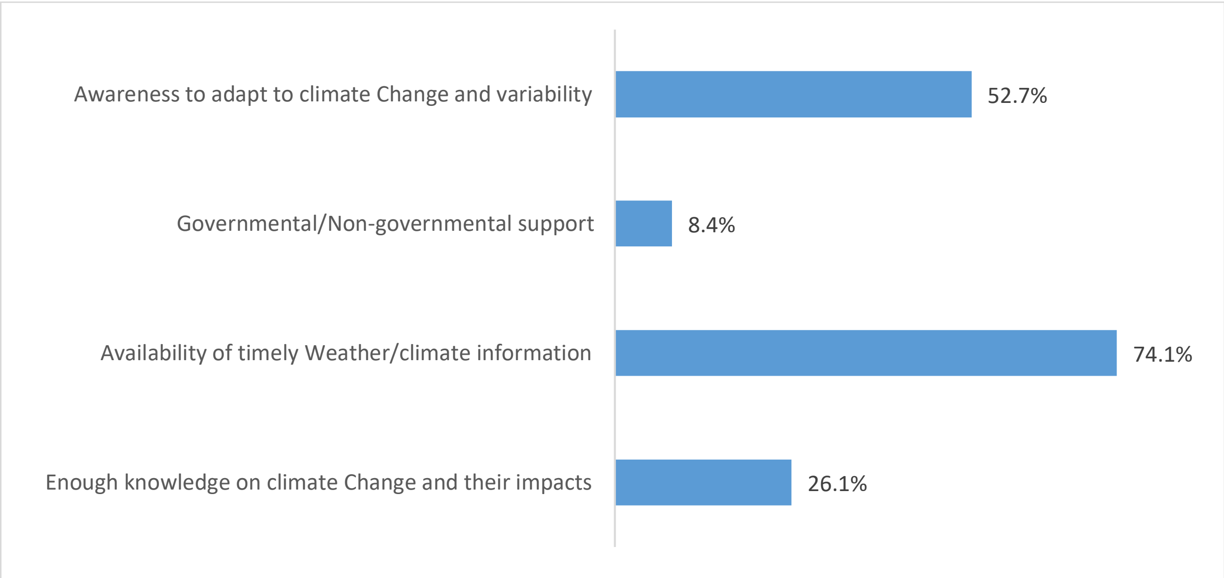
Figure 67: Impacts of climate change on the business linked with the use of clay product in construction



Source: *Clay Tech Audit survey, 2020*

It was revealed that the majority of respondents (74.9%) are aware that climate change and variability has caused flooding episodes. The respondents are also aware that climate change may lead to the soil erosion, landslides in clay mines and increase the spread of the sicknesses (e.g. malaria, flu, etc). It was highlighted by the interviewees in FGD that the holes full of stagnant water host mosquitoes which are susceptible to cause Malaria and skin diseases. They may also cause the accident if any person falls down in the hole. It may lead also to the long dry spells causing water scarcity to be used in clay related activities. The study explored whether the firm's members have the capacity to deal with the impacts of climate change and variability and the collected findings were summarized in figure below.

Figure 68: Availability of capacity to deal with the impacts of climate change and variability



Source: *Clay Tech Audit survey, 2020*

Despite the fact that 74.1% of respondents declared to have access to timely weather/climate information, they still have limited knowledge on climate change and its impacts as reported by 26.1% of respondents. However, 52.7% of respondents said that they are aware that they need to develop adaptation measures to deal with adverse impacts of climate change. But, when asked what measures they are ready to implement in FGDs, most of them were not able to propose appropriate adaptation measures to put in place. This shows that the capacity of clay value chain actors to deal with the impacts of climate change and variability is still low. Therefore, there is a need to provide capacity building, financing tools, equipment and technical support to help them to implement long-term, innovative and far-reaching climate change mitigation and adaptation practices.

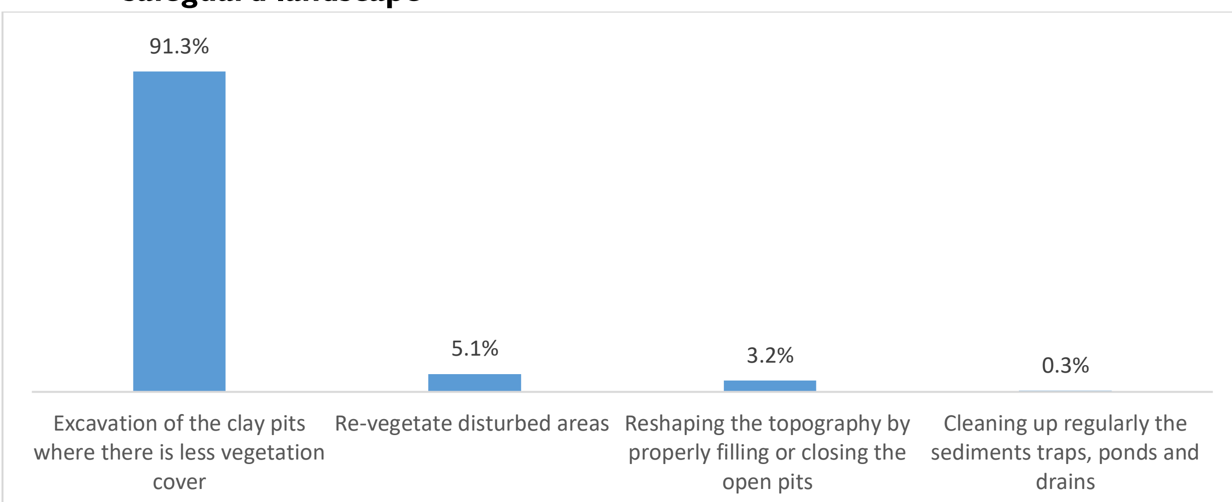
It is necessary to mention that this study demonstrated that extraction and processing of clay for construction materials exert a negative effect on landscape through destruction of vegetation cover and creation of geomorphological structures including rills, gullies, and scars. Such structures accelerate erosion and induce landslides in mining zones. In some points, the eroded materials that reach the streams and rivers contribute to the disruption of the drainage systems.

Figure 69: Samples of disrupted landscape due to clay extraction and processing

Source: *Clay Tech Audit survey, 2020*

The figure above shows that landscape was disrupted in areas where clay was extracted and processed. The following figure summarizes actions and practices that may be adopted in order to minimize mining impact on the landscape.

Figure 70: Environmental best practices used by clay value chain actors to safeguard landscape



Source: *Clay Tech Audit survey, 2020*

The vast majority of firm representatives (91.3%) reported on implementing the practice of excavation of clay pits where there is less vegetation cover to safeguard the landscape. The other measures as proposed by the survey were very rarely implemented as shown in the graph above. During the FGDs the clay value chain actors were recommended to avoid disturbing large and/or mature trees because of their importance to avoid erosion and landscape degradation. In addition it was also recommended to avoid cutting trees' rootstocks to allow easy regeneration and regrowth along with avoiding the clearing of the vegetation surrounding the mining pit,;

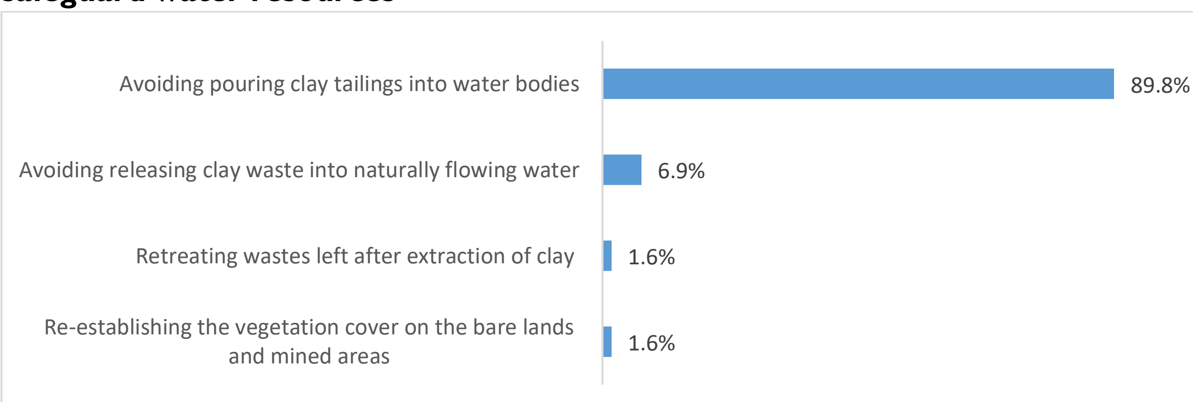
It is important to highlight that clay extraction and processing for construction materials also causes modification of physico-chemical properties of water, siltation and sedimentation of streams and flooding risks.

Figure 71: Samples of polluted water due to the extraction and processing of clay

Source: *Clay Tech Audit survey, 2020*

The figure above shows that the water was polluted due to the extraction and processing of clay. Best practices to contain and prevent such negative effects are summarized in the figure below.

Figure 72: Environmental best practices used by clay value chain actors to safeguard water resources

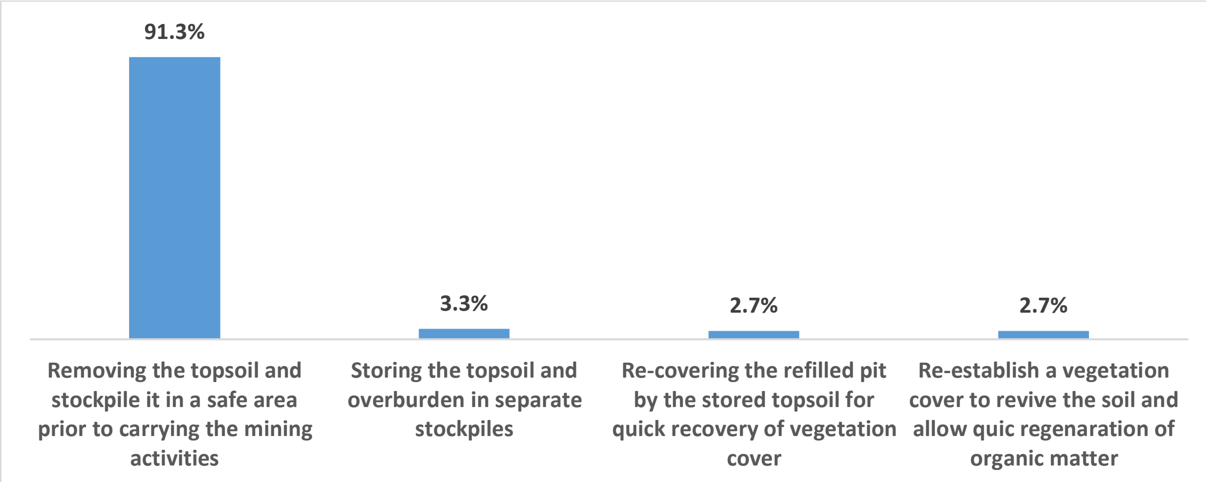


Source: *Clay Tech Audit survey, 2020*

Avoiding pouring clay tailings into water was the environmental best practices agreed by the majority respondents (89.8%). The other best practices adopted by limited number of respondents include avoiding releasing clay waste into naturally flowing water, retreating wastes left after extraction of clay and re-establishing the vegetation cover on the bare lands and mined areas.

It is necessary to note that extraction and processing clay for construction materials may result into degradation of soil physio-chemical properties and contamination by metals and metalloids. There have losses of agricultural soil by accumulation of clay overburden. The soil texture is dominated by clay fraction and not suitable for agriculture. Such a soil will hardly retain nutrients/minerals and water necessary for plant growth, hence reduced vegetation cover and increased downstream erosion in clay extracted areas if the site is located on hillside. The following figure summarizes actions and practices to adopt in order to minimize adverse effects of clay extraction and processing on the soil.

Figure 73: Environmental best practices used by clay value chain actors to safeguard soils



Source: *Clay Tech Audit survey, 2020*

The majority of the respondents (91.3%) accepted to remove the topsoil and stockpile in safe area prior to the clay extraction. The respondents are aware that storing the topo and overburden soil in separate stock piles, recovering the refilled pit and re-establishing vegetation cover to revive the soil and allow quick regeneration of organic matter which are among the most strategies to implement to safeguard soils in clay extraction area.

Clay extraction and processing has a negative effect on the biodiversity through pollution of toxic metals and metalloids, loss of habitat and the pollution of water. Therefore, the following best practices to contain and prevent such negative effects summarized in the table below should be implemented across the country by the extractors and processors.

Table 23: Environmental friendly guidelines to be put in place to contain adverse effects of clay extraction and processing

Key impacts on biodiversity	Environmental friendly guidelines
Mixing clay wastes with agricultural land reduces its potential productivity	• Dumping clay wastes in exhausted pits and tunnels to reduce contamination of nearby soil and water bodies. • Reclaiming the clay extracted areas to restore the physio-chemical and biological quality previously disturbed by clay extraction activities.
Loss of vegetation cover and suitable habitats	• Removing the topsoil and stockpile in a safe area prior to carrying the extraction and processing activities, and then bring it back when clay extraction operations have ended. • Re-establishing the lost vegetation cover to rapidly allow the colonization of essential soil micro-organisms and to re-attract wildlife presence in clay extracted areas; • Afforestation of clay extracted areas to re-establish the lost trees.
Spoilage of water	• Providing safe access to water for livestock and native animals by artificially creating hard surfaces and ponds to retain water. • Avoiding dumping sediments and effluents in the water bodies.
Water pollution	• Monitoring water quality for ground and surface waterbodies, tailings or overburden soil storage facilities, effluent quality and quantity to limit water pollution. Monitoring should also entail periodic inspection of the vegetation for signs of erosion damage or failures of vegetation establishment process.

Source: *Clay Tech Audit survey, 2020*

3.13. SWOT analysis of clay value chain for construction materials in Rwanda

Clay value chain for construction materials in Rwanda has not evolved to become a formal cluster. Most of operators are still using traditional technology and kilns, they have dwelt on the availability of clay as in input, proximity to the factories, and a large clientele attracted to the area for the finished products. The fact that the idea of the cluster has not been established from the ground up, various operators see themselves as competitors as opposed to the complementary agents. This therefore sets the tone for the SWOT analysis presented below.

Table 24: SWOT analysis of clay value chain for construction materials

Strength: - Availability of high quality clay deposits which makes the local products competitive; - Good governance which promote business and investments especially in industrial sector; - Promotion of made in Rwanda products which prioritize Rwandan products on the local market; - Availability of cheap labour with local skills that can be imparted; - High demand of clay construction materials on the market; - Low investment to start small scale business for clay construction materials; - Availability of a number of research on the quality and quantity of clay in Rwanda; - Low competition of local products with imported clay products; - Availability of clay in quantity and quality; - Availability of water in clay prone areas, etc.	**Threats:** - Environmental degradation from unsustainable clay extraction; - Pollution to the population from emissions of gases from brick kilns; - Exposure of ones' own known-how when competitors are given access (causing a likelihood of challenges in enforcing property rights); - Expensive and irregular supply of utilities like water and electricity; - Poor quality of roads around processing place of clay-based construction materials; - Natural hazards such as sedimentation, silting, flooding at clay extraction and processing place; - There remains information asymmetry arising from lack of information flow on what constitutes the right quality; - Misconception on the tiles which make them to be less attractive in construction sectors;
Weaknesses - High cost of machinery (including repair costs) to be used clay processing; - Low level of technology in processing stage - Access to technology and finance? - Limited availability of critical service provided (including machine operators and engineers); - Lack of drillers and geo-physical sensors to be used in the exploration and determination of quantities and quality of clay. - Firing materials are not readily available. - The brick business is seasonal (dry seasons) due to the lack of appropriate warehouses causing changes in production and demand patterns; - A lot of losses during rainy seasons due to the lack of warehouses; - Unskilled staff are still dominating in clay value chain for construction materials;	**Opportunities** - Brick sector is a high turn-over business that presents an attractive proposition for the financial sector; - Housing and settlement sector has gradually expended due to a gradual growth of the economy and population; - The high demand of clay products especially bricks and tiles to construct the needed houses as projected in 2050 Rwanda's vision. - Existing of the policy, legal and regulatory framework that is supportive of the clay based construction materials; - Availability of basic transport infrastructure(roads-paved and

- Use of traditional technology and kilns resulting into poor quality of clay products and then low annual turn-over; - Many operators are still working on the same official document (License). Then a failure of one operator to comply with environmental, standard requirements, etc make the whole team to stop operating; - Limited training centres in mining sector especially in clay extraction and processing. - Inadequate marketing analysis of majority of clay firms; - Irregular functional operations especially during rainy periods	non-paved) to have access to clay based construction materials; - Existence of the political will to support the development of the clay sector through "Open Call Programmes";

Source: *Clay Tech Audit survey, 2020*

The above SWOT analysis is not exhaustive but indicative as clay value chain for construction materials is a very large business involving various stages. Therefore, it is open to further analysis at each stage of clay value chain for construction materials. The findings and SWOT analysis lead to conclusion and recommendations below.

4. GENERAL CONCLUSION AND RECOMMENDATIONS

4.1. General conclusion

The clay value chain for construction materials in Rwanda has a large potential for increasing its contribution to economic growth. It has already grown faster than the overall economy, driven by a construction boom especially in urban areas. Notwithstanding that the construction materials based on clay have high demand on the markets, there is as yet no countrywide map showing the total volume of clay in Rwanda. It is thus not possible to accurately estimate the lifespan of the deposits and no idea when to start thinking on alternative source or even other materials once the clay deposits although of high quality will be exhausted.

Though the majority of existing clay operators are still at small scale level with hard working conditions, poor salaries and traditional operating systems, there are also few promising clay operators who use either semi-automated or automated machines with permanent kilns. This contributes to the production of improved clay products in quantity and quality. Therefore a call is made to different stakeholders to put together their efforts to be able to respond to the governmental aspiration of vision 2050 using land efficiently by phasing investment strategically and integrate green principles with development, improve the quality of individual houses and build high quality new houses, and facilitating housing through appropriate financing mechanisms.

Moreover, the sector faces several challenges. Broadly speaking, they can be divided into regulatory and productivity challenges. The regulatory challenges arise from five causes: the lack of knowledge about clay deposits across the country, the informal operation of clay value chain actors (e.g. individual, cooperatives and companies), a lack of coordination among government agencies and other stakeholders in clay based construction materials, competition of clay products with other construction materials, and conflict between environmental protection regulations and need for construction materials for the construction boom. Productivity challenges arise from limited use of advanced technology in processing namely machinery and firing materials and technology, limited skills in the sector, among others. All these factors make a call for a rapid intervention of various stakeholders in the clay value chain.

Promotion of automated, semi-automated along with the use of permanent energy efficient kilns which are energy efficient should be among the priority to be done in the process of modernizing the sector and reducing Greenhouse gases emissions and reducing the demand of firewood which is detrimental to the problem of deforestation. Integrate the learnt experience from other countries in term of technologies in use at various stages of clay value chain (e.g. extraction, processing, firing transport and trading) should help clay industry in Rwanda to be more competitive both internally and externally. Moreover, this will require to conduct a systematic market analysis of clay-based construction materials. Formalization of clay extraction and processing by providing the individual licence to all actors in the sectors will help the sector to be formalized. Furthermore, regular inspection and follow up on the implementation of environmental best practices are highly needed to save our environment from progressive degradation. Nonetheless, the clay cadastre map can help to estimate available clay deposits in quantity and quality, it will also help in avoiding conflicts between license holders arising from overlapping licenses. The best solution would be to integrate the database with the cadastre, so that it becomes an additional layer in the geographical information system (GIS) underlying it. Evidently, the contribution of the database and the cadastre to the development of the sector is enhanced if both are publicly accessible.

4.2. General recommendations

The following are key recommendations that should be taken into account by relevant stakeholders in the development of clay based construction materials.

To the Government of Rwanda and its partners:

- There should be transformation of Rwanda's brick industry though targeted interventions and investments all along the value chain. There should also be greater cooperation with the Swiss Agency for Development Cooperation which has already mandated SKAT Consulting to offer the following services to entrepreneurs, investors and technicians in the following areas: Site and Clay Analysis Business Design Support Access to Technologies + Skills Marketing Support.
- The Kigali PSF Demonstration House should continue with the plan to introduce the "S.M.A.R.T. Tafali Etage" concept to the general public. This is made entirely of local materials and it displays the possibility of what the Rwandan construction industry would be capable of supplying on mass scale. Therefore with this guide all relevant stakeholders, from the brick maker to engineers and architects, should work together to address the high demand for quality, affordable construction for rapidly urbanizing districts, cities and towns.
- Creation of an online one-stop centre for special licensing of natural resource extractors aimed at improving the business environment for investors in construction materials industry.
- Development of an up-to-date database on quantities of naturally occurring construction materials by Initiating detailed studies to confirm quantities of clay. Also by digitizing and making this information Available online for prospective investors.

- Promote innovation through establishing of Innovative construction products, seeking alternative construction technology, and ensuring cleaner and safer environment for all extraction practices.
- It is important that the clay cadastral map is prepared, accessible and used also by district and sector administrations. Otherwise, the potential problem of overlapping licenses will not be resolved.
- There is a need to facilitate access to capital to acquire technologies, particularly for advanced and semi-modern industries to increase quantity and quality of products to make them more competitive but also to be able to export the local products on international markets.
- It would be helpful to establish mining services aggregation centres to support technically the extractors and processors.
- Determine the physico-chemical characteristics of the available materials in relation with the possible techniques to be used for exploitation and processing;
- Define technical and economic standards for the clay products (type, specification, quality standard) as well as certification (originality);
- Look for innovations by carrying out a series of experimental tests;
- Point out the relevant and competitive technologies and appropriate equipment, in order to come up with a high quality final product;
- Assess the conditions and the costs in which the expected production could be achieved;

To clay value chain actors:

- The extractors and processors are also requested to respect rules and regulations on mines and quarries.
- The extractors and processors should put a fence on the total area on extraction in order to protect people and livestock from accidents related to extraction.
- The extractors and processors should respect Law No 58/2018 signed on 13/08/2018 guiding mining and quarrying activities in Rwanda.
- The extractors and processors should respect Law No 48/2018 signed on 13/08/2018 regarding the environmental protection in Rwanda.

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5. APPENDIX

5.1. Individual Questionnaire for the key actors

Introduction of interviewer to the respondent(s)
Greetings

My name is …………………………………We are here to collect information related to value chain analysis including technology audit of clay value chain for construction materials on behalf of ENABEL and NIRDA. The information you provide will help in better knowing the technologies in use in clay value chain for construction materials for better improving the sector. Moreover, the information provided will be kept confidential and only used for the purpose of this study. Thus, Honest cooperation in this process is solicited for this purpose.

1. Identification of respondent

1. Province / City of Kigali
2. District:
3. Sector:
4. Cell:
5. Village:
6. Name of enumerator:
7. Name of respondent:
8. Age of respondent:
9. Sex of respondent:
10. Marital status:
11. Education level:
12. Position of respondent:
13. Respondent's phone number:
14. Date of the survey:
15. Starting Time:
16. GPS coordinates:
17. Name of site/firm:

2. Identification of the firm

Question 2.1: Category of respondent

Choose	**Yes**	**No**
Extractors		
Processors		
Users/constructors		
Haulers		
Retailers		
End-user		

Question 2.2: Firm's category

Choose	Yes	No
Micro scale firm (1 – 5 employees)		
Small scale firm (6 – 30 employees)		
Medium scale firm (31-100 employees)		
Large scale firm (above 100 employees)		

Question 2.3: Firm's legal status and registration

Choose	Yes	No
Sole proprietorship		
Cooperative		
Limited by shares		
Limited by guarantee		
Limited by shares and by guarantee		
Unlimited		
Partnership		

Question 2.4: Firm's ownership status

Choose	**Yes**	**No**
Private firm		
Public firm		
Mixed ownership (Private and public partnership)		
Owned by institution		
Any other (specify)		

Question 2.5: The Origin of firm's owners

Choose	Yes	No
Rwandan		
Foreign (East African Community)		
Foreign (other African Country)		
Foreign (country of outside of Africa))		
Joint (Rwandan + EAC countries)		
Joint (Rwandan + country of outside of Africa)		

Question 2.6: The main activities of the firm (tick the right answer)

	Producing	Selling	Transporting	Using
Adobe bricks				
Modern bricks				
ISSB bricks				
CEB bricks				
Roof tiles				
Floor tiles				
Tableware				
Sanitary ware				
Ceramics				
Porcelain				
Insulting and electric fitting materials				
Decoration materials on the house				
Drainage pipes				
Raw materials to be mixed with clay and firing materials				
Any other (specify)				

Question 2.7: The main raw materials used in past 12 months in processing

	Estimated quantity	Source
1.		
2.		
3.		
4.		
5.		

3. Working conditions

	Yes	No
3.1. Do you have an appropriate cloths and protection to reduce/avoid accidents		
3.2. Do you have any insurance?		
If yes name it		

Question 3.3: Working schedule

	Number of working hours	Number of males	Number of females
Full time			
Part-time			
Occasionally			
Professional internship			
If any other (specify)			

Question 3.4: Number of workers

	Number of females	Number of males
Manpower		
Technicians		
Engineers		
Administration staff		
Sellers		
Drivers		

3.5. Qualification of staff

	Number of males	Number of females
Do not know either to read or to		
Know to read and write		
Primary school		
Secondary school		
TVET		
University		
Interns from different schools/university		

Question 3.6: Working hours per day

Choose	Yes	No
Occasionally		
Less than 4 hours		
4 – 8 hours		
8 – 12 hours		
More than 12 hours		

Question 3.7: Working days per week

Choose	Yes	No
Occasionally		
1 – 3 days		
4 – 5 days		
5 – 7 days		

Question 3.8: Received incentive (Possibility of more than one answer)

Choose	Yes	No
Fixed monthly salary		
Salary on done activities		
Trainings		
Getting insurance from firm's owner		
Bonus		
Any other (specify)		

Question 3.9: Employee monthly income

Choose	**Yes**	**No**
< 30,000		
30,000-100,000		
100,000-200,000		
Above 200,000		
Don't know		

Question 3.10: What is type of contract existing between the following?

	No contract	Verbal	Written	Other (specify)
Between the firm and employee				
Between the firm and firing material supplier				
Between the firm and trader/seller				
Between the firm and hauler				
If any other (specify)				

Question 3.11: Number of Partners we work with in the value chains (Upstream and downstream)

	Number
Between the firm and firing material supplier	
My firm and processors	
Between the firm and trader/seller	
Between the firm and hauler	
Between my firm and research institutions or TVET (RD)	
If any other (specify)	

Question 3.12: If yes does the contract specify any of the following?

Choose	Yes	No
Length of agreement		
Delivery and payment conditions		
Duties and rights of each party		
Existence of sub-contracting		
Conflict resolution method		
If any other (specify)		

5. **Productivity and financial data**

4.1. Quantity of production per year

	Tones of extracted clay
Extracted clay	

(b) Quantity of production (for processors) per year

	Production in number
Bricks	
Tiles	
Tableware	
Sanitary ware	
Ceramics	
Porcelain	
Insulting and electric fitting materials	
Decoration materials on the house	
Drainage pipes	
Raw materials to be mixed with clay and firing materials	
Any other (specify)	

(c) Sold quantity (retailers and traders) per year

	Sold quantity
Adobe bricks	
Modern bricks	
ISSB bricks	
CEB bricks	
Roof tiles	
Floor tiles	
Tableware	
Sanitary ware	
Ceramics	
Porcelain	
Insulting and electric fitting materials	
Decoration materials on the house	
Drainage pipes	
Raw materials to be mixed with clay and firing materials	
Any other (specify)	

(d) Transported quantity (haulers and transporters) per year

	Transported quantity
Adobe bricks	
Modern bricks	
ISSB bricks	
CEB bricks	
Roof tiles	

Floor tiles	
Tableware	
Sanitary ware	
Ceramics	
Porcelain	
Insulting and electric fitting materials	
Decoration materials on the house	
Drainage pipes	
Raw materials to be mixed with clay and firing materials	
Any other (specify)	

(e) Used quantity in construction

	Used quantity on specific house
Adobe bricks	
Modern bricks	
ISSB bricks	
CEB bricks	
Roof tiles	
Floor tiles	
Tableware	
Sanitary ware	
Ceramics	
Porcelain	
Insulting and electric fitting materials	
Decoration materials on the house	
Drainage pipes	
Raw materials to be mixed with clay and firing materials	
Any other (specify)	

a. Matching needs and demand in construction materials

	% of my production/ delivery capacity
Extractors	
Processors	
Transporters	
Retailers/traders	

b. Types of standards followed

Choose	**Yes**	**No**
None		
Fixed by Rwandan legislation		

Fixed by client		
Fixed by company		
International standards		
If any other (specify)		

c. **Destination of products**

Choose	**Yes**	**No**
Rural areas in Rwanda		
Urban areas in Rwanda		
In EAC countries		
In African countries outside EAC		
Outside Africa		
Any other (specify)		

d. Do you have enough market to consume the following products?

Choose	**Yes**	**No**
Adobe bricks		
Modern bricks		
ISSB bricks		
CEB bricks		
Roof tiles		
Floor tiles		
Tableware		
Sanitary ware		
Ceramics		
Porcelain		

e. **What are the main problems hindering the competitiveness of the products**

Choose	**Yes**	**No**
Limited capital		
Cost of clay extraction		
Cost of clay processing		
Cost of raw materials to mix with clay		
Cost of firing materials/limited energy for firing		
Patents and royalties cost		
Poor marketing		
Limited awareness on the size of the market		
Accessibility to the working area/road network		
Complicated environmental protection requirement		
Poor /limited technology		
High production cost		
Limited staff /Limited labour		

High cost of labour		
High competition		
Limited assistance technical and RD)		
If any other specify		

4.7. Invested capital

	Tick the right answer
Less than one million	
Between 1,000,000 and 10,000,000	
Between 10,000,000 and 50,000,000	
Between 50,000,000 and 100,000,000	
More than 100,000,000	

4.8. Annual total firm's turn over (income)

	Tick the right answer
Less than one million	
Between 1,000,000 and 10,000,000	
Between 10,000,000 and 50,000,000	
Between 50,000,000 and 100,000,000	
More than 100,000,000	

4.9. Do you pay any of the following taxes

Choose	**Yes**	**No**
Value Added Tax (VAT)		
Any taxe		
TPR/PAYE		
Withholding Income Tax		
Import Duties Tax		
Trading License Tax		
Rental income Tax		
RSSB fund		
If any other (specify)		

5. Infrastructure and technologies in place

5.1. Infrastructure in place

Choose	**Yes**	**No**
Nothing		
Water		
Electricity		

Roads		
Kilns		
Warehouses		
If any other (specify)		

5.2. Source of skills and knowledge used in performing daily duties

Choose	**Yes**	**No**
From working experience		
From trainings		
From schools		
Personal insights		
Guidance from my supervisors		
If any (specify)		

5.3. How are you identifying a clay of good quality/clay product of good quality?

Choose	**Yes**	**No**
Using personal experience		
Laboratory test		
Using experts in the domain		
Using external consultants		
Using appropriate machine		
Internal R &D		
I don't know		
If any other (specify)		

5.4. What are materials are you using to do the following?:

	Materials used
Extraction of clay	
Transporting clay to prepare a product (e.g. brick, tile, tableware, ceramics, etc.	
To produce Adobe bricks	
To produce Modern bricks	
To produce ISSB bricks	
To produce CEB bricks	
To produce Roof tiles	
To produce Floor tiles	
To produce ceramics	
To produce tableware	
To produce floor tiles	
To produce Sanitary ware	
To produce porcelain	

To produce drainage pipes	
If any other (specify)	

5.5. What are products (ingredients) are you putting together to produce the following?

	Products/ingredients
A brick	
A roof tile	
A ceramics	
A tableware	
A floor tiles	
A sanitary ware	
A porcelain	
A drainage pipes	
If any other specify	

5.6. What are materials are you using for firing the following?

	Firing materials
No firing is done	
A kiln of brick	
A kiln of roof tile	
A ceramics	
A tableware	
A kiln of floor tiles	
A sanitary ware	
A porcelain	
A drainage pipes	
If any other specify	

5.6. What are the main sources of firing materials?

Choose	Yes	No
Sourced locally (same district)		
Sourced nationally (any area of Rwanda)		
Sourced regionally (in EAC and Great Lake country)		
Sourced internationally		
If any other specify		

f. How long it takes to produce the following

	Less than 1 hour	1 to 4 hours	4 to 8 hours	Above 12 hours
Adobe bricks				
Modern bricks				
ISSB bricks				
CEB bricks				
Roof tiles				
Floor tiles				
Ceramic				

Tableware				
Sanitary ware				
Porcelain				
Drainage pipes				
If any other specify				

5.8. Name the materials (if any) using for packing the following:

	Packing materials
No packaging is done	
Adobe bricks	
Modern bricks	
ISSB bricks	
CEB bricks	
Roof tiles	
Floor tiles	
A ceramics	
A tableware	
A floor tiles	
A sanitary ware	
A porcelain	
A drainage pipes	
If any other specify	

6. Quality control and standards status assessment

6.1. Do you have any quality/ standards control system for the following

Choose	**Yes**	**No**
Nothing is done		
Clay		
Raw materials to be mixed with clay		
Processed products from clay		
Firing materials		
Packaging materials		
Transport means		
Roads		
Houseware		
Constructed kilns		
If any other (specify)		

6.2. What are quality/safety certificates or product certificates do you have?

Choose	**Yes**	**No**
Nothing		
Exploration certificate		
Standardization mark (S mark)		

Environmental impact assessment certificate from RDB		
Quarrying License for 5 years		
Quarrying License for 15 years		
Permanent quarrying License		
Packaging materials certificate		
Firing materials certificate		
If any other (specify)		

6.3. What strategies did you take among the following to upgrade your business?

	Yes	**No**
Nothing to do		
Comply with fixed standards		
Improving research and exploration component		
Improving the quality of our products		
Technology modernisation		
Capacity building of the staff		
Increase capital		
Regular quality control by competent experts		
Automation		
Invest in the new clay products		
Improving supervision in the firm		
Appointing technical staff		
Engaging in all process of value chain		
If any other (specify)		

6.4. Comparing the local products with external (imported ones) on Quality and preference

Local products quality and preference by local customers compared with imported ones	**More preferred**	**Equal**	**Less**	**Don't know**
Adobe bricks				
Modern bricks				
ISSB bricks				
CEB bricks				
Roof tiles				
Floor tiles				
A ceramics				
A tableware				
A floor tiles				
A sanitary ware				
A porcelain				
A drainage pipes				

If any other specify				

6.5. Production cost and price

Products	Production cost per unit	Selling price	Selling price imported	Don't know
Adobe bricks				
Modern bricks				
ISSB bricks				
CEB bricks				
Roof tiles				
Floor tiles				
A ceramics				
A tableware				
A floor tiles				
A sanitary ware				
A porcelain				
A drainage pipes				
If any other specify				

6.6. Comparing competitor of production Technology

Products	In Rwanda (local firm)			Outside Rwanda &Foreigner in Rwanda		
	Yes	No	Don't know	Yes	No	Don't know
Green technology						
Modern/efficient technology						
Bigger investments						
Any other specify						

7. Environmental issues and ways to deal with them

7.1. Are you aware that clay extraction may have the following impacts on the environment?

Choose	Yes	No
Destruction of vegetation cover		
Creation of gullies, rills and scars		
Landslides at fragile landscape		
Disruption of drainage system		
Creation of unsafety pits		
Siltation and sedimentation of drainage system		

Degradation of soil properties		
Spoilage of water		
Air pollution		
If any other (specify)		

Choose	Yes	No
7.2. Are you aware of adverse effects of climate change?		
If yes mention them		

7.3. Energy used for firing the construction materials

Choose multiple	**Yes**	**No**
Woods		
Sawdust		
Crops wastes		
Biogas		
Fossil fuels (i.e oil changed)		
Any other specify		

7.4. What are the impacts of climate change are you facing in your business among the following?

Choose	**Yes**	**No**
Occasionally flooding episodes		
Landslides in clay mines		
Soil erosion		
Long dry spells causing water scarcity		
Sickness (e.g. malaria, flu, respiratory track, infections, etc.)		
If any other (specify)		

7.5. Do you have the following capacity to deal with climate change/variability impacts?

Choose	**Yes**	**No**
Enough knowledge on climate change and their impacts		
Financial capacity		
Availability of timely weather/climate information		
Governmental/non-governmental support		
Awareness to adapt to climate change and variability		
Availability of water channels		

Availability of basic infrastructure (e.g. roads and bridges, rain-water channels, etc.)		
a) Others (specify)		

7.6. What are environmental best practices are used to safeguard landscape

Choose	**Yes**	**No**
Excavation of the clay pits where there is less vegetation cover.		
Re-vegetate disturbed areas at the completion of clay extraction.		
Reshaping the topography by properly filling or closing the open pits and/or re-arranging the overburden stockpiles.		
Regularly inspect the status of pits to prevent erosion and weakening of the embankments.		
Excavation of the new pits after closing and refilling the existing open pits and tunnels.		
Minimizing at all cost the potential runoff by channeling water in less risk zone and by increasing the land vegetation cover		
Cleaning up regularly the sediments traps, ponds and drains to maintain them in an effective working order		
Fencing off and post warning signs to prevent livestock, native animals and even humans being accidentally trapped in the pits		
If any other (specify)		

7.7. What are environmental best practices are used to safeguard water resources

	Yes	**No**
Avoiding pouring clay tailings into water bodies		
Retreating wastes left after extraction of clay before releasing them into the environment because mineral content in the effluent should be maintained within the permissible concentration		
Avoiding releasing clay waste into naturally flowing water.		
Monitoring regularly the water quality in the mined areas through the analysis of physico-chemical parameters in order to take appropriate adaptation and mitigation measures in due time		
Constructing the check dams or silt retention ponds to prevent silt runoff from mined area		
Re-establishing the vegetation cover on the bare lands and mined areas to slow down erosion on slopes		
Avoiding the accumulation of clay sediments into water bodies that may reduce the size of water channels		
If any other (specify)		

7.8. What are environmental best practices are used to safeguard water resources

Choose	Yes	No
Removing the topsoil and stockpile it in a safe area prior to carrying the mining activities		
Storing the topsoil and overburden in separate stockpiles		
Re-covering the refilled pit by the stored topsoil for quick recovery of vegetation cover		
Re-establish a vegetation cover to revive the soil and allow quick regeneration of organic matter		
If any other (specify)		

5.2. FGD and KII guides

(i) FGD Guides for Processors

1. (a) Describe the main products do you get from clays……………………………………..
…………………………………………………………………………………………
(b) Describe production process/technologies of each product?...
…………………………………………………………………………………………
2. (a) What are the main challenges are you facing during production process?...............................
…………………………………………………………………………………………….
(b) How are you proceeding to overcome them?..
……………………………………………………………………………………………..
4. (a) What are the main raw materials are you using in your firm/industry?
………………………………………………………………………………………......
(b) What are the main challenges are you facing in getting raw materials and other supplies?
……………………………………………………………………………………………..
(c) What are the strategies are you using to overcome them?
……………………………………………………………………………………………..
5. What are recommendations are you giving to make your products competitive internationally?
…………………………………………………………………………………………...
6. (a) What are the environmental issues are you facing in production process?.....................
………………………………………………………………………………………………..
(b) What are you doing to mitigate them……………………………………………
……………………………………………………………………………………..

(ii) FGD Guides for extractors

1. (a) How are you identifying the good quality of clay to extract…………………………
………………………………………………………………………………………….
(b) Describe the main products which are got from the clay you extract…………………
………………………………………………………………………………………….
2. (a) Describe briefly the extraction process of clay up to the production stage………………..
………………………………………………………………………………………….

(b) What are the potential synergy with other actors to optimize the profit?
……………………………………………………………………………………………

3. (a) What are the main challenges are you facing during clay extraction?...................................
……………………………………………………………………………………..

(b) What are you doing to mitigate them?...
……………………………………………………………………………………

4. (a) What are the environmental issues are you facing in production process?...................
……………………………………………………………………………………..

(b) What are you doing to mitigate them?………………………………………………
……………………………………………………………………………………………..

(iii) <u>KII Guides</u>

1. What are the main clay products manufactured in Rwanda?……………………………..
2. How competitive are the national clay products on international market?…………………
3. What are the main technologies in use for processing clay in Rwanda?..............................
4. What are the sittings in place in Rwanda to promote clay products? ……………………….
5. (a) What are the technologies to import in Rwanda to enhance the sector
   (b) What are the advantages of each of those technologies? ……………………..
6. What are the environmental and health issues caused by extracting and processing clay in Rwanda?...
7. (a) What are strategies in place for environmental protection while extracting and processing clay?...
   (b) How each strategy will be valuable in the Green Building Minimum Compliance system developed by RHA with GGGI vis a vis to CO_2 emission?...
   (b) What are the standards which are still needed to be developed?......................................

5.3. List of key informant interviewees

No	NAMES	INSTITUTION NAME	POSITION	CONTACT NUMBER
1	NTITANGURANWA Jean Paul	RWAMAGANA	Buildings Inspector	0788383686
2	MUSENGIMANA Aline	RWAMAGANA	School Construction	0788681585
3	KWIZERA Alphone	KAYONZA	Forestry and Natural Resources	0783085175
4.	MUSHIMIYIMANA Cyprien	KAYONZA	Director of Agriculture and Natural Resources	0788804897
5.	GAKUNZI Emmanuel	KAYONZA	Director of On Stop Center	0788529572
6.	MUNGANYINKA Hope	KAYONZA	Vice Mayor in charge of Economic Development	0788841117
7.	MUSHIMIYIMANA Jean Claude	NGOMA	Forestry and Natural Resources Officer	0788463780
8.	MUSHIMIYIMANA Pierrine	NGOMA	Mineral Field Officer	0788912200
9.	NGOGA Gilbert	NGOMA	Director of BDE	
10	SHYIRAMBERA Innocent	NGOMA	In charge of Construction Permit	0786511656
11	KARINDA Vital	KIREHE	Forestry and Natural Resources	0788454456
12	DUSENGIMANA Donatien	NYAGATARE	Mineral Field Officer	078871711
13	SAFARI François	GATSIBO	GIS Professional	
14	NAMUHORANYE Sylver	GATSIBO	Forestry and Natural Resources	0783181571
15	NYAKAGABO Emile	GICUMBI	Forestry and Natural Resources	0789355485
16	GAHIRE Aimable	GICUMBI	Start-up Development Officer	0788555277
17	NYIRANSABIMANA Béatrice	GICUMBI	Mineral Field Officer	0788764920
18	MULINDWA Prosper	RURINDO	Vice Mayor in charge of Economic Development	0788600037
19	MUREKATETE Grace	RURINDO	Mineral Field Officer	0781012005
20	NSHUTIRAGUMA Esperance	NYARUGENGE	DDEA	0788352027
21	UWIMANA Redempta	NYARUGENGE	Forestry and Natural Resources Officer	0788575637
22	MUGABO Faust in	BUGESERA	Director of BDE	0788522825
23	Gasaraba John	Gakenke	Director of Business Development and Employment Unit	0788639730
24	HARERIMANA Valens	Gakenke	District Forestry and Natural Resources Officer	0789601750
25	NIZEYIMBABAZI Jean de Dieu	Burera	Director of Agriculture and Natural Resources	0788448869
26	NIZEYIMANA Ildephonse	Burera	Water and Sanitation Officer	0781979399

27	SELEMANI Assia	Musanze	Construction Permit Officer	0788613670
28	NGENDAHAYO Jean	Nyabihu	Director of Agriculture and Natural Resources	0787209263
29	DORISI Melchiade	Nyabihu	Building Inspection Officer	0788679458
30	HATANGIMBABAZI Theodore	Nyabihu	Acting Director of Business Development and Employment Unit	0788602681
31	MWISENEZA Emmanuel	Rubavu	Director of Business Development and Employment Unit	0788848602
32	HARERIMANA Innocent	Rubavu	Environment Officer	0788776202
33	MAHORO Jerome	Rutsiro	GIS Professional for Land Title	0789526546
34	BIMENYIMANA Francois	Karongi	District Forestry and Natural Resources Officer	0785546792
35	MUVUNYI Jean	Karongi	Director of One Stop Center and Land Notary	0783507802
36	MUCYO Romuald	Nyamasheke	District Infrastructure and Property Management Engineer	0786471275
37	NZARAMBA Jean Claude	Nyamasheke	Mining Officer	0788798434
38	NTEZIMANA Aphrodice	Nyamasheke	District Agronomist	0785813813
39	NIYIBESHAHO Ananias	Nyamasheke	Environment Management Officer	0785813817
40	NTAKIYIMANA Jean Pierre Celestin	Ngororero	Director of One Stop Center and Land Notary	0783693888
41	KAYITSINGA Jean	Ngororero	District Forestry and Natural Resources Officer	0788550383
42	NGORORANO Jean	Gasabo	Director of Agriculture and Natural resource	
43	TUYIZERE Thadée	Kamonyi	Vice Mayor in charge of Economic Development	0788436029
44	ABRAHAM Willius	Kamonyi	Director of One stop center	
45	KAYIRANGA Innocent	Muhanga	Vice Mayor in charge of Economic Development	0788635553
46	MUKAMANA MUPENZI M.Goreth	Muhanga	Acting Director of Agriculture	0788558945
47	RUSILIBANA Jean Marie Vianey	Ruhango	Vice Mayor in charge of Economic Development	0788490642
48	NYIRANSABIMANA Aloysie	Nyamagabe	Mineral field officer	0788534060
49	NSANZABARINDA Anasthase	Huye	Small and Medium enterprise and Cooperative development officer	0783036927
50	Humuza Oswald	Gisagara	Mineral field officer	0788506824
51	Kasayizi Lambert	Nyamagabe	Vice Mayor in charge of Economic Development	0788890074
52	ISHIMWE Grace	RLMUA	Head of Department	0788874562
53	NSENGIYUMVA Jacques	REMA	Ag. Director	078624431

54	NSENGUMUREMYI Donat	RMB	Division Manager of Mining Extraction & Inspection Division	0781521358
55	NINGABIREYves Bernard	MINALOC	DG	0788387998
56	NGENDABANGA Jean Pierre	NIRDA	Technical Support Specialist	0788530679
57	TWAHIRWA Gervais	Ministry of Justice (MINIJUST)	Director General of Corporate Services	0788303383
58	BANAMWANA Marshall	Ministry of Environment (MoE)	Acting D.G. Environment and Climate Change	0788861374
59	MURINDANKAKA Emmanuel	Ministry of Trade and Industry	Industrial Development Specialist	0788782956
60	AHABWE Emmanuel	Ministry of Infrastructure (MININFRA)	Affordable and Social Housing Engineer	0783466825
61	BIMENYIMANA Eraste	Rwanda Housing Authority (RHA)	Acting Director of Government Assets	0788439600
62	Eng. Theodore DUSABIMANA	Rwanda Polytechnics, IPRC Kigali	Head of Civil Engineering Department	0788441130

5.4. List of interviewees during FGDs with extractors

Nº	NAMES		SEXE		TELEPHONE	VILLAGE	CELL	SECTOR	DISTRICT	Date
			Female	Male						
1	1	NDAYISENGA Cedric		M	0786466761	Kabaya	Rusagara	Gakenke	Gakenke	1/09/2020
	2	NKUMBUYE Fidele		M	0783128086					
	3	MUKAMUKWIYE Jacqueline	F		0785082974					
	4	TUYISHIMIRE Clementine	F		0780577231					
	5	MPAKANIYE Jean		M	0783791076					
2	1	NYIRANTEZIMANA Scholastica	F		0781178163	Rubabi	Nturo	Rwaza	Musanze	3/09/2020
	2	NIYOMAZE Protase		M	0789938771					
	3	IRADUKUNDA Fabrice		M	0783704878					
3	1	DUSHIMIRIMANA Claudine	F		-	Kagera	Buhimba	Nyundo	Rubavu	5/09/2020
	2	MUKAMURENZI Alexia	F		-					
	3	UWIRINGIYIMANA Agatha	F		0780186746					
	4	GATONGORE Yahaya		M	0783226373					
	5	TWIZERIMANA		M	0784588095					
4	1	UWAYISABA Drocella	F		0722643791	Rwagisasa	Musasa	Gishyita	Karongi	8/09/2020
	2	HATEGEKIMANA Daniel		M	0724265033					
	3	NTIHEMUKA Epimaque		M	0789862207					
	4	NZARAMBA Vincent		M	-					
	5	NIYOGISUBIZO William		M	0725745214					
5	1	HABUMUGISHA Emmanuel		M	0724894729	Birambo	Gaseke	Nyange	Ngororero	10/09/2020
	2	UFITENYINA Skola	F		0727539336					
	3	IRADUKUNDA Cynthia	F		-					
	4	NIYIGENA Angelique	F		-					
	5	MUKESHIMANA Theogene		M	07335205755					
	6	KWIZERA Emmanuel		M	-					
6	1	NIYITA Valens		M	0787906051	Rugende	Ruhanga	Rusororo	Gasabo	02/09/2020
	2	MURENGERANTWALI Francois		M						
	3	MUTARAMBIRWA Fidele		M	0787688609					
	4	NZABONIMANA Ildephonse		M	0782538915					

7	1	UZABAKIRIHO Monica	F			Murembere	Kambali	Shyogwe	Muhanga	
	2	NYANDWI Vicent		M	0739881353					
	3	SIBOMANA Joseph		M	0789669117					
	4	RIBERAKURORA Wellars		M	0727280217					
8	1	Gusenga Paul		M	0728354517	Gishiki	Nyanza	Busasamana	Nyanza	07/09/2020
	2	Nshimyumukiza Samson		M						
	3	Nyiraneza Christine	F		0783895956					
	4	Niyonzima Ananias		M						
9	1	Muhawenimana Florence	F		0725913993	Mubuhiga	Nyanza	Cyanika	Nyamagabe	08/09/2020
	2	Masengesho Clementine	F		0725642377					
	3	Bizimana Claver		F	072779061					
	4	Nyiransabimana Rose	F							
10	1	Nyiramisigaro Mediatrice	F			Mirayi	Bweya	Ndora	Gisagara	10/09/2020
	2	Ahobantegeye Angelique	F							
	3	Kanamugire Joseph		F	0728577575					

5.5. List of interviewees during FGDs with Processors

Nº	NAMES		SEXE		TELEPHONE	VILLAGE	CELL	SECTOR	DISTRICT	Date
			Female	Male						
1	1	HABIMANA Fulgence		M	-	Kabuye	Kirebe	Karambo	Gakenke	1/09/2020
	2	UWIJURU Eric		M	0789872440					
	3	SIBOMANA Gaspard		M	-					
	4	HABIMANA Jean Paul		M	0725423580					
	5	TURAMAHORO J. Damascene		M	-					
2	1	NYIRAMAGAMBO Consolata	F		-	Gashushura	Kivumu	Nemba	Burera	2/09/2020
	2	MUKABUTERA Seraphine	F		-					
	3	UWIMANA Leoncia	F		0785251946					
	4	MUKANDORI Josiane	F		-					
	5	MUSENGIMANA Florence	F		-					
	6	NSABIMANA Pascal		M	0781172854					
	7	HAKIZIMANA J.M.V.		M	0783098194					
3	1	BARAWEREKANA Eric		M	0786651996	Gitovu	Kabirizi	Gacaca	Musanze	3/09/2020

	2	NIZEYIMANA Albert		M	0786627257					
	3	HATANGIMANA Ernestine	F		0784860239					
	4	NIYODUSABA Emerine	F		-					
	5	DUSENGUMUREMYI Christine	F		0782565285					
4	1	NIYONSENGA Gervais		M	-	Maziba	Rurengeri	Mukamira	Nyabihu	4/09/2020
	2	KAREKEZI Jean d'Amour		M	0788410832					
	3	TUYIRINGIRE Olivier		M	0785444038					
	4	NZAFASHWANAYO Samuel		M	0781973772					
	5	UWIRAGIYE Oliva	F		-					
5	1	DUSHIMIRIMANA Emmanuel		M	07832116229	Nkora	Mukondo	Nyundo	Rubavu	5/09/2020
	2	DUKUZIMANA Florence	F		0785139165					
	3	HABAKURAMA Jean Paul		M	0782370871					
	4	HAMISA Clementine	F		-					
6	1	DUSABIMANA Vianney		M	0781434560	Kabingo	Musabike	Kanama	Rubavu	5/09/2020
	2	NTUYENABO Emmanuel		M	0785148907					
	3	NYIRANTEZIMANA Clementine	F		0784022955					
	4	NTEGEREJIMANA Laurent		M	-					
	5	MASHYENGO Aloys		M	0782487383					
7	1	NYIRARUKUNDO Emertha	F		0783475672	Rutambi	Kabujenje	Kivumu	Rutsiro	7/09/2020
	2	DUSENGIMANA Innocent		M	0786383685					
	3	NIZEYIMANA Peter		M	-					
	4	NGANGWIKI Bellancile	F		-					
	5	MANIRAMBA Venantie	F		-					
	6	NIYITEGEKA Emerine	F		-					
	7	MANIRAGUHA Celestin		M	0780448969					
	8	NGAYABAHEMU Francois		M	0787459446					
	9	NYIRABARIYANGA Claudine	F		0787884287					
8	1	HAKIZIMANA Francois		M	0728041505	Nyabikenke	Kayenzi	Bwishyura	Karongi	8/09/2020
	2	MUKAGIHANA Christine	F		-					
	3	MUKUNDIYABO Esperence	F		0738404919					
	4	NKURUNZIZA Silas		M	-					
	5	BIKORIMANA Daniel		M	0787656261					
	6	HAGENIMANA Fils		M	0730066447					

	7	BUGINGO Antoine		M	0726661547					
	8	DUSHIMIRIMANA Emmanuel		M	0729063622					
	9	NYIRANSENGIYUMVA Bonifrida	F		0722788950					
9	1	MUKAMWIZA Domina	F		0789413877	Cyambogo	Nsibo	Nyange	Ngororero	10/09/2020
	2	YANKURIJE Claudette	F		-					
	3	TWAYIGIZE Cyliaque		M	0723952952					
	4	AYIRWANDA Jean Baptiste		M	0728952323					
	5	UMUTESIWASE Beatrice	F		-					
	6	HAKIZIMANA Fabien		M	-					
	6	MUKESHIMANA Claudine	F		-					
10	1	Shyaka Jean Claude		M	0723113398	Rukore	Mulinja	Gahanga	Kicukiro	01/09/2020
	2	Nzabanita Alphonse		M	0782023215					
	3	Gabiro Pascal		M	0787698647					
	4	Hagenimana j.Claude		M	0788959272					
11	1	Kayonga Joseph		M	0782150333	Nyenyeri	Bunyonga	Karama	Kamonyi	03/09/2020
	2	Tabaro Sylver		M						
	3	Habineza Martini		M	0780849717					
	4	Nyirabanyiginya Oliver	F							
12	1	Bayavuge Joseph		M		Bukomero	Muhororo	Byimana	Ruhango	05/09/2020
	2	Ngirinshuti Samuel		M						
	3	Ndagijimana Joseph		M						
	4	Niyonteze Francois		M						

5.6. Table of interviewed respondents by district

District	Extractor	Processor	Hauler / Transporter	Retailer	End-user	Total
Bugesera	6	7	1	2	1	17
Burera	4	6	1	0	1	12
Gakenke	3	6	1	1	2	13
Gasabo	1	2	1	2	3	9
Gatsibo	3	9	3	4	2	21
Gicumbi	4	9	1	0	2	16
Gisagara	8	8	4	1	1	22
Huye	6	9	2	1	1	19
Kamonyi	4	3	2	2	1	12
Karongi	5	6	2	1	2	16
Kayonza	3	8	1	1	1	14
Kirehe	6	8	1	1	1	17
Muhanga	4	9	1	2	0	16
Musanze	3	6	1	1	3	14
Ngoma	5	7	2	1	1	16
Ngororero	3	6	1	2	1	13
Nyabihu	3	6	1	1	2	13
Nyagatare	5	4	2	2	1	14
Nyamagabe	5	5	2	0	1	13
Nyamasheke	4	6	1	1	1	13
Nyanza	4	8	1	1	1	15
Nyarugenge	6	8	2	3	0	19
Nyaruguru	5	9	1	1	2	18
Rubavu	5	6	1	1	3	16
Ruhango	7	9	2	1	1	20
Rulindo	3	11	4	2	2	22
Rutsiro	5	6	1	2	1	15
Rwamagana	2	6	0	1	1	10
Kicukiro	1	2	1	1	3	8
Total	123	195	44	39	42	443

5.7. List of firms/companies which may participate in open call

Category	SN	NAME OF THE FIRM	Products	Province	DISTRICT
Category 1: Automated with drying facility, Energy efficient facility for firing	1	Ruliba Ltd	Bricks and Tiles	City of Kigali	Nyarugenge
	2	MCECO Ltd	Bricks and Tiles		Rwamagana
	3	Ngororero district clay resources	Bricks and Tiles		Ngororero
	4	MAX7 COMPANY LTD	Bricks and Tiles	City of Kigali	Nyarugenge
	5	BDC Ltd (Jean Pierre Mataba)	Bricks and Tiles	City of Kigali	Nyarugenge
Category 2 (a): Semi-automated with modern brickyards	6	COBRIKA Ltd	Bricks	Eastern	Gatsibo
	7	BRIQUETERIE DE GATI LTD	Bricks	Eastern	Rwamagana
	8	IN-SITU KANOMBE	Bricks	City of Kigali	Kicukiro
	9	PYRAMID	Bricks	City of Kigali	Gasabo
	10	MUNYANKINDI Francois	Bricks and Tiles	City of Kigali	Gasabo
	11	AMEGERWA	Bricks	City of Kigali	Gasabo
	12	PJK TRADERS	Tiles	City of Kigali	Nyarugenge
	13	DUSABEYEZU Emmanuel	Bricks	City of Kigali	Nyarugenge
	14	CLAY'S FACTORY	Bricks	Eastern	Bugesera
	15	DESOTECH	Tiles	Eastern	Bugesera
	16	BRIQUETERIE INDUSTRIELLE	Bricks	Eastern	Bugesera
	17	ECO CLAYS	Bricks	Eastern	Bugesera
	18	MUTOKAMBARI Jacques	Tiles	City of Kigali	Kicukiro
	19	Cooperative INTARUSHWA za Rusiga	Bricks	North	Rulindo
	20	KAVUBI Elise	Bricks and Tiles	North	Burera
	21	COOPERATIVE COMIVA	Bricks and Tiles	North	Musanze
	22	COOPERATIVE MFASHANGUFASHE	Bricks and Tiles	North	Gakenke
	23	BRIQUETERIE NOUVELLE	Bricks and Tiles	South	Huye
	24	COOPERATIVE DUKUNDUMURIMO	Bricks	South	Nyamagabe
	25	COOPERATIVE NEW BWEYEYE	Tiles	Western	Rusizi
	26	NGIRINSHUTI Theobard	Bricks and Tiles	Western	Rusizi
	27	BRIQUETERIE KAMONYI	Bricks and Tiles	Western	Nyamasheke
	28	COOPERATIVE TUNOZE UMURIMO	Bricks and Tiles	Western	Nyamasheke
	29	COJETRACO	Bricks	Western	Karongi
	30	TUGOBOKANE	Tiles	Western	Karongi
	31	COOPERATIVE TWIYUBAKIRE	Bricks	Western	Rutsiro

	32	COOPERATIVE KOPTKA	Bricks	Western	Ngororero
	33	SKAT VSBK	Bricks	Western	Ngororero
	34	ABAHARANIRA KWIGIRA	Tiles	South	Ruhango
	35	OPTIMAL CLAYS LTD	Bricks and Tiles	South	Muhanga
	36	ABISHYIZEHAMWE	Bricks and Tiles	South	Ngororero
Category 2 (b): Semi-automated with permanent kiln, Energy efficient facility for firing	37	COOPERATIVE TURANEZA	Bricks	North	Musanze
	38	MAHANO Alexis	Bricks	North	Musanze
	39	COOPERATIVE ABADAHEZA	Bricks	North	Musanze
	40	HABUMUREMYI	Bricks	North	Musanze
	41	COOPERATIVE TWIBATURE	Bricks	North	Musanze
	42	HITIMANA Joseph	Bricks and Tiles	West	Rutsiro
	43	BAPFAKWITA Francois	Bricks	West	Rutsiro
	44	NTEZIYAMBERE Jean Piere	Tiles	West	Nyamasheke
	45	MUSABYIMANA Andre	Bricks	West	Nyamasheke
	46	NSENGIYUMVA Salathiel	Bricks	West	Nyamasheke
	47	HABIYAMBERE Viateur	Bricks	West	Nyamasheke
	48	NATHANAIRE	Tiles	West	Nyamasheke
	49	MUKANDAHINDURWA Jeannette	Bricks	West	Nyamasheke
	50	NDUWAMUNGU Athanase	Bricks	West	Nyamasheke
	51	COOPERATIVE	Tiles	West	Nyamasheke
	52	COOPERATIVE TURAHEZA	Bricks and Tiles	West	Nyamasheke
	53	COOPERATIVE TURAHEZA	Bricks	West	Nyamasheke
	54	TEBUKA MUTUNTU	Bricks and Tiles	West	KARONGI
	55	APAFBR	Bricks and Tiles	West	KARONGI
	56	TWITEKUBUZIMA	Bricks and Tiles	West	KARONGI
	57	UBAKUSAKARE RUGANDA	Bricks and Tiles	West	KARONGI
	58	KIGOGWE Cell	Bricks	West	KARONGI
	59	UWIFASHIJE Pelacie	Tiles	West	KARONGI
	60	DUKOMEZINKUTA	Bricks and Tiles	West	KARONGI
	61	COOPERATIVE COOPENYARU	Bricks and Tiles	East	BUGESERA
	62	BIZIMUNGU Oswald	Bricks and Tiles	East	NGOMA
	63	NTAGANDA		North	Rulindo
	64	KARIMBA Jean Paul	Tiles	Kigali City	Nyarugenge
	65	COOPDEM	Bricks	North	Rulindo
	66	COOPERATIVE TWUZUZANYE GICUMBI	Bricks	North	GICUMBI
	67	UBUDEHE(Sector)	Bricks	North	Rulindo
	68	SINA Gerard	Tiles	North	Rulindo
	69	C00PABIC(NIZEYIMANA)	Bricks and Tiles	North	Rulindo

	70	COOPERATIVE TABARA(KABENGERA)	Bricks and Tiles	North	Rulindo
	71	KAMARI Elisaphan	Bricks	Kigali City	Nyarugenge
	72	COOPERATIVE TUZAMURANE	Bricks	West	Rusizi

5.8. List of clay sites and their location in Rwanda

Site name	District	Sector	GPS Coordinates	
			X	Y
	Nyaruguru	Kivu	442168	4709970
	Huye	Ngoma	470942	4714241
	Huye	Ngoma	469772	4713291
Mugogwe	Huye	Rusatira/Ruhashya/save	476040	4722712
	Huye	Ngoma	469355	4714035
	Huye	Mbazi	470613	4717446
	Huye	Mbazi	468594	4717282
	Huye	Karama	462738	4711924
	Huye	Tumba/Ngoma	468969	4711599
	Huye	Ngoma	469687	4711415
Maza	Huye	tumba	474199	4707766
Akakanyamanza	Huye	Tumba	471102	4707751
	Huye	Tumba	470503	4710213
	Nyanza	Kibirizi	482673	4734532
	Nyanza	Mukingo	470486	4742618
	Nyanza	Mukingo	465833	4743599
	Nyanza	Cyabakamyi	465622	4743468
	Nyanza	Cyabakamyi	464699	4742200
Buroro	Nyanza	Mukingo	473118	4747308
	Nyanza	Busasamana	470049	4742239
Bishya	Nyanza	Busasamana	470125	4741963
Coop. Ineza	Nyanza	Busasamana	470322	4741846
Nyakibyeyi	Nyamagabe	Kibirizi	451671	4726782
Nyaruhanga	Nyamagabe	Tare	443063	4721257
Uwinkomo	Nyamagabe	Tare	442019	4723364
Gafuhisha	Nyamagabe	Kamegeli	452430	4720228
Cyamugongo	Nyamagabe	Gasaka	449083	4724995
Rwona	Nyamagabe	Kamegeli	453987	4722987
Mwogo Valley	Nyamagabe	Kamegeli	454686	4722027
Ruyenzi	Kamonyi	Runda	499003	4783064
Songa	Muhanga	Shyogwe	476042	4764850
Nyabigongo	Muhanga	Shyogwe	475482	4765136
Nyiramusenyi	Muhanga	Shyogwe		
Mapfundo	Muhanga	Shyogwe	475275	4765480
Mapfundo	Muhanga	Shyogwe	474935	4765953
Gatare	Muhanga	Shyogwe	474905	4766030
Songa	Muhanga	Shyogwe		
Nyabigono	Muhanga	Shyogwe		

Nzabigono	Muhanga	Shyogwe		
Karama	Muhanga	Shyogwe	478935	4789412
Karama	Muhanga	Shyogwe	474346	4769700
Ruhina	Muhanga	Shyogwe	474362	9769806
Nyirangari	Muhanga	Shyogwe	476246	4767549
Nyirangari	Muhanga	Shyogwe	475785	4767688
	Muhanga	Shyogwe	476633	4767578
	Muhanga	Shyogwe	474299	4769714
	Muhanga	Shyogwe	476556	4767463
	Muhanga	Shyogwe	474122	9769611
	Muhanga	Shyogwe	474359	4769874
	Muhanga	Shyogwe	474419	4769652
	Muhanga	Shyogwe	474586	4769613
	Muhanga	Shyogwe	474413	4769840
	Muhanga	Shyogwe	474432	4769579
Gakombe	Muhanga	Shyogwe	474472	4769789
Ruhina	Muhanga	Shyogwe	474432	4769579
Muremberi	Muhanga	Shyogwe		
Rubuye	Muhanga	Shyogwe		
Nyakiburira	Muhanga	Shyogwe		
Nyirangari	Muhanga	Shyogwe	474564	4769498
Gasharu	Muhanga	Nyamabuye	471808	4770448
Nyiramvumba	Muhanga	Nyamabuye	470099	4767728
Vunga	Muhanga	Shyogwe	29.7924	-2.10427
Songa	Muhanga	Shyogwe	475135	4765920
Nyabigono	Muhanga	Shyogwe	475658	4764955
Vunga	Muhanga	Shyogwe	477332	4767506
Gasharu	Muhanga	Nyamabuye	2.0766	29.44921
Kavumu	Muhanga	Nyamabuye	1.0631	29.4418
Cyakabiri	Muhanga	Kiyumba	471934	4789547
Nyamagana	Ruhango	Ruhango	474259	4754136
Rwoga	Ruhango	Ruhango	473025	4750134
Bunyogombe	Ruhango	Ruhango		
Nyakabuye	Ruhango	Byimana	470112	4764809
Nyakabuye	Ruhango	Byimana	471002	4762773
Mpanda	Ruhango	Byimana	469298	4753136
Mpanda	Ruhango	Byimana	475516	4753246
Remera	Ruhango	Kabagari	457939	4752203
Muhororo	Ruhango	Byimana	470500	4765306
Karambi	Ruhango	Kabagari	461402	4752264
Bunyogombe	Ruhango	Ruhango	474064	4754521

Gitisi	Ruhango	Bweramana	472215	4753943
Kabugusu	Ruhango	Bweramana	464116	4752675
Karenge	Ruhango	Byimana	470631	4764534
Kimwamagana	Gisagara	Kigembe	469732	4693204
Nyamugari	Gisagara	Ndora	489610	4712459
Akajerema	Gisagara	Ndora	482975	4710811
Kibindyi	Gisagara	Gishubi		
Kirira cya Kavumu	Gisagara	Gishubi	488213	4711136
Bweya	Gisagara	Ndora	477382	4711437
Gishya	Gisagara	Ndora	485154	4716738
Mpaza	Gisagara	mukindo	485127	4700467
Nyakariba	Gisagara	Mukindo	484904	4700126
Kibayi	Gisagara	mugombwa	484415	4701057
Kidaturwa I	Gisagara		487368	4708259
Kidaturwa II	Gisagara		487410	4708666
Nyarugenge	Gisagara		492085	4726200
Kinase	Gisagara	Mamba	492148	4725968
Rurama	Gisagara	musha	482880	4720947
Gahishyi	Gisagara	musha	483307	4720901
	Musanze	Remera	468070	4831339
Nganzo centre	Musanze	Remera	466540	4830196
Rusenge	Musanze	Remera	466545	4827935
	Musanze	Remera	467063	4827566
	Musanze	Gashaki	470667	4824986
	Musanze	Gashaki	470570	4825079
	Musanze	Rwaza	463239	4829006
Nyakarambi	Musanze	Rwaza	463231	4829213
	Musanze	Rwaza	463919	4830476
	Musanze	Gacaca	463540	4830476
	Musanze	Gacaca	463286	4830686
	Musanze	Gacaca	463387	4830689
	Musanze	Gacaca	463453	4830718
	Musanze	Gacaca	463418	4830707
	Musanze	Gacaca	463256	4830993
	Musanze	Gacaca	462907	4831134
	Musanze	Gacaca	462968	4831296
	Musanze	Gacaca	462897	4831268
	Musanze	Gacaca	462882	4831445
	Musanze	Rwaza	461148	4828056
	Musanze	Rwaza	461043	4828053
	Musanze	Rwaza	461061	4828091

	Musanze	Muhoza	461948	4832142
	Musanze	Muhoza	461915	4832223
	Musanze	Muhoza	461929	4832134
	Musanze	Muhoza	462686	4831787
	Musanze	Muhoza	462469	4832201
	Musanze	Muhoza	461183	4832705
	Musanze	Muhoza	460827	4832645
	Musanze	Muhoza	460704	4832582
	Musanze	Muhoza	461383	4832405
	Musanze	Muhoza	461465	4832376
	Musanze	Muhoza	461370	4832401
	Musanze	Muhoza	462208	4831662
	Musanze	Muhoza	461520	4832067
	Musanze	Muhoza	461437	4832091
	Musanze	Muhoza	461510	4832129
	Musanze	Muhoza	460213	4833157
	Musanze	Muhoza	460738	4832501
	Musanze	Muhoza	461696	4833415
	Musanze	Muhoza	461727	4833465
	Musanze	Muhoza	461826	4833501
	Musanze	Muhoza	463152	4834309
Kabumba	Musanze	Gacaca	466187	4836073
	Musanze	Gacaca	463946	4834170
	Rulindo	Buyoga/kisaro	503105	4814985
Ruganda	Gakenke	Rushashi	485023	4806712
Kirehe	Gakenke	Nemba	478056	4817879
Kabungo	Gakenke	Cyabingo	466249	4827324
Kamwumba	Gakenke	Kivuruga	470814	4823952
Kanyansho	Gakenke	Kivuruga	474149	4822685
Nyarongo	Gakenke	Kamubuga	476620	4826612
Kinini	Rulindo	Mbogo	492662	4804382
Gicumbi	Rulindo	Mbogo	493153	4803201
Karombero	Burera	Kagogo	473840	4848549
Nkamba	Gicumbi	Rushaki	510395	4838635
Kabuga	Gicumbi	Rushaki	511227	4837971
Kamutora	Gicumbi	Rushaki	512057	4836489
Karambi	Gicumbi	Rushaki	511688	4832012
Gishari	Gicumbi	Rubaya	500252	4838620