STUDY ON ECONOMIC POTENTIAL OF PLASTIC WASTE COMPOSITE MATERIALS IN GHANA

Prepared by Growth Mosaic Limited, July 2019

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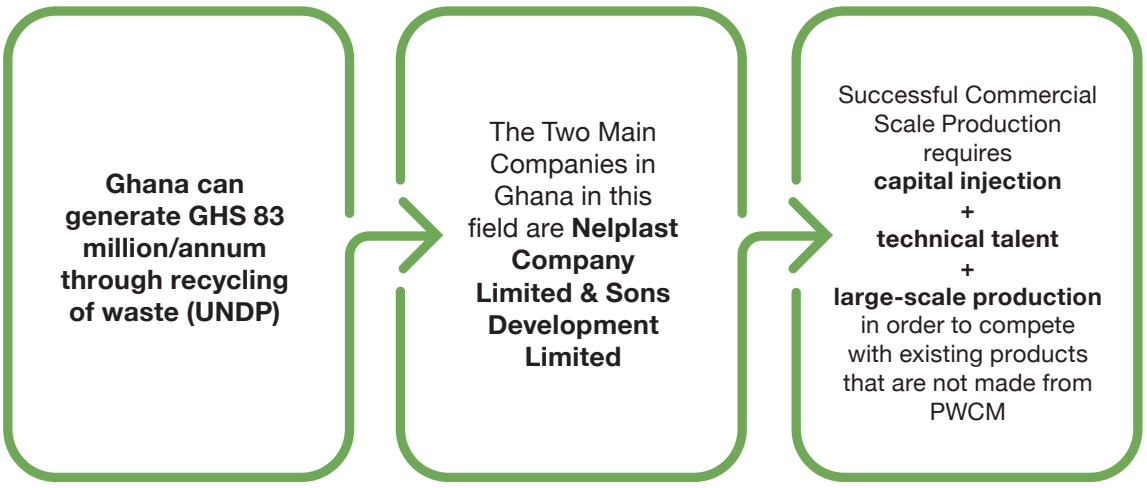
Contents

Summary

Plastic Waste Composite Materials (PWCM) include wood-plastic, sand-plastic, agro-waste-plastic, metal-plastic and concrete-plastic composite materials. PWCM are used for various applications on the commercial market including:

Decking | Fences | Cladding | Building Construction Blocks | Roofing Shingles Decorative Tiles | Paving Blocks | Roads | Insulated Cable Connectors

Key stakeholders identified for the PWCM market in Ghana include the government, raw material suppliers, support and advocacy organizations, composite manufacturing companies, and experts across the private and public sectors. After preliminary desk research and the comprehensive development of a map of raw material sourcing and availability in Ghana, sand-composite and wood composite were found to be the highest prospects for PWCM in Ghana currently.



THE MARKET

PWCM	Market value	Set-up Cost (USD)	Returns (USD)
WPC	GH¢ 180mm/yr.	650k	A 4 million kg/hr factory yields US$4-5 mm/yr.
SPC	GH¢ 1b/yr.	200k+	$800k - $1.2mm/yr.

This study showed that there is a strong opportunity to commercialize the use of Plastic Waste Composite Materials for some applications/products in Ghana. This requires structuring the value chain for this market. Although not seen in Ghanaian examples yet, in more developed economies, there are companies that focus solely on producing PWCM to sell to manufacturers of specific products made from PWCM.

As such, there is specialization of activities to enable manufactures concentrate on specific products made from PWCM, while other experts focus on the technical formulas of producing PWCM with sophisticated technologies that in some cases are patented and licensed. Given the case studies of growing businesses such as Polywood® in the United States and Corec Limited in Kenya, there is a need for major stakeholders in Ghana to collaborate to develop the PWCM industry.

Given the challenges with plastic waste management in Ghana, creating a well-structured supply chain for sourcing waste plastic could strongly reduce the environmental pollution that inappropriate disposal waste plastic has been causing in the country.

Nonetheless, it is critical to recognize that, setting up a commercial scale production of any products made from wood plastic composites or sand plastic composites requires a significant level of capital injection and a relatively large-scale production in order to compete with existing products that do not focus on sourcing plastic waste for their production. Collecting waste plastic for producing pavement blocks, roofing shingles or using wood waste for producing cladding and fencing may only be practical when they meet or exceed the high-quality standards that existing manufacturers of pavement blocks, roofing, cladding, etc have.

It is therefore critical for any parties involved in spurring innovation in this sector in Ghana to bring on-board not only capital, but technical experts as well to support the set-up and running of factories that make applications from PWCM.

1.0 Plastic Waste Composite Material (PWCM) Technologies and Ecosystem

This study introduces various kinds of plastic waste composites that are in commercial use, as well as those that are still undergoing testing and research. The technologies used in producing these materials and their applications is critical for any policy and development interventions that seek to influence the commercialization of applications made from PWCM as a means to generate impact on the environment. This section also looks into the state of the enabling environment for the commercialization of PWCM.

Technologies & Applications

Technologies and applications for the production of waste plastic composite are dependent on the type of plastic composite being produced. Some major production technologies used in the production of major PWCM are described below:

Technologies Generally Used in Plastic Waste Composites

Extrusion Process

It is a process via which large volumes of constitutes are produced. Raw materials such as thermoplastic granules, pellets or powder are placed into a hopper and fed into a barrel of a screw extruder. The barrel is equipped with a helical screw that blends the mixture and conveys it down the barrel toward the die. The internal friction from the mechanical action of the screw heats the mixture and liquefies it. The screw has three distinct sections for the performance of each action. These are the feed, melt and pumping sections.
Injection Molding: In this process the constitutes of the composite material are fed into the heated cylinder, and the melt is forced into the mold either by a hydraulic plunger or by the rotating screw system of an extruder.

Injection Blow Molding

This is a modified extrusion and injection molding process. Depending on the materials, the blow ratio may be as high as 7:1. Blowing is usually done with a hot air blast at pressures ranging from 350 - 700 KPa. In some operations, extrusion is continuous, and the molds move with the tubing.

Compression Molding

This process usually utilizes a pre-shaped mold. A pre-measured volume of powder, or viscous mixture or liquid-resin and filler is placed directly into a preheated mold cavity (around 200˚C but can be much higher). Forming is done under pressure from a plunge or from half of the die, thus, the process is somewhat similar to closed die forging of material. The process is usually used in thermosetting plastics with the original material being in a partially polymerized state.

Co-Extrusion Process

Involves simultaneous extrusion of two or more constitutes through a single die. The product cross-section thus, contains different constitutes each with its own characteristic and function. It is used for products such as flat sheets, films and tubes. It is especially used in food packaging where different layers of polymer constitutes have different functions.

Thermoforming Process

It is the process of forming thermoplastic sheets or films over a mold by means of the application of heat and pressure.

Wood Plastic Composite

Wood plastic composites (WPCs) are composite materials made of wood fiber/wood flour and thermoplastic(s) such as PE (polyethylene), PP (polypropylene), PVC (polyvinyl chloride) or PLA.

Evolution Of Wood Plastic Composite Technology

Developed between 1907 and 1909, wood-plastic composite was one of the very first polymers. In the 1920's wood flour was added to Bakelite and the result was the foundations for wood composite.

It was however the Clextral patent, filed on 24 April 1985 and titled "Method of producing

composite materials comprised of a mix of cellulose particles and a thermoplastic bond" that saw the creation of wood composite. The large-scale production of WPCs began in the 1950's in the automotive industry using wood fibre filled polypropylene (PP) composites for package shelves, spare tire covers and door lineals. For other applications the production of WPCs has been dominated by the use of PE, with the limited use of PVC and PP as the matrix. The properties of wood composite were improved through the use of plastics such as PE, PP, PVC and ABS (acrylonitrile butadiene styrene).

At the start of the 1990s, A.E.R.T and the Mobil Chemical Company, later Trex, began to extrude composite products made from around 50% wood fibre and 50% polyethylene. Most of this was for composite decking boards. Around the same time, the Anderson Corporation started making PVC-based wood composite products, such as door profiles and window frames. During the 1990's, the wood composite market took off in the USA growing from 50,000 tonnes produced in 1992 to 300,000 in 2000 and 1 million in 2010.

Companies with patented technologies

Wood Plastic Group - Czech Republic, sells wood plastic products to construction companies/ interior & exterior decorators etc. such as Silvadec in France, Ply Gem Industries USA, Ply Gem Industries- USA and Sekisui Chemical-Japan.

Green Dot Bioplastic deals in the manufacturing of biocomposites as well as biocomposite pellets. The company also deals in wood plastic composites, which are used for outdoor decking materials, fencing materials, furniture, toys, etc
Roots Espresso produces decking boards such as composite boards, pool-decking boards etc. It is based in the Shanghai.

Jeluplast, a German company converts plastic and wood fibres into Wood Plastic Composites. The process involved in this conversion includes injection molding, extrusion, compression molding, blow molding and foaming.

Processes For Producing Wood Plastic Composites

Extrusion: Reactive extrusion is the term used to describe the use of an extruder as a continuous reactor for polymerization or polymer modification by chemical reaction. A reactive extrusion process combines different polymers together via melt processing, which allows for the development of high value, and new products from plastic waste. This innovation provides the basis for the development of a pipeline of novel polymer blend .

Injection Molding

The injection molding process for producing wood plastic composites requires the use of an injection molding machine, raw plastic materials, and a mold. The plastic and wood dust mixture are melted in an injection molding machine and then injected into the mold, where the solution cools and solidifies into the final part. Injection molding is used to produce thin-walled plastic parts for a wide variety of applications.

Compression molding or thermoforming (pressing): AIT developed a process for producing wood composites using compression molding machines. Compression molding machines recycle plastic waste into other composite materials such as roof tiles, furniture, etc.

Blow Molding

Blow molding is a manufacturing process developed by Jeluplast that is used to create hollow wood plastic parts by inflating a heated plastic tube until it fills a mold and forms the desired shape.

Sand Plastic Composite

Sand plastic composites (SPCs) are composite materials made of sand and thermoplastic(s) such as PE, PP, PVC, or PLA.

Evolution of Sand Plastic Technology

Virgin polymer sand composites were introduced in the late 1950's for high performance applications such as repairs, thin overlays and precast components. By the 1970's "polymer concrete," as it is still often termed, were extensively used in fast repair applications because of their excellent bonding strength and rapid curing times .

The first attempts towards waste-plastic-sand composites were in the 1990's following initial work to use recycled plastics in concrete as an aggregate replacement, and then later as a binder, replacing cement . The process involves the use of basic plastics recycling equipment to melt and mix the waste with a filler, such as sand, to produce highly durable products, like paving stones. In its most basic form, it comprises waste plastics acting as a binder mixed with an aggregate (sand) and molded into a shape.

Nelplast Limited for example uses basic plastics recycling equipment to melt and mix the waste with a filler, such as sand, to produce sand composite bricks and paving stones. Nelplast's process involves mixing sand with shredded plastic and red oxide to make one-square foot pavement blocks.

Polymer Modified Bitumen (PMB)

PMB consists of bitumen mixed with polymers to give it extra strength, high cohesiveness, resistance to fatigue, stripping and deformations for infrastructural purposes.

Research was conducted into finding an optimum process for producing polymer modified concrete. The research came up with two major processes, namely, the wet process and dry process .

DuPont is partnering to certify that the recycled plastic pellets perform identical to the virgin polymer they pioneered for bitumen modification, which has been state-of-the-art for several decades.

Agro-waste Plastic Composite

Agro-waste plastic composites are made up of agro-wastes filled with plastic polymer (virgin or recycled). The resultant composite material has multi-functional applications and has superior properties to its individual constituents. These properties include improved mechanical strength, water and oxygen barriers, dimensional stability, thermal wear resistance etc. Agro-waste raw materials used include residual stalk, straw, leaves, husk, hull, nut or seed shells, and waste wood.

The inherent advantages of agro-waste plastic such as low cost, renewability, biodegradability, low specific gravity, availability, high strength and non-abrasiveness offer their use in a variety of practical applications. Agro-waste are thus normally used as filler and reinforcement in thermoplastics. Agro-waste fibre reinforced thermoplastic composites are gaining significant roles in building and automobile industries, and other

consumer applications. Presently, agro-waste plastic composites are prepared based on different formulations, filler loading, polymer plastic (virgin or recycled), additive aggregate, processability techniques, fibre type and required characterizations. The characteristic of composites depends on the nature of the reinforcement, the ratio of resin to reinforcement, and the mode of fabrication. Researchers in the Department of Metallurgical and Materials Engineering, University of Lagos conducted a study on the mechanical behaviour of coconut shell reinforced polymer matrix composite. Findings from the study indicated that the coconut shell particles have a significant effect on the strength, hardness, and impact energy of the composite.

The tensile strength of the composites decreased with an increase in the volume percent of the coconut shell particles within the matrix of the composite.

Process For Producing The Composite

Coconut shells were dried in open air and grinded into powder using a pulverizing machine then sieved (particle size 100 μm). Pelletized polyethylene waste was sun-dried and shredded in a plastic crusher machine. The coconut shell powder and the ground pellets (polyethylene) were blended together using a two-roll rheomixer at 50˚C and a rotor speed of 60 rpm. Mixture was then compressed with a hydraulic pressing machine for 7 minutes under controlled pressure (30 tons) at 150˚C.

Samples were then cooled to room temperature under sustained pressure before they were removed from the press.

Metal-Plastic Composite (MPC)

MPC's are composite materials made of metal and thermoplastic(s) to achieve higher strength, fracture toughness and stiffness than their polymer counterparts.

Injection Molding

Germany's Fraunhofer Institute for Manufacturing Technology and Applied Material Research (IFAM) has developed a new polymer-metal composite material. The polymer-metal composite can be made with a wide variety of plastics and is easily processed using conventional machines such as extruders and injection molders – this means it can be custom-made for specific applications. It can also be laminated into large mats, and in the future could be sprayed onto geometrically complex surfaces.

Developers also claim that it is lightweight and is a very good conductor of both heat and electricity. Its conductivity can be tweaked by varying the amount of metal it contains, which can be as much as 90% by weight.

STATUS OF THE ENABLING ENVIRONMENT

This section elaborates the status of the enabling environment toward the development of plastic waste composite materials in Ghana and its potential for adoption, factoring raw material availability, enabling policy environment, technical capacities, demand, supply chains, and access to finance.

Potential for Adoption

The potential adoption of plastic waste composites in Ghana is dependent on a number of factors such as stakeholder involvement, availability of raw materials as well as an available market for finished products.

Stakeholders Involved And Their Roles

The proper establishment of plastic composite plants in the country is highly dependent on the interventions of all the various stakeholders involved.

The Government of Ghana

The key stakeholder organizations here include: Environmental Protection Agency (EPA), Ministry of Sanitation & Water Resources (MSWR) and Ministry of Environment, Science, Technology & Innovation (MESTI). The Government of Ghana is responsible for making plastic waste management policies to improve the plastic waste management ecosystem. These policies are aimed at ensuring consistency and cooperation amongst all the stakeholders involved.

The Ministry of Environment, Science, Technology and Information (MESTI) is the official body handling plastic waste management in Ghana. In 2010, the ministry acknowledged that the management of plastic waste in Ghana was afflicted with numerous challenges including the use of poor technology, inadequate governance and negative attitude of citizens towards the use and disposal of plastics. The ministry has thus been working on plastic waste management policies to curb these issues. The Environmental Protection Agency of Ghana provides legal frameworks, compliance and notification procedures for waste recycling.

In 2016, the Ministry of Environment, Science, Technology and Innovation (MESTI) held an inception technical workshop for the “Environmentally Sound Disposal and Recycling of E-waste in Ghana” project in Accra. The project is assisting the Ghanaian Ministry of Environment, Science, Technology and Innovation (MESTI) in improving the framework for sustainable e-waste management.

Citizens

The plastic waste management environment is greatly influenced by the behaviors of citizens in terms of the use of plastics and its disposal. Waste collection services are limited in the country with only 40% of households in the city having waste collection bins. Active participation in recycling programmes is required to boost the recycling ecosystem in the country. There are organizations that are making it easier for plastic waste to be collected in the city. These include Environment 360 and Plastic Punch who conduct activities such as organizing plastic collection events.

Producer/Manufacturers/Importers

About 2.58 million metric tonnes of raw plastics are imported into Ghana annually of which about 73% of this effectively end up as waste. Some companies such as Voltic and Nestle

are actively involved in reducing the harm caused by the plastic used in packaging their products. In 2016, Voltic Ghana Limited, which is one of the largest producers of bottled water in the country, launched a second phase of a PET plastic recycling project that aims to help reduce the amount of scattered plastic waste. The project as at January 2016, had collected and recycled over 400 kilograms of PET waste and reached over 200 households. Voltic and Coliba (a local start-up collecting recyclables), have partnered on a new initiative called IRecycle, to establish plastic collection centres in partnership with Total Ghana to enhance plastic waste recovery.

Plastic Waste Aggregators/Raw Material Suppliers

Sourcing of plastic waste that is processed and used in the production of Plastic Waste Composite Materials is critical for large scale production of PWCM applications. In Ghana, one key aspect of sourcing is through plastic waste aggregators. Many individuals are actively involved in the collection of plastic waste. These waste pickers aggregate and sell used plastic containers and sachets to recycling companies from a starting price of about 0.50 GHS for clean waste, and 0.30 GHS for unclean waste. A key raw material in PWCM is plastic waste. As such, the quality of waste plastic sourced as well as the quantities sourced affect the production volume of manufacturers that use PWCM to make various products.

Through Pick-It, an initiative by Environment 360, over 300 waste pickers have been empowered through training to increase the amount of recovered plastics while improving their daily wages.

Some Plastic Waste Aggregators in Ghana include

Jekora Ventures is a Ghanaian waste management company offering recycling services to its clients along with a solid waste source segregation programme. Their work involves: organic waste recycling, plastic waste recycling, paper waste recycling, among others. Coliba is a Ghanaian company involved in waste collection, sorting, processing and recycling. The company has a mobile application designed to manage plastic waste. The application enables homes, institutions and communities to request for recycling services. Coliba seeks to improve the management of plastic waste through a franchise model that integrates Coliba Rangers (Waste pickers) onto a digital platform.

Environment 360

Environment360 specializes in creating community education campaigns and collection systems that support the work of informal waste workers. They work with value chain stakeholders, private sector and local and national government to create ecosystems that support the growth of circular economies and adoption of sustainable consumption patterns throughout West Africa. They have collected more than 300MT of plastic waste since their inception in 2014

City Waste Management Co. Limited (CWR) is a recycling company that operates in Ho in the Volta Region of Ghana. This company sources waste plastic from local industries and plastic waste collectors. Products generated includes plastic pellets, printed circuit boards and compost and exports recycled e-waste products.

Development Agencies, and Private Sector sponsors

Development agencies and private sector sponsors include the following:

Öko Institut

The Öko-Institut is a non-profit, private-sector environmental research institute. The Sustainable Recycling Industries project is implemented together with the Ghana National Cleaner Production Centre, and is supported by the Ministry of Environment, Science, Technology and Innovation and the Ghana Environmental Protection Agency. Switch Africa Green Project: SWITCH Africa Green project was designed and implemented in Ghana to achieve sustainable development by supporting the transition towards an inclusive green economy, based on sustainable consumption and production (SCP) patterns, while generating growth, creating decent jobs and reducing poverty (UNDP). The total funding for the project is 19 million Euros.

United Nations Development Plan (UNDP)

UNDP's multi stakeholder waste recovery initiative is a project geared towards creating a digitally enabled multi-stakeholder platform to connect key stakeholders with data and technological solutions for resource recovery.

Some of the objectives of the project is to increase access to knowledge on the best technologies available for waste valorization and to create an online marketplace for waste resource exchange . The programme is supposed to demonstrate the potential economies of scale for waste recovery businesses whilst meeting social and environmental needs.

Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) (2019) is currently funding a partnership between Environment 360 and Qualiplast and seeking to decrease the amount of plastic litter found in Kumasi by creating a sustainable collection system for PET bottles via informal sector workers. 2 tons of plastic wastes were collected within the first two weeks with more than 300MT of plastic waste estimated to be collected.

Raw Material Availability

Raw materials for composites such as waste plastic, saw dust and sand are widely available in Ghana.

Current State of Plastic Waste in Ghana

According to research published by MESTI in the National Plastics Management Policy, more than 1.1 million metric tonnes (MT) of waste plastics are generated every year in Ghana. In addition to this, about 100,000 MT of finished plastic goods are imported into the market. These contribute to the high volume of plastic waste generated in the country, yet only a small fraction of this (2-5%) is recycled. According to the Accra Plastic Waste Management Program, 120 MT of waste is recycled daily in Accra, with empty plastic water sachets accounting for about 40% of this figure.

The different types of Plastic materials used in Ghana and their classifications are: Polyethylene (PE) The two main types of polyethylene are low-density polyethylene (LDPE) and high-density polyethylene (HDPE).

High Density Polyethylene (HDPE)

HDPE is one of the two main types of Polyethylene. It is generally very safe and not known to transmit chemicals into food and drinks. It has an excellent moisture barrier and it is resistant to heat. It is commonly used to package detergents, shampoos and conditioners,

milk, bins, etc.

Low Density Polyethylene (LDPE)
LDPE is one of the two main types of polyethylene. It is generally healthy and flexible. It has a waxy surface and low melting point. It is used to make bin liners, sandwich bags, bubble wrap, flexible bottles and thick shopping bags.

Other Plastic Materials
Other plastic materials include Nylon or Polyamide (PA), Polycarbonate (PC) and Acrylonitrile butadiene styrene (ABS) Polyurethane (PU)

The 4 common types of plastic waste recycled are:
Polyethylene Terephthalate (PET)
PET is one of the most commonly recycled plastic materials. It has a high heat resistance, clear and resistant to solvents. It is commonly used to package household products such as water, drinks, oils, personal care products and fibre for clothing and carpets. This type of plastic is used in Ghana by companies that produce water, drinks and personal care products. Products such as Voltic, Bel-Aqua, Coke and Fanta are all packaged in PET.

Polyvinyl Chloride (PVC)
PVC is commonly used as pipes. It is generally not safe to be used as packaging for food and drinks. It has strong electrical properties and is chemical resistant. Commonly used to make windows and door frames, credit cards, pipes, wires and cable sheathing.

Polypropylene (PP)
PP is strong and can withstand higher temperatures than some plastic materials. It has a high melting point and excellent chemical resistance. It is used to make bottle covers, margarine containers, lunch boxes and drinking straws.

Polystyrene (PS)
PS is hard, has a glassy surface and is affected by fats and solvent. It is commonly used to make fast food trays, coffee cups, egg boxes, coat hangers and low-cost toys. Polyethylene, polypropylene, polystyrene and polyvinyl chloride which are created by municipal (household, public places), commercial (supermarkets, restaurants, etc) and industries (plastic processing and manufacturing).

Source of definitions of different types of plastic: Society of the Plastics Industry (SPI) classification system.

Common Types of Plastic waste and their sources

Category of waste	Common type of plastic	Quality	Volume
Municipal (households, public places)	Polyethylene	Low	Large
Commercial (restaurants, hotels)	Polyethylene	Medium	Reasonably large
Industrial (manufacturing, packaging)		High	Medium

Usage of plastic waste by recycling companies

Ghana currently recycles only 2% of plastic waste generated. The most common type of plastic recycled in Ghana are HDPE, LDPE and PET.

Enabling Policy Environment

There is currently one existing policy under review, one proposed policy, a levy and a directive, all pertaining to plastics and aimed at resolving pollution challenges. The United Nations Development Programme (UNDP) under its Waste Recovery Platform Initiative organizes multi-stakeholder dialogue to improve plastic waste management in Ghana. Over 100 stakeholders including government officials, development organizations, academia, etc. comprise the membership of the platform.

Members attend quarterly forums to discuss relevant topics concerning Ghana's transition to a circular plastics economy.

Plastic and Plastic Waste Policies in Ghana

Environmental Sanitation Policy (revised 2009)

Published by the Ministry of Local Government and Rural Development, the Environmental Sanitation Policy (2007, revised 2009) was crafted with the theme Materials in Transition (MINT). MINT is the underlying philosophy for creating awareness for change of attitude towards the handling and disposal of all types of waste by demonstrating that there is value in all the National Plastics Management Policy (2019)

The Ministry of Environment, Science, Technology and Innovation (MESTI) thus released a draft National Plastics Management Policy for public review in January 2018. The policy aligns with the objectives set out in the Environmental Sanitation Policy and attempts to translate the broad objectives of the Environmental Sanitation Policy into specific activities that are sufficiently detailed to be actionable and accountable. According to the Policy Committee, the Plastics Management Policy has been designed to bring cohesion and clear accountability to all plastic related issues.

Directive on the use of (Oxo) biodegradable Plastics (2015)

The Ministry of Environment, Science, Technology and Innovation (MESTI) published a "Press Release on Plastic Waste Management in Ghana" on 27 July 2015 directing:

1. That all stocks of flexible plastics will have to be cleared in three months effective from 1st August 2015 to 31st October 2015;

2. On 1st of November 2015 all flexible plastics produced in the country will have bio-degradable additive added to them to make them bio-degradable for easy management components of wastes. MINT is envisioned to create 'green collar' jobs and has the potential to reduce MMDAs' cost for waste management. Analysis shows that the existing Environmental Sanitation Policy (revised 2009) is ambitious and holistic and has great potential to be effective if implemented. However, lack of direction on how to implement and lack of supporting resources are factors influencing the failure of the well-intended policy.

3. All flexible plastics below 20 microns produced in the country and imported including those used for water sachets and carrier bags of the said microns shall not be allowed in the country from the 1st of November 2015;

4. All flexible plastic products should be labelled with the manufacturer's name, logo, date and location of the company for easy identification where necessary

The Environmental Protection Agency was further directed to enforce the relevant provisions of the EPA Act 1994(490) and Environmental Protection Assessment Regulations 1999, LI 1652 to ensure that the above directives were complied with to bring sanity to the environment.

Act 863 – Customs and Excise (Duties and Other Taxes) (Amendment) Act (2013)

Passed by Parliament and assented to by the President, Act 863, commonly referred to as the "Environmental Tax," places an excise duty of 10% on the ex-factory price of plastics and plastic products listed under chapters 39 and 63 of the Harmonized System and Customs Tariff Scheduled 2012. The Act stipulates that no less than 50% of the revenue accruing under the tariff shall be paid into a Fund designated as a "Plastic Waste Recycling Fund."

Enabling Policy Environment

Local firms lack the technical capacity to produce plastic waste composites on a large industrial scale. Technical challenges include lack of access to funding to set up factories as well as to purchase equipment. A 200kg/hr waste plastic composite factory would cost about $650,000 to set-up. Other technical challenges include low technical expertise and lack of funding to train staff, engage technical consultants and researchers and high electricity tariffs coupled with power fluctuations. As a result of these challenges, all the local manufacturers of plastic waste composites interviewed were operating on a relatively small scale.

Demand

Companies involved in the manufacture of plastic waste composites operate on a small scale which makes it difficult for them to compete with substitute products in the market. Nelplast Limited for instance receives orders for composite bricks, however, the lead time of production is significantly long. This is often due to lack of funding to produce at large capacity, drives the demand to concrete bricks which are readily available. The company currently recycles 2,000 kilos of plastic waste even though it has the capacity to produce 200,000 plastic pavement blocks. Plastic pavement blocks are 30% cheaper than conventional ones.

Supply Chain

The supply chain for waste plastic in Ghana consists of producers, collectors, aggregators, recyclers and exporters. Currently, most plastic waste recycling companies depend on individual collectors for their raw materials. Nelplast for instance collects plastic waste from individual collectors for between GHS0.30 - GHS0.50. However, companies such as Jekora Ventures are actively involved in picking up waste from residents and then separating the waste. Recycling companies have stated that the supply of plastic waste is not a challenge in the industry. There is enough plastic to be recycled. According to Nelplast Limited, the company receives on average 10 times more waste than it can process.

Access to Finance

- The Ghana Recycling Initiative by Private Enterprise (GRIPE), an industry-led initiative by 8 manufacturing companies under the Association of Ghana Industries (AGI), donated a sum of GH¢10,000 and some items to the University of Ghana Plastic Recycling Project (UGPRP).

- GH¢20 million state funds go into the collection, transport and landfilling of waste.
- The UNDP Waste Recovery Innovation Challenge is offering a matching grant of 40,000 USD each to four companies in Ghana to support their businesses.
- Approximately GHS 1 billion collected from 10 per cent of Environmental Excise Tax (EET), has not yet been disbursed. It is being kept in consolidated fund.
- Raphael Bendugo of the British Department for International Development disclosed that DFID would provide a US $1billion assistance to tackle the problem of plastic pollution, adding that DFID was committed within the GPAP initiative to addressing the plastic menace.

2.0 Mapping of Resources and Key Stakeholders

The earlier section showed various kinds of materials that can be used in combination with plastic waste to make composite materials. In considering the economic viability of producing such PWCMs, it is essential to understand how sourcing of raw materials for such materials flows locally. Aside understanding this, it is critical to know the key ecosystem players, as well as the work they are involved in, in order to obtain a better understanding what has been tested and worked in Ghana. In this section, we present a map of raw materials used for composition materials, as well as some insights obtained from interviews with major stakeholders in the private sector, government and academia. Our analysis of theoretical and economic availability of materials aims to present the current prospects for PWCMs in Ghana.

MAP FOR RAW MATERIALS

It is critical to understand the ecosystem around raw materials used for Composite Materials such as the availability, the costs involved, and the expected trends for both availability and cost of raw materials. A summarised map is shown below (detailed map available as separate document).

WOOD

- 50% of sawdust is dumped or burned
- The Ghana timber industry is declining due to deforestation
- Sawdust is also used for briquettes, fertilizer and poultry beds

PLASTIC

- Some of the plastics used in composites include LDPE, PET, PP and HDPE.
- Approx. 2.58 million MT of raw plastics are imported into the country and 500,000 tons are produced locally.
- Some aggregators such as Coliba and Plastic Punch sell plastic waste to several other recycling companies.

SAND

- Increasing demand of sand is causing erosion of beaches and communities.
- A kilogram of sand costs GHS0.09 and GHS1,800 for one trip (transportation).
- Competing industries for sand include construction and real estate.

CEMENT

- Cement production has a yearly surplus of 2 million tons with a stable growth of 6%.
- The average price of cement is GH¢ 34.
- Competing industries include construction and real estate.

BITUMEN

- The world market price of Bitumen ranges from $300-$350/drum.
- Importation of bitumen increased by close to 50% from 2010-2016.
- Competing industries include road construction.

ADDITIVES

- Some of the additive included in composites include lubricators, colorants, UV stabilizers, talc and fame retardants.
- Most of these additives are imported.
- Competing industries include furniture, water, pharmaceuticals and electronics.

Analysis Of Theoretical And Economic Availability Of Raw Materials

In this section, an analysis of the theoretical and economic availability of raw materials for plastic waste composite materials is presented to provide a deeper outlook of the industry that surrounds PWCMs in Ghana.

Plastic Waste

To cater for lower-income consumers, companies are shrinking product-distribution sizes, creating more units of plastic packaging per gram of product. About 2.58 million MT of raw plastics are imported into Ghana annually of which about 73% (~1.88 million MT) of this effectively ends up as waste. Waste plastic generation levels are forecasted to increase due to decreasing poverty, growing incomes and rising consumption in Ghana coupled with an underdeveloped waste-management system.

According to research of experts in this field, it has been found that theoretically, this should generate an abundant supply of plastic for recycling, however only 2%-5% of plastic waste is currently being recycled or downcycled into single-use films (rapidly become waste, plastic pollution). Of the remaining 98%, 38% is landfilled, 11% is incinerated, 28% is littered on land and 23% ends up in the ocean.

Factors leading to inefficient collection and management of plastic waste include lack of infrastructure to collect and recycle waste, ineffective waste management systems and attitudinal challenges towards waste. For example, plastic waste collected from households is often not segregated at source because most households do not have segregated bins for different types of waste. They are also not incentivised to sort waste for recycling as waste collectors aggregate the different waste types and then transport them to landfill.

This results in plastic waste being contaminated with other waste types such as organic waste. This increases the costs incurred in recovering plastic waste, especially from landfills, as the contaminated waste must be sorted and cleaned before it can be recycled. These costs coupled with rising transportation costs increase the unit price of plastic (GHS 0.8 to 1.4 per kilogram) sold to recyclers. Source separation of waste is crucial for the implementation of recycling and resource recovery schemes. According to the United Nations Development Programme (UNDP), Ghana can generate GH ¢83 billion annually through recycling.

73% of the 2.8 million MT of raw plastics are imported annually into Ghana.

Only 2% - 5% of plastic waste is currently being recycled or downcycled into single-use films.

Rising Transportation Costs increase the unit price of plastic sold to recyclers.

Source Separation of waste is crucial for the implementation of recycling and resource recovery schemes.

Ghana can generate **83 billion GHS/annum** through recycling.

Sand

Sand is the second most consumed natural resource after water. In West Africa, the construction boom (due to the need to reduce the housing deficit) has increased the demand for sand.

However, this increase in the demand for sand has also increased the impact of unregulated sand winning on the environment namely, the destruction caused to vegetation cover and water bodies. A parliamentary report in 2017 indicated that 85% percent of sand winners in the country are operating illegally. The report attributed this phenomenon to the cumbersome and long procedure which a prospective sand winner has to go through to secure a licence to operate.

In Ghana, the Mining and Minerals Act (Act 703), regulates the activities of stone and sand winners. It classifies sand and stone as major minerals and therefore subjects them to the same process of obtaining permits as those who mine gold, diamond, and other precious minerals. Also, by the Minerals and Mining Act, 2006 and the Environmental Assessment Regulations, the maximum duration for the issuance of a license is about 11 months, however the report gathered that in practice, it takes over two years to acquire a license.

The report thus recommended getting the Minister responsible for mining to submit a bill to Parliament to amend the Minerals and Mining Act, 2006 (Act 703) to provide for a more decentralised system of license acquisition for sand winning. Theoretically this should increase the number of sand winners obtaining licences and aid the ministry in regulating their activities.

Wood Waste (Wood-Plastic Composite)

Ghana's timber industry is declining due to distance to harvesting sites and number of trees allowed to be harvested especially since the Timber Industry Development Division (TIDD) has started an initiative to manage deforestation. The minimization of wood waste through the production of plastic wood composite is thus vital not only to the efficient use of wood resources but also for reducing the environmental impact of the timber sector in Ghana.

The recovery rates of sawmills in Ghana are low (about 28-64%), leading to pressure on limited available resources. A study on wood residue generation and utilization for some selected sawmills in Brong Ahafo and Ashanti Regions in Ghana determined the average percentage lumber recovery at four sawmills was 38.08% with residue (wood waste) forming 61.92% of the total input volume. About 60% of sawdust generated is not utilized but either dumped or burnt openly. If recovered, these could provide about 75,000 to 95,000 cubic metres of sawdust for wood composite production in Ghana.

Sand is the Second Most Consumed Natural Resource after water.

MAJOR STATISTICS

Recovery Rates are Low among sawmills in Ghana 28-64%

60% of sawdust generated is not utilized but either dumped or burnt openly

75,000 to 95,000 Cubic Metres of Recovered Sawdust can be available for the production of Wood-Plastic Composite in Ghana

Concrete (Concrete-Plastic Composite)

Ghana currently has more than 2 million tons of cement surplus being produced domestically each year. Local cement manufacturers in Ghana have an installed capacity to produce about 7.4 million tons of products every year. This is above the annual consumption of cement in Ghana, which is estimated to be 5 million tons per year . Cement consumption in Ghana is among the lowest in the world (the global average for consumption is about 340kg per capita yet in Ghana, it is about 70kg per capita . That means pricing within this sector will likely continue to fall due to increased competition until the government of Ghana can gain some measure of control over how much cement is being imported and produced. In 2016, when Dangote Cement Ghana Limited dropped its price, GHACEM Limited also reduced its price by the same margin.

From 2009-2013, production levels rose from 1.8 million tons to 3 million tons. In 2017, an estimated 5 million tons was achieved . Despite the high levels of installed and actual production capacity, from 2001-2007, Ghana was a net importer of cement jeopardizing the local cement industry.

About 500,000 tons of bagged cement are imported into Ghana every year. Chinese cement imports are estimated to cost the Ghana cement industry more than $13 million per year.

In 2015, however, Ghana's construction sector experienced a 6.2% growth from the previous year, helping to support expanding domestic production of cement . With current added support by the government to require import licensing for new cement imports, domestic demand should continue to grow. Production levels are forecasted to reach as high as 9 million tons in the next 5-year period. If domestic demand continues to rise as well (as a result of the current construction boom), then the Ghana cement industry may soon become stronger than it has ever been.

Bitumen (Bitumen-Plastic Composite)

Bitumen in Ghana is primarily used for road construction. Bitumen consumption in 2016 was estimated to be about 11,000MTs. Presently, no oil marketing company in Ghana supplies Polymer Modified Bitumen (PMB) for road construction and most major road contractors import the product in bitumen containers from abroad, particularly from Côte d'Ivoire, which has been supplying 80% of Ghana's bitumen requirement.

Goil Ghana has entered into a joint venture with Société Multinationale de Bitumes (SMB) of Cote d'Ivoire to construct a $35 million bitumen plant in Tema. The plant, which has the capacity to produce 8,000 tonnes of PMB and Bitumen Emulsion, is expected to be completed in two years (by 2021). The plant is expected to supply AC10, AC 20 and the PMB, the quality of bitumen used for the construction of the N1 road. The plant is expected to be a change changer especially in the road construction industry with supply of quality bitumen. The high cost of road construction in Ghana, estimated at GH¢1 million per kilometre of asphalt road, is mainly attributed to the unavailability of bitumen in Ghana. GOIL and its partners thus believe that the local production of bitumen will help reduce the cost of the raw material and road construction significantly.

Tema Oil Refinery also plans to make bitumen and lubricants significant components of its production slate by 2020. It is considering producing 60,000 tonnes of bitumen on a dedicated CDU or VDU by 2020.

Existing suppliers of bitumen include Total Ghana, Vivo energy, Ghana Highway Authority (GHA), Platinum seal, Societe Multinationale de Bitumes (SMB) and Gbewaa Petrochemicals.
The National Petroleum Authority (NPA) is in the process of beginning the regulation of bitumen. In April 2017, the NPA set up a committee to streamline the operations of Bitumen Marketers in the country and identified the quality of bitumen as some of the challenges in the sector.

Additives

Proper additive choices for WPCs are critical to both performance and processing. Additive use is growing as wood-plastic composites penetrate new markets. Additives used in plastic composites in Ghana are mostly imported. Additives are typically used in producing plastic wood composites and are either organic or inorganic. Inorganic additives include coupling agents, lubricants, inorganic fillers, colorants, UV stabilizers, biocides, fire retardant and these are typically imported into Ghana. Organic additives such as coconut oil can however be sourced locally.

3.0 Market & Technical Analysis, and Case Studies

In addition to understanding research and the status of the enabling environment of PWCMs, as well as the supply side for producing PWCMs at scale, it is critical to know from a market and technical stands, the potential to run commercial scale businesses that make applications from PWCMs. This section presents the market analysis and technical analysis for Wood-Plastic Composites and Sand-Plastic Composites. Based on the analysis of findings from the preliminary desk study, and in consultation with the SNV team, the two PWCM selected are: Wood-Plastic Composites and Sand-Plastic Composites. This final section of the report also highlights exemplary case studies from businesses operating in this sector globally, in Africa and in Ghana.

MARKET ANALYSIS

This section describes in more detail the market analysis for both Wood-Plastic Composites and Sand-Plastic Composites.

Table 3.1 Showing Market Analysis for Wood Plastic Composite

COMPOSITE MATERIAL Source	Wood Plastic Composite Mostly imported
 Market Value/Industry Outlook	• Global market value in 2017 was estimated at $4.01 billion and is expected to increase to $5.84 billion by 2021 (at a CAGR of 12.4% from 2016 to 2021) and $8.15 billion by 2025 • Global annual WPC production increased from 50 000 tonnes in 1997 to almost 2.5 million tonnes in 2012 • Threats from imports, but Ghanaians are not familiar with WPC or T&G for ceilings hence patronage is low.
 No. of local players	One (1)
 Applications in Ghana	Outdoor applications: decking, railing, interior auto parts, cladding and window frames, doors, fencing, gazebo, flooring, sidings, garden chairs, flowerpots Indoor Applications: Portable furniture, cabinets, ceilings, etc.
 Priority Customer segment	• Parks and gardens • Real Estate Agents • Artisans (ceiling and flooring for kiosks)

Market barriers/Sector Challenges	• Transporting of raw materials is costly (GH¢600-GH¢900) • Challenges with the sourcing of plastic (different suppliers charge different prices, lack of source segregation) • Lack of financing (e.g. to purchase needed equipment) • Lack of government support. • High electricity tariffs.
Opportunities	• Housing deficit of 1.7 million. • Growth of the real estate market (offices, hotels etc.). • Current housing deficit has attracted many investors to the housing sector leading to the construction of several flats, apartments and estates. • Portable furniture for Ghanaians who rent houses. • High cost of wood furniture. • Opportunity to replace vinyl flooring and ceiling. • Technological improvements in processes and equipment for producing bricks. • WPC is more durable, eco-friendly, fire resistant and stronger than plastic. • WPC retains the best properties of wood while eliminating its problems (WOODPLASTIC®).
Environmental Impact	• Reduction in plastic waste sent to landfill -Prevents deforestation -Reduces incineration of wood waste thereby reducing greenhouse gas emission • A Sons Plastico house made from WPC would utilise 2.8 tons of waste plastic and 6.4 tons of wood waste
Emissions	• Wastewater

Table 3.2 Showing Market Analysis for Sand Plastic Composite

COMPOSITE MATERIAL Source	Sand Plastic Composite Locally Manufactured
 Market Value/Industry Outlook	• Lesser-known industry (small). • Recycling efforts are largely concentrated in and around the capital
 No. of local players	Two (2)
 Applications in Ghana	Pavement bricks, roofing tiles for the construction of roads, blocks for real estate, etc.
 Priority Customer segment	• Construction companies • Real estate companies • Ministry of Roads and Highways
 Market barriers/Sector Challenges	• High Cost of producing large scale • Unmet demand due to lack of inventory/capacity • Inadequate local research knowledge (Small pool of experts) • Inadequate/lack of policy support
 Opportunities	• Cost advantage (cheaper than concrete blocks and pavement bricks) and Availability of plastic waste (Ghana only recycles 2% of plastic waste generated) • Durability as compared to concrete (3 times lighter, stronger and more durable than concrete and clay) • High growth potential • Cures faster than regular products • Durability and comparatively low price of sand plastic composites is expected to increase patronage of product • Research and Development • Development of a viable business model

 Environmental Impact	• Nelplast recycles an average of 400 tons of plastic waste every 8 months . • 70% of plastic waste generated could be recycled and the environment in the long run preserved.
Emissions	• Some rudimentary processes produce smoke during manufacture of blocks.

TECHNICAL ANALYSIS

In this section, we present patterns in market data that enable us to determine the potential trends within the wood plastic and sand-composite sectors.

Table 3.3 showing Technical Analysis for Wood-Plastic Composite

COMPOSITE MATERIAL	Wood Plastic Composite
 Cost Summary	• Plant capacity: 200kg/hr Plant & machinery: $578,000 Operating Costs: $72,000
 Proven technology	• Extrusion, injection molding, and compression molding or thermoforming (pressing) • Four types of extrusion process, 1) single screw, 2) corotating twin screw, 3) counter-rotating twin screw, and 4) Woodtruder™. • Strandex Corp. Patented Technology: an extrusion technology that is licensed to WPC businesses (i.e. WOODPLASTIC®)
 Plant Capacity	200kg/hr
 Operating Costs	Additives: Energy: 2,487.5 kw/d Water:2,722-4,536 l/hr Raw Materials: Plastics (Plastic Punch GHS/kg 0.60- GHS/kg 0.70) Waste collectors/aggregators (0.8 GHS/kg to 1.4GHs/kg)
 Plant and Machinery	• Plant: $150,000 • Machinery (conical twin-screw extruder (equipped with spring feeder), calibration unit, hauloff unit, cutter (CNC cutting and drilling machine), stacker): $428,000 • Sources of equipment: Japan and China

 Certifications	• Companies are certified according to ISO 9001 and ISO 14001 • ISO 9001 is a Quality Management System (QMS) which gives organizations a systematic approach for meeting customer objectives (providing consistent quality). • ISO 14001 is an Environmental Management System (EMS) which gives organizations a systematic approach for measuring and improving their environmental impact. • PEFC Certification: Programme for the Endorsement of Forest Certification, is a leading global alliance of national forest certification systems • Forest Stewardship Council (FSC) Certification: commitment to responsible forestry • EPA permit for operations in Ghana
 Total Cost of project	$650,000
RETURN	A 4 million kg/yr. factory will yield about $4-5million in sales. A 45 million kg/yr. factory will yield about $50-60million

Table 3.4 showing Technical Analysis for Sand-Plastic Composite

COMPOSITE MATERIAL	Wood Plastic Composite
 Cost Summary	• Plant capacity: Plant & machinery: $15,000
 Proven technology	• Currently, there is no standardization of waste-plastic sand composites. Material performance, appearance and cost are dependent upon preparation conditions, binder content, aggregate size, type and distribution, nature and content of the microfiller, curing condition, addition of additives, processing temperatures and times.
 Plant Capacity	200kg/hr

 Operating Costs	Additives: Energy: 2,487.5 kw/d Water: 2,722-4,536 l/hr Raw Materials: 220,000 carrier bags needed to make enough Polysand roofing tiles to cover one average house. (Polysand)
 Plant and Machinery	• Grinder and Extruder: $15,000 • Sources of equipment: China with potential to assemble/ manufacture equipment locally (e.g. Nelplast)
 Certifications	• No major certifications specifically for this composite material • EPA permit for operations in Ghana • ISO 9001

CASE STUDIES

In this section, we present case studies of businesses that make various applications using wood-plastic composite and sand-plastic composites.

Wood Plastic Composites

On a global level, wood-plastic composites have received a lot more attention, thus has developed more in terms of commercialization of products made from this composite. A case study is presented on Polywood ® which is based in South Africa.

Case Study: Polywood Business Case

POLYWOOD

polywoodoutdoor.com

Products: Furniture (rocking chairs, benches, gliders, deep seating, dining sets etc.

Triple bottom line (Social, environmental and Economic impact):

- 750 jobs by 2022.
- Recycles 400,000 milk jugs/day
- "Waste" wood is reused for furniture resulting in zero waste.
- 22-25 tonnes of finished product produced per day.

Business model: Previously bought recycled HDPE flake from outside vendors now operates as a recycler and as a manufacturer. Sells products online, ships for free in the US, through retail partners or showrooms.

Key partnerships: Lindner ReSource America (Plant construction), Wypromote (Web Content), Antiunity (streamlines data warehouse creation)

Achievements: Increase in sales, 51% decrease in cost-per-order and 2% increase in Average Order Value in Quarter 2.

Challenges: The outdoor furniture marketplace is highly competitive, with medium-size ecom-merce competitors and big-box retailers vying for the same consumers.

Success Factors

Planned recycling plant from scratch. Key aspect was to ensure a high level of sustainability through efficient use of water, heating and energy power, as well as low-maintenance operation, maintenance-friendly design and a high nominal throughput in long-term operation. Aimed to achieve outstanding cost-efficiency to make the recycling of plastics a success both technically and economically .

Lean manufacturing processes that minimize waste streams and ensure that products are built quickly and accurately.
Invested heavily in advanced techniques/technologies (pioneer in manufacturing techniques and operations)

- Continual innovation is a driving force
- Focusing on audiences and purchase intent
- Differentiating the brand through unique brand messaging and landing page experiences
- Utilizing a wide variety of campaign types and targeting capabilities
- Analysing cross-media and competitor trends to optimize for growth

Opportunity in Ghana

If we assume that the Ghanaian WPC market could follow a similar development trend to that observed in South Africa or Western markets, then the prospects are great. South Africa hosts dozens of manufacturers of WPC for all varieties of products ranging from decking, outdoor and indoor furniture, doors, window frames, interior panelling and more.
Just a few examples of the many companies in South Africa alone:

- New TechWood
- EnviroDeck
- Moisture Shield
- NURV Projects
- Black Health Trading
- Earth Friendly Solutions
- Eva-Last
- Seven Trust
- Best Deck
- Ecowood Decking

Market Interest

Current industry data for the WPC industry in Ghana is unknown. However, anecdotal investigations reveal that products made from WPC are on the market. For example, many hotels around the country are using WPCs. Outdoor furniture and decking, flooring panels, doors and trimming can be found in the traditional markets.

Size of the Ghanaian market for the product

According to Oxford Business Review in 2017 no less than 40,000 residential units are built per year across Ghana. It is expected that the residential segment represents less than half of the total market for building accessories, with the commercial segment being the largest and the industrial segment being the smallest.

Materials currently being used: Wood, metal, cane, plastic.

Pricing: WPCs are cheaper than wood and metal but more expensive than plastic.
Number of units per year: Doors: >500,000 pieces, Decking: >300,000 m2, Flooring: >1,000,000m2, outdoor furniture: <10,000 pieces, indoor furniture: <1,000,000 pieces

Perceived Reception Of New Material On Market

Ghanaians are typically slow to uptake a new product or material unless the value proposition is clearly understood. It is advised that new entrants to the WPC market in Ghana should invest in marketing and consumer outreach to enable potential customers to understand the many benefits of using WPCs over traditional materials. Start-ups should consider targeting popular community centres, such as places of faith and other large institutions (e.g. commercial spaces, universities, etc.) where many people can be exposed to the new material.

SWOT of the Ghanaian Wood-Plastic Composite Industry

SWOT (strengths, weaknesses, opportunities, and threats) analysis is a framework used to evaluate an entity's competitive position and to develop strategic planning. SWOT analysis assesses internal and external factors, as well as current and future potential.

STRENGTH	WEAKNESS
• Climate-appropriate material (resistant to water, bugs and fungi) • Cost-competitive with conventional materials • Minimizes pressure on wood resources, including deforestation • Utilizes two waste materials as raw material namely wood shavings and waste plastics, both of which are in high supply in Ghana	• New material to the Ghanaian market, which will require more intense efforts in marketing and consumer awareness to penetrate conventional market.
Opportunities	**Threats**
• Most of the directly competing products (e.g. water-resistant/outdoor furniture and decking) are imported, therefore there is an opportunity to exploit "Made in Ghana" branding and incentives. • As the economy grows in tandem with the middle-class and the leisure economy, we can expect to see a rapid increase in market demand for these products. • WPC has been proven as a material that can be used in affordable housing	• Potential ban on plastics can affect production. • Competition from existing mainstream competitors such as producers of wood furniture.

Sand Plastic Composites

Since sand plastic composite is marketed as a quality and affordable alternative to conventional bricks and other products, an ideal model should have been successful at making sand plastic composite materials at a low cost and in a quality form. The model should also be sustainable. The most common applications for this composite material are roofing shingles, pavement blocks, and decorative tiles.

Companies that focus on manufacturing of applications include:

Company Name	Year Established	Location	Application(s)
Polysand	On/Before 2013	Canada	Roofing tiles, pavers
Corec	2013	Kenya	COREC Resin roofing Tile and Fencing Posts
Resintile (EA) Ltd.	In/Before 2013	Uganda	Roofing tiles

Pierre Kamsoumloum	2008	Yaoundé, Cameroon	Pavers
Polimer-Krovlya		Russia	Tiles and Pavers
Britanica Tiles		India	Roofing tiles

Out of these companies, we have selected Corec Limited from East as a case study to obtain a stronger understanding of the market interest for products. Made from sand-plastic composites.

Snapshot: Corec Case Study

Continental Renewable Energy Co Ltd. (Corec)

https://goexplorer.org/recycled-plastics-for-construction-and-fencing/

Products & Services: Plastic roofing tiles, fencing posts, plastic lumber, pavement blocks, walk-way slabs, manhole covers, etc. Key products are COREC Resin roofing Tile and Fencing Posts. sets etc.

Triple bottom line (Social, environmental and Economic impact): 300 jobs (including former street boys) created since their launch in 2013 . 1,000MT of plastic waste from landfills recycledxxx . 1kg plastic waste recycled saves 2.5 Kg of carbon emissions, and for every 10 plastic posts produced, one tree is saved". Produced and sold 96,000 posts as at 2016 .

Business model (Supply Chain, Target Market etc.): Developed a product portfolio of relevant and quality products. Production capacity – recycles 560 tons of plastic waste annually. Target market consists of developers who need quality and affordable construction materials . It also targets local individual home builders, county government contractors, and private real estate developers. Export market includes Ethiopia, Kenya, Namibia, Nigeria, Rwanda, Somalia, South Sudan, Tanzania, United Republic of Zambia. Revenue is generated from the sale of the company's four key products: fencing posts, lumber planks, roofing tiles and machine fabrication .

Achievements:

- Established a customer base of 2,000 clients.
- Set up a production plant .
- Recipient, National Environment Trust Fund (Nefund) award, KES 50,000,000 (about $483k) as part of Green Innovations Award III. Award used to purchase equipment and machinery, business expansion and marketing activities.
- Listed on VC4A (a global startup community connecting entrepreneurs creating innovative and scalable businesses with the knowledge, network and funding they require to succeed).
- Listed on Global Opportunity Explorer. The Global Opportunity Explorer is a joint project of Sustainia, DNV GL, and the UN Global Compact, created on the conviction that the SDGs offer a myriad of business opportunities with great value to companies, society, and the environment.
- Jitihada Business Plan Competition, 2009.
- Innovation to Impact, 2013.
- Sankalp Africa Award, 2014.

Challenges: Current key competitors include producers of concrete tiles, clay tiles and iron roofing sheets. High cost of recycling machinery is a serious constraint.

Requirements for Expansion: Seeking investment of KES. 10,000,000 about USD 96,418 to acquire a new tile line that will increase its production output.

Success Factors

- High demand for building products in Kenya
- High demand for Corec's products due to susceptibility of alternatives to vandalism (for firewood and scrap metal)
- Environmentally friendly products
- Quality products (more durable than timber)
- Experienced team with the requisite expertise
- Budget friendly products (cheaper than timber)

MARKET INTEREST

There is a large opportunity for commercial production of pavement blocks and other applications using sand-plastic composites. However, there is a critical need to manage the demand side, expertise of the team, and the scale of production of the operations in order to match existing competitors making similar products form conventional raw materials.

STRENGTH	WEAKNESS
• Cost advantage - pavement blocks made of sand plastic composites are cheaper than concrete blocks and pavement bricks) • Durability as compared to concrete (3 times lighter, stronger and more durable than concrete and clay) • High growth potential • Durability and affordable price of sand plastic composites is expected to increase patronage of product according to Sons Development Company	• Low knowledge of sand plastic composites in Ghana. • Some rudimentary processes produce smoke during manufacture of blocks. • Recycling efforts are largely concentrated in and around the capital • There is no standardization of waste-plastic sand composites. • Material performance, appearance and cost are dependent upon preparation conditions, binder content, aggregate size, type and distribution, nature and content of the microfiller, curing condition, addition of additives, processing temperatures and times.
Opportunities	**Threats**
• Growth of the real estate market (offices, hotels etc.). • Current housing deficit has attracted many investors to the housing sector leading to the construction of several flats, apartments and estates- (Ghana Real Estate Developers Association (GREDA). • Availability of plastic waste (In Ghana only recycles 2% of plastic waste generated) • Ongoing research and development to combat the current plastic menace by exploring plastic composite material options	• Potential ban on plastics can affect production.

Appendices

This section presents detailed additional information on this research which are useful for understanding the Plastic Waste Composite Material market in Ghana and beyond. It includes information gathered from interviews with key stakeholders in the PWCM market in Ghana, detailed processes for basic plastic-composite production, as well as additional information on existing businesses that serve as case studies for any entrepreneur seeking to manufacture products at commercial scale using PWCM as inputs.

Table A1 Showing Key Stakeholders Interviewed

SECTOR	SPECIALIZATION	ORGANIZATION	NAME	RATE
Academia	Sand plastic composites. Pavement blocks	CSIR	Mr. Mutala Mohammed	Research Scientist
	Plastic-bitumen composite	KNUST	Johnson Kwabena Appiah	PHD Candidate
	Policy research (science and technology)	STEPRI (Research Institute)	Dr. Gordon Akon-Yamga	Research Scientist
	Plastic+bitumen, mortar, concrete, plastic pavement blocks to assess its properties. Construction of toilet facilities		Dr. Ama Tagbor	Researcher
Composite Manufacturer	Sand plastic composites for pavement blocks, blocks and interlocking bricks	Nelplast Company Ltd	Mr. Nelson Boateng	Founder
	Fabrication of plastic components for use in home gardening and other applications. Manufacturing of pavement blocks, concrete slabs	Green-Ef Eco-Business Village Ltd	Dr. Sachibu Mohammed	CEO
	Recycling of plastic waste into building bricks. Plastic waste used is PET, PVC	Ohemaa Green Housing	Augustina B. Busiah & Alice Busiah	Founder & Co-founder
	Recycling – Manufacturing of wood plastic composites. Brand names are Sons Plastico wood, Sons plastic system, T&G ceilings	Sons Development Company	Edinam Folikumah	Founder & CEO
Raw Material Supplier	Plastic Shredding company that sells to a pavement block manufacturer & export to India manufacturers of thread, fibre, etc.	Premium Waste Services	Edmund	
NGO/ Development Partner	Awareness workshops in schools, churches & universities, beach cleanups.	Plastic Punch	Elisa Marraco Anda	Secretary
Government Institutions	Development of standards Conformity Assessment	Ghana Standards Authority	Priscilla Asantewaa Boateng	Assistant Scientific Officer

Findings from Key Experts in The Value Chain in Ghana

Familiarity with Composites and their use for the Ghana Market

- All four Stakeholders in academia interviewed were familiar with and endorsed composite plastic.
- Respondents from government institutions indicated that they were familiar with waste plastic composites as a result of the UNDP Multi – Stakeholder platform.
- Out the four manufacturing companies interviewed, two endorsed waste plastic composites, one mentioned that they endorsed some but not all and one declined to comment.

Knowledge of the diversity and size of the industry locally and externally

- The Plastic recycling industry in general is quite large with a large number of players within the value chain. However, waste-plastic composites are a lesser-known industry comparatively with the industry largely concentrated in and around the capital, Accra.
- There is strong competition from foreign-owned companies for some composites.
- At the same time, people are fixated on conventional materials in recycling thus more sensitization is needed on plastic composites.
- According to one wood-plastic composite company in the space, global market size to be 9.6 billion. The expert also mentioned that there are threats from imports, but Ghanaians are not familiar with waste-plastic composite or tongue and groove (T&G) for ceilings hence patronage is low.

Activities currently taking place in the sector

- Research activities include policy research under science and technology, research into plastic composite specifically plastic-bitumen composite, mortar and concrete. A PHD candidate at KNUST is currently conducting research into plastic-bitumen composite. One researcher interviewed is currently conducting tests with plastic pavement blocks to assess their properties. Researchers at CSIR are working on plastic composites research including road construction and production of pavement blocks.
- Governmental activities taking place currently include development of standards and conformity assessments.
- Regarding awareness creation, NGO's and advocacy groups are conducting awareness workshops in schools, churches & universities, beach clean-ups.
- Other activities taking place in the value chain include picking, shredding as well as manufacturing. Waste collectors and pickers (both large scale and individuals) collect waste plastic, recyclers such as Premium Waste Services shred and bale plastic (for sale locally or for export to countries such as India), manufacturers such as Universal Plastic manufacture products such as bins, thread, fibre, etc.
- Composite plastic products being manufactured include sand plastic composites (pavement blocks and building bricks)

Source of inputs

- Equipment: Local sourcing, most of the equipment are assembled and manufactured here in Ghana and typically sold in the open market. One composite manufacturer mentioned that he manufactured and assembled his own equipment. One researcher however mentioned that equipment sourced locally are inefficient however sourcing equipment from overseas is expensive. Some companies source equipment from China and Japan.
- Raw materials: Plastic is sourced from Waste/refuse collectors, Sand is sourced from quarries – stone dust, women who sweep roadsides, etc. Wood is sourced from timber manufacturers

Challenges in the industry

- Uncoordinated method for raw material sourcing affects the entire value chain. There is no transparency on the information needed regarding plastic sourcing, aggregation, pricing etc.
- High transportation costs from pick-up points to destinations: Transporting the waste from one point to another is costly. GHS 800 for 8 trips, in some areas GHS 900 for one trip.
- No technological advancement and low technical expertise are affecting growth of the sector. An example of a

technical challenge includes product cracking after remoulding (sand-plastic composite). After seeking expert advice, there is a need for an extruder to be purchased to rectify this issue.
- Composite manufacturers also face the challenge of high electricity tariffs during production periods.
- Lack of financial assistance to acquire appropriate equipment, train personnel and engage technical consultants and researchers. Although there has been talks about the need to take action against the plastic waste menace in Ghana, no concrete steps have been taken to provide funding for R&D.
- Poor attitudes towards waste management: Waste materials not being segregated and sent to landfills makes it very difficult to separate. Refuse collectors lack education on the need for segregating waste materials right from pick up points.
- No existing government policy that is supportive of plastic composites.
- Development organisations/partners are only concerned about advocacy programmes and pay less attention to implementing solutions to the problem of plastic pollution. Banning plastics is not the solution

Support needed in the sector

- Government and NGOs could provide financial support (e.g. grants) as to research institutions.
- Government and stakeholders need to have an open forum to better tackle the issue of plastic waste composites. The growth of the sector is also dependent on the management of waste plastics and not necessarily a ban.
- Government support in terms of policies and regulations as well as ECG subsidies for manufacturers of waste composites.
- More awareness is needed on the segregation of waste.
- Funding for manufacturing companies in setting up factories/plants including finance to acquire appropriate equipment, train staff and engage technical consultants and researchers.
- Need for decentralisation of the sector.

Opportunities in the industry

- Schools lack toilet facilities and these composite materials can be used for construction of these facilities. Pavement blocks made of plastics and sand can also be used in construction sites since they tend to be durable, non-absorbent of water and stronger than concrete.
- Tests are also being conducted on the plastic to sand ratio for pavement blocks. Since there is no ban on plastics, manufacturers can still rely on plastics for packaging products such as sachet water for those who cannot afford any other form of packaging for water.
- Governmental policy support
- Creation of a viable waste management system
- Creation of employment avenues for the informal sector
- Increasing environmental awareness will gradually change waste management attitudes.
- High growth potential
- Durability & price of sand plastic composites will increase patronage of product as compared to concrete blocks. Hence, there is potential for a huge regional market (namely the West African market with its large population)
- High growth potential for the market once stakeholders in the sector play their respective roles
- High growth potential as more and more research done on innovative solutions to tackle the plastic waste menace.

Potential impact of plastic composite materials

- Preservation of the environment against floods - 70% of plastic waste generated could be recycled and the environment in the long run preserved. Plastic composites could potential solve problems associated with improper waste disposal.
- Creation of employment avenues for the unemployed.

Appendix 2 – Detailed Technical Process For Plastic Composites

Wood Plastic composite: Technical Process in detail

This section outlines the inputs, outputs, capacity, process overview and process flow in the production of wood plastic composite material.

Inputs

1. **Energy:** 2,487.5 kw/d
2. **Water:** 2,722-4,536 l/hr.
3. Additives (colorants, stabilizers, compatibilizers, flame retardants, moisture retardants, biocides, lubricants, fillers, UV stabilizers, etc.)
4. Wood (shavings/four)
5. Plastic pellets (clean, shredded/pelletized)

- **(PP & HDPE):** Widely used, available at low cost, and have good performance for intended applications. For example, both have a melting point lower than the degradation temperature of powdered wood products (220°C).
- **LDPE:** Also, possible but not generally recommended as it has a lower melting point and therefore will become gaseous when processed with other polymer grades thereby causing weak points in the final product.
- PET and PVC are not compatible with WPC applications.

Outputs

- **Products:** Products can be formed into almost any shape and thus are used for a wide variety of applications, including windows, door frames, interior panels in cars, railings, fences, landscaping timbers, cladding and siding, park benches, molding and furniture.
- **Emissions (land, air, water):** wastewater, air emissions (both must be captured and treated).

Capacity

- 200 kg/hr. (smallest commercially viable operation) ► 2,000 kg/hr. (sophisticated operation)

Process Overview

Extruded or Injection Molded processes are both possible for wood composites. "A wide variety of PP and HDPE polymers are available, however careful selection is important because extrusion and injection molding require different characteristics. For example, a critical need in injection molding is good flow of the material into the mold, whereas a critical need in extrusion is melt strength to enable handling of the hot material as it comes from the die. Choice of polymers for these technologies is therefore quite different. Injection molding requires a polymer with a low molecular weight to maintain low viscosity. By contrast, extrusion requires a polymer with a higher molecular weight for better melt strength"

Extrusion Process: The process begins with clean, ground plastic pellets and wood flour. Manufacturing facilities can be equipped to take dirty material. If this is the case, two parallel processes must occur before mixing of wood flour, plastic pellets or ground plastic, and additives (if desired).

Process flow

1. **Manufacture of wood-plastic pellets**
   - Preparation of plastic:

   Process: washing, grinding, washing of plastic wastes.
   Equipment: conveyor, crusher, friction loader, floating washer, high-speed dewatering machine, dryer, blower/pipe, storage unit

- Preparation of wood flour:

Process: grind, sieve, dry
Equipment: crusher, vibrating sieve, dryer

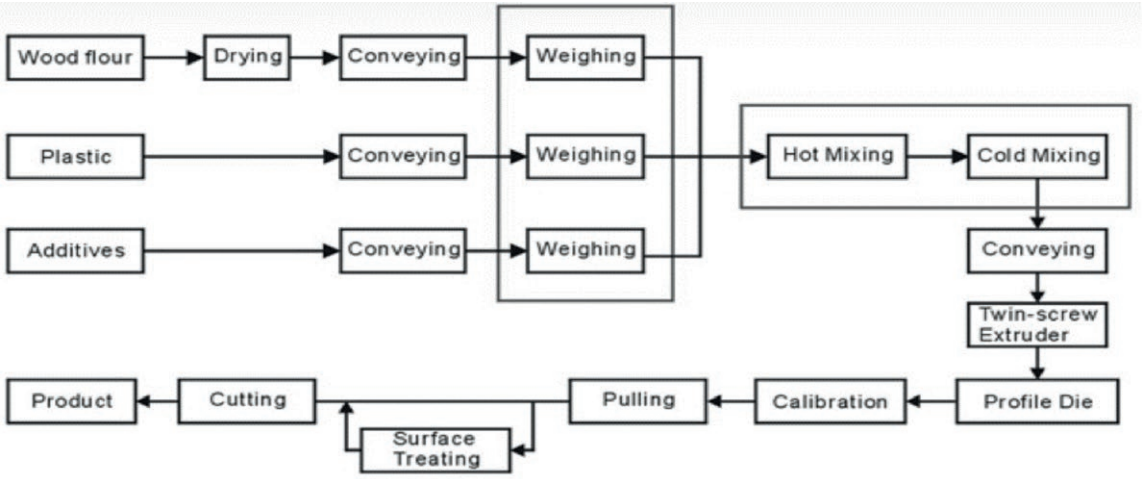
2. **Mixture of wood and plastic**
   - high-speed mixer
   - screw-type feeder
   - co-rotating parallel twin screw extruder pelletizer
   - three-stage air blowing process

3. **Extrusion line for finished product**
   - Extrusion line

Equipment: conical twin-screw extruder (equipped with spring feeder), calibration unit, haul-off unit, cutter (CNC cutting and drilling machine), stacker, brushing machine, embossing machine.

Schematic Diagram for process flow for producing wood plastic composite

The diagram below illustrates the process flow for the production of wood plastic composite. It shows the process of conversion of inputs wood flour, plastic and additives into a final product.



Costs

- Smallest recommended size (2-5 tonnes/day production)
- 1-2 million USD capital investment
- 25% factory cost
- 65% equipment cost
- 20% 6-month operational-contingency costs

Employment opportunities:

- Direct staff - 20 for production and management
- Indirect staff: Value Proposition: Cost savings (from 100% plastics products or 100% wood products): reduced processing time, reduced processing temperature, reduced material use.

Capital Costs

"A 4 million kg/yr. facility has been suggested as the minimum size for a successful commercial compounding venture. Such a facility would employ 13 persons- 8 production workers, 1 production supervisor, 1 clerical worker, and 1 general manager. Total sales would be approximately $4-5 million, based on the assumptions described in this section. At 45 million kg/yr., total employment would probably approach 10, with total sales of $50-60 million.

Current utilization in Ghana: Several entrepreneurs are exploring WPCs in Ghana for various applications from affordable housing to external toilet structures and furniture. However, there are no known existing companies that are manufacturing WPCs in Ghana although you can find WPC products on the market.

Challenges

The major challenges faced by local entrepreneurs exploring WPCs is lack of access to funding.

Sand Plastic composite: Technical Process

Inputs

Polymer grades: HDPE, LDPE, LLDPE, mixed post-consumer wastes – waste plastics can be added from 9-60% of total product weight

Additives: NONE (simplified process); UV stabilizers, colorants, anti-fungals, flame retardants, plasticizers may all be used

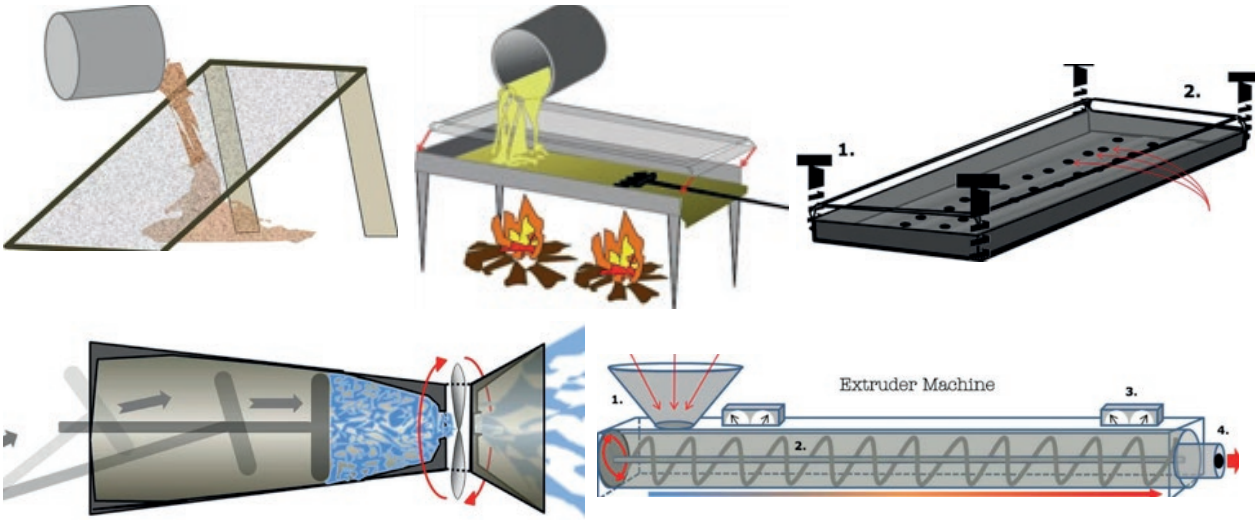
Energy: low – light washing, grinding, mixing and extruding

Water: low – light washing

Simplified Process

Industrialized Process

(1) Raw sand is fed through a metal screen to remove impurities, (2) sand is heated to remove moisture, (3) pre-sorted, washed and dry plastic is shredded, (4) sand and shredded plastic are blended at 70% sand and 30% plastic (not shown), (5) mixture is driven down the length of the extruder by a rotating screw. Temperature must be monitored to keep temperatures below the incineration temperature of plastics (approximately 250°C, but varies depending upon plastic grade), (6) plastic-sand paste is weighed, (7) placed into mold, where uniform screws ensure uniform pressure, (8) tile is left to cool for several minutes, (9) compressed air is blown through tiny holes to remove tile, (10) excess plastic is trimmed from surfaces (Eco Blocks).



Outputs/Products:

Slate imitation roofing tiles: 3.81 cm thick 30.48 cm wide, 17.78 – 26.67 cm long, 1.63 kg (4 times lighter than natural slate) Tiles are installed the same way as slate tiles, with two nails holding the tile in place. The tiles are designed with a locking mechanism, which obviates the need for adhesives

Terracotta clay replica roofing tiles: 1.75 kg (3 times lighter and stronger than clay or concrete)
Concrete imitation paving bricks: 0.91 kg (3 times lighter, stronger and more durable than concrete pavers, and oil stains can be washed off)

Appendix 3 – Additional Information On Case Studies

Wood-Plastic Composites

In addition to the example of Polywood® described in the study, we present 2 additional examples of companies that produce for the same target market as that of manufacturers that use wood plastic composites to make their products. We describe Ecowood Decking from South Africa, and Furnart Company Limited from Ghana. Description is below:

Africa Example

Company name: Ecowood Decking

Year incorporated: 2002

Location(s): One, South Africa

Product(s): Five different board types/finishing are available in six different colors.

Residential products

Commercial decking applications

Target Market: Upper-class families and commercial products

Retail Strategy: Online

Ghana Example

Company name: Furnart

Furnart is a leading furniture, joinery, and office manufacturer in Ghana, and has developed its products for the export market as well. Furnart Ghana has the vision to be the leading lifestyle brand in the design and manufacture of quality furniture and joinery in Ghana and beyond, with a strong unified team that creates value for stakeholders while delivering social and environmental sustainability. Although Furnart does not make products from wood-plastic composites, it is a good example of a major competitor to any new company seeking to enter the market.

Website: https://www.furnart-gh.com/product/

Year incorporated: 1974 | **Location(s):** One, Osu-Accra

Product(s): All types of furniture: chairs, sofas, tables, desks, doors.

Target Market: High-income earners. Furnart customizes artistic furniture for homes, offices, commercial spaces, restaurants and religious settings.

Product Positioning: The company was established by two leading families in Ghana, Omaboe and Quarcoopome, in partnership with an Italian furniture designer, Benjamino Stephani.

Management Structure: Family-owned and operated.

Sand Plastic Composites

In addition to Corec, Polysand and IBF Ghana are presented.

Africa Example
Company name: Corec
Year incorporated: 2013 | **Location:** Nairobi, Kenya
Product(s): Plastic roofing tiles, fencing posts, plastic lumber, pavement blocks, walkway slabs, manhole covers, etc. Key products are COREC Resin roofing tile and Fencing Posts


Plastic fencing


Walkaway Slabs


Plastic roofing tile


Plastic lumber

Target Market: Developers who need quality and affordable construction materials. It targets locals including individual home builders, county government contractors, and private real estate developers. Current key competitors include producers of concrete tiles, clay tiles and iron roofing sheets.

Markets: Ethiopia, Kenya, Namibia, Nigeria, Rwanda, Somalia, South Sudan, Tanzania, United Republic of Zambiaxxxii.

Number of employees: 300 jobs have been created since their launch in 2013

Production/turnover: 1,000 tonnes of plastic waste from landfills have been recycled

Business model: Revenue is generated from the sale of the company's four key products: fencing posts, lumber planks, roofing tiles and machine fabrication.

Traction: Production capacity – recycling 560 tons of plastic waste annually. Established a customer base of 2,000 clients. Developed a product portfolio of relevant and quality products. Set up a production plant.

Competitive Advantage

- Environmentally friendly products
- Project Management package
- Quality products
- Experience and expertise
- Budget friendly

Revenue Forecast

2018	2019	2020
84m KES ($811k)	104m KES ($1m)	129m KES ($1.2m)

Funding

The National Environment Trust Fund (Nefund) awarded COREC KES 50,000,000 (about $483k) as part of their Green Innovations Award III. This was used to purchase equipment and machinery, business expansion and marketing activities. As at that period, COREC had 15 employees. Listed on VC4A (a global startup community connecting entrepreneurs creating innovative and scalable businesses with the knowledge, network and funding they require to succeed). Listed on Global Opportunity Explorer. The Global Opportunity Explorer is a joint project of Sustainia, DNV GL, and the UN Global Compact, created on the conviction that the SDGs offer a myriad of business opportunities with great value to companies, society, and the environment.

Company name: Polysand

Website: http://www.polysand.ca/index.html

About: Manufacturer of synthetic roofing tiles and driveway pavers.

Year incorporated: In/Before 2013

Location(s): Vaughan, Ontario, Canada.

Product(s): Paving stones, bricks.

Pavers: Polysand pavement slabs are made of a mixture of sand, recycled polymers and high quality color and protective additives. Over 70% of the paver is sand. It can withstand temperatures from -60C to +80C degrees. The weight of one brick is only 2 pounds. It is 3 times lighter than a concrete brick. Composite Material: Products are made from Polysand™ which is an innovative material that has been developed with the advent of new technologies and development of polymer recycling industry. Roofing tiles are made using carefully separated recycled polymers and fillers.

Target Market: Likely local construction companies and individual home builders.
Retail Strategy: Comprehensive information available on their website with technical specifications on pavers and roofing shingles, mainly useful for building contractors with this technical knowledge.

Production/turnover: 0.82M USD- 5.6M CAD

Company name: IBF Ghana LTD
Although IBF does not use sand-plastic composites in its production. It gives an example of a commercial scale company that will be competing with any company that begins production of similar products with sand-plastic composites.
Website: https://www.ibf.dk/gh/ibf-ghana
Year incorporated: 2013

Location(s): Kpone, Tema

Product(s): IBF Ghana LTD is producing concrete products such as paving stones, curbs, patio´s, water/slurry tanks etc.

Positioning: Deliver high quality products helping to develop the infrastructure in Ghana as well as developing the local society by supporting with employment of local staff helping with running our plant.

End Notes

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