The oil Palm tree: A renewable energy in poverty eradication in developing countries

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ABSTRACT

This paper highlights the role of the oil palm tree (Elaeis guineensis) as a renewable energy in poverty eradication in developing countries. Many uses of the oil palm are known. This paper describes the processing of palm oil fruits for the extraction of both palm oil and palm kernel oil at the small-scale level. Palm oil and palm kernel oil are the primary major products of the oil palm tree. These oils also are raw materials for the production of a variety of products such as cooking oils, biodiesel, edible fats in the confectionery and bakery trades, ice-cream, mayonnaise, toilet soap, powder detergents, pomades, candles, etc. The palm kernel cake is a major ingredient in the livestock feed manufacture. Palm wine, an alcoholic beverage produced from the sap obtained by the tapping of the male inflorescence is sweet when fresh and sugar can be produced from it. Gin is distilled from the fermented wine. The trunk and the leaflet of the tree are also used for the production of various materials. The sale of all these products of the palm tree will yield cash (money) and social recognition for the oil palm tree farmer. It is also argued that adequate support from the government in terms of research in oil palm, training of farmers, provision of processing facilities, and social amenities will help to promote the quality of products and increase the earnings of the oil palm farmers and processors. In order to attract the land-less farmers, incentives are should be offered to them in the shape of land and seeds at an affordable price. They should also be provided road approach, drinking water facility, low cost sanitation, primary education, basic health facilities, oil extraction mill and market to the nearest township to enable them to sell the fruit, seed, oil and inter-cropped vegetables. These facilities if provided would be result oriented, functional and economically viable thereby eradicating poverty in the society.

Keywords: Palm oil tree; variety of products

INTRODUCTION

The oil palms (Elaeis) comprise two species of the Arecaceae, or palm family. They are used in commercial agriculture in the production of palm oil. The African oil palm tree (Elaeis guineensis jacq.) is native to West Africa, occurring between Angola and Gambia, where it grows in the wild and later was developed into an agricultural crop. While the American Oil Palm Elaeis oleifera is native to tropical Central America and South America.

Oil palm is a tropical crop now grown mainly in Southeast Asia and Western and Central Africa. Oil palm plantations were first established in Malaysia and Indonesia in the early 20th century, together with others in Africa, particularly in Nigeria, Cameroon and the Congo. Oil palms need a tropical climate with plenty of sunshine, rain and year round temperatures of 25-28°C. New leaves appear less frequently at lower temperatures, and as a bunch of fruit is produced by flowers formed at the base of each leaf, this means fewer flowers and lower yields. Oil palm plantations are best sited on deep, fertile, well drained soils. A flat terrain is preferable to avoid soil erosion and for easier harvesting and transportation of the fruit. Oil palms leaves emerge from a single growing point on top of a straight trunk (stipe), without branches, often growing 20m tall. Fifteen to 20 leaves emerge each year with separate male and female flowers arising at the base of each leaf. The flowers are produced in dense clusters; each individual flower is small, with three sepals and three petals. The fruit takes five to six months to mature from pollination to maturity; it comprises an oily, fleshy outer layer (the pericarp), with a single seed (kernel), also rich in oil. Unlike other relatives, the oil palm does not

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produce offshoots; propagation is by sowing the seeds. Oil palm fruit are like large reddish plums; clustered in large bunches weighing 10-40 kg. Bunches are continuously harvested as they ripen on each tree every 7 to 10 days. Individual fruit comprise the outer fleshy pulp (mesocarp) around a nut, inside which is a kernel. Palm oil is extracted from the pulp of the fruit and palm kernel oil from the kernel. Ten times more palm oil is produced than palm kernel oil and their major components are palmitic and lauric acids, respectively. Each ripe bunch is commonly known as Fresh Fruit Bunch (FFB). The oil palm is the most efficient oil-bearing crop in the world, requiring only 0.26 hectares of land to produce one tonne of oil while soybean, sunflower and rapeseed require 2.22, 2 and 1.52 hectares, respectively, to produce the same.

Oil palm now covers more than 12 million ha, a 50% increase over the past 10 years. Three countries account for about 80% of the cropped area: Malaysia, Indonesia and Nigeria (Fig.2). Each harvest similar areas, but yields are 7-8 times greater in S.E. Asia than Africa. Oil palm is both economically and socially important to these countries.

Fig.2: Global oil palm distribution (FAO, 2004 statistics)

Oil yields from oil palm are more than five times that of other vegetable oil crops (Fig.3 and Fig. 4). This is because unlike annual crops like soybeans, rape (canola) and sunflower, or the similarly perennial crop olives, which are harvested once a year, oil palms are harvested throughout the year and benefit from the strong equatorial sunlight and ample soil moisture.

Fig.3: Global vegetable oil production (USDA, 2005)

Oil palm is No.1. It is official; the US Department of Agriculture (USDA, 2005) calculates that global production of palm oil has now overtaken soybean oil to be the world’s leading vegetable oil. Palm oil has a plethora of food and industrial uses. Many nutritional health experts believe that palm oil has several important benefits, particularly in lowering the risk of heart disease. The high yields of palm oil have attracted the interest of producers of ‘biodiesel’, a more environmentally sound alternative fuel based on renewable resources rather than inevitably diminishing petroleum reserves. Some say that the rise of oil palm has come at a price. They claim that expanding areas of production are bound to result in the further destruction of tropical rainforests, removing an invaluable carbon sink, destroying habitats, so reducing biodiversity, and causing severe soil erosion on sloping terrain. Oil palms are grown for their clusters of fruit, which can weigh 40-50 kg. Upon harvest, the drupe, pericarp and seeds are used for production of soap and edible vegetable oil; different grades of oil quality are obtained from the pericarp and the kernel, with the pericarp oil used mainly for cooking oil, and the kernel oil used in processed foods. The pericarp is also used as a food ingredient itself such as in the Middle African palm butter, moambe. For each hectare of oil palm, which is harvested year-round, the annual production averages 10 tonnes of fruit, which yields 3,000 kg of pericarp oil, and 750 kg of seed kernels, which yield 250 kg of high quality palm kernel oil as well as 500 kg of kernel meal. Palm fronds and kernel meal are processed for use as livestock feed. Some varieties have even higher productivities which have led to their consideration for producing the vegetable oil needed for biodiesel. Palm oil and its fractions are practical and attractive choice for importers and food manufacturers, especially in 3rd world countries due to its price competitiveness, year-round supply, diversity and versatility for edible and non-edible applications.

Palm oil and palm kernel processing.

Processing oil palm fruits for edible oil has been practiced in Africa for thousands of years, and the oil produced, highly coloured and flavoured, is an essential ingredient in much of the traditional West African cuisine. The traditional process is simple, but tedious and inefficient. Palm oil is rich in carotenoids, (pigments found in plants and animals) from which it derives its deep red colour, and the major component of its glycerides is the saturated fatty acid palmitic; hence it is a viscous semi-solid, even at tropical ambient, and a solid
fat in temperate climates. The individual fruit, (Fig. 5) ranging from 6 to 20 gm, are made up of an outer skin (the exocarp), a pulp (mesocarp) containing the palm oil in a fibrous matrix; a central nut consisting of a shell (endocarp); and the kernel, which itself contains an oil, quite different to palm oil, resembling coconut oil.

Table 1: Ideal composition of palm fruit bunch

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bunch weight</td>
<td>23-27 kg</td>
</tr>
<tr>
<td>Fruit/bunch (%)</td>
<td>60-65 %</td>
</tr>
<tr>
<td>Oil/bunch (%)</td>
<td>21-23 %</td>
</tr>
<tr>
<td>Kernel/bunch (%)</td>
<td>5-7 %</td>
</tr>
<tr>
<td>Mesocarp/bunch (%)</td>
<td>44-46 %</td>
</tr>
<tr>
<td>Mesocarp/fruit (%)</td>
<td>71-76 %</td>
</tr>
<tr>
<td>Kernel/fruit (%)</td>
<td>21-22 %</td>
</tr>
<tr>
<td>Shell/fruit (%)</td>
<td>10-11 %</td>
</tr>
</tbody>
</table>

However, such high yields are rarely achieved in practice because climatic conditions are usually less than ideal. Rainfall is erratic in Central and West Africa and hence the tree suffers water-related stresses. The management of costly inputs of labour, imported fertilizers, pesticides and harvesting machinery, is also a difficulty that hampers the yield of plantations. Plantation farming is a new phenomenon to West African culture. In most parts of Africa the farm culture is basically subsistence. The family cultivates a small plot for their food needs and interplant tree crops. After three years or more the tree crop takes over the plot and the farmer moves to another. The new plot may be acquired from the Chief in a location far removed from the old plot. Farm-holdings are therefore small and scattered. The land tenure system does not permit large-scale farming unless the government steps in to acquire the land for public use. Thus it is difficult to think of one family owning a large contiguous estate suitable for plantation farming. A small-scale palm oil farm may cover 7.5 hectares. The farm’s production of fruits may be processed by the farmer, using the traditional method of palm oil extraction, or sold to other processors. During the lean season the farmer sells to the small-scale processors at prices higher than those offered to the larger mills. The small-scale farms are normally well maintained even though they may not adopt modern agronomic practices such as application of fertilizer, cover cropping, etc. to improve soil fertility and yields. Palm fruit contains about 56 percent oil (25 percent on a fresh fruit bunch basis) which is edible with no known toxins. It is thus suitable for small-scale processing. Harvesting involves the cutting of the bunch from the tree and allowing it to fall to the ground by gravity. Fruits may be damaged in the process of pruning palm fronds to expose the bunch base to facilitate bunch cutting. As the bunch

In the palm oil milling process, the oil palm fruit bunches are transported after harvesting from the palm trees to the oil palm mill. The palm fruit bunches are split into four or six smaller pieces and left for some days to ferment so that the whole palm fruits can easily come off from the split bunches. The palm fruits are sieved from the sepals and loaded into a large cooking vessel (sterilizer) where they are cooked overnight. Cooked whole palm-nut fruits are removed from the vessel with a metal bucket and transferred into a digester. The fruits are digested into whole nuts, pulp, husks (fibre), and free flowing palm-oil. Hot water is added to the digester as necessary. The palm-oil is scooped off while the mixture of nuts, pulp, and husks are transferred to a mechanical “presser” where pressure is applied to extract or recover palm-oil and liquid effluent. The nuts and husks are removed from the presser for separation after which the husks can be returned to the presser to further extract or recover more palm-oil. The husks are separated from the nuts and nuts are left to dry after which the nuts are transferred to the nut cracker or “sheller” which cracks the nuts into kernels and shells. The dried husks and kernel shells and empty bunches are used as fuel for the cooking of whole palm-nut fruits and for boiling the water used for processing. The Figures 6 to 12 below show the stages of oil palm processing in Nigeria.
There are two distinct methods of extracting oil from the digested material. One system uses mechanical presses and is called the ‘dry’ method. The other method uses hot water to leach out the oil. The main point of clarification is to separate the oil from its entrained impurities. The fluid coming out of the press is a mixture of palm oil, water, cell debris, fibrous material and ‘non-oily solids’. Because of the non-oily solids the mixture is very thick (viscous). Hot water is therefore added to the press output mixture to thin it. The dilution (addition of water) provides a barrier causing the heavy solids to fall to the bottom of the container while the lighter oil droplets flow through the watery mixture to the top when heat is applied to break the emulsion. Small-scale mills simply pack the dried oil in used petroleum oil drums or plastic drums and store the drums at ambient temperature. The residue from the press consists of a mixture of fibre and palm nuts. The nuts are separated from the fibre by hand in the small-scale operations. The sorted fibre is covered and allowed to heat, using its own internal exothermic reactions, for about two or three days. The fibre is then pressed in spindle presses to recover a second grade (technical) oil that is used normally in soap-making. The nuts are usually dried and sold to other operators who process them into palm kernel oil. The oil mills use the recovered fibre and nutshell as fuel to fire the boilers. The oil palm tree yield is distributed over the entire year. Most of Central and West Africa experience two rainfall seasons. The oil palm bears fruit in response to the rainfall pattern and hence there are two peak harvesting periods in these regions. The best plant size option for rural Africa is still unknown. Today decentralised small-scale processing operations are preferred in most parts of Africa. Another limiting condition is the affordability of capital equipment. Where the capital equipment cost exceeds a certain value villagers will shy away from taking loans to purchase the combination of operations. “Small-scale” does not necessarily mean a significant decrease in efficiency. It does, however, mean a reduction in working capital and operating costs. The small mills can be placed at the heart of local communities, minimising reliance on vehicular transport that is normally unavailable in rural communities, given the poor condition of road networks and other infrastructure. This increased accessibility serves to dramatically reduce fruit spoilage and consequent post-harvest losses. Culturally, men cultivate or produce while women process and sell. Traditionally, women decide the form in which the produce is to be traded and hence determine the degree of processing they are willing to undertake.

Palm kernel oil extraction

Traditional method of palm kernel extraction

Palm kernel extraction is a specialised operation undertaken by a completely different set of processors. They are usually better organized as a group and are not as dispersed as palm oil processors. The kernel processors have to go around the palm oil processors during the peak season, when prices are lowest, to purchase the nuts for drying. The nut processing and oil extraction is undertaken in the dry season when the pressure to obtain raw materials has subsided. The traditional palm oil processing starts with the shelling of the palm nuts. The shelling used to be performed using two stones to crack each nut and separating the kernel and shell simultaneously. This manual operation has been largely superseded by the use of nut-cracking stations. The mechanical nut-crackers deliver a mixture of kernels and shells that must be separated. The kernel/shell separation is usually performed in a clay-bath, which is a concentrated viscous mixture of clay and water. The density of the clay-bath is such that the shells sink while the lighter kernels float to the top of the mixture. The floating kernels are scooped in baskets, washed with clean water and dried. Periodically, the shells are scooped out of the bath and discarded. The traditional oil extraction method is to fry palm kernels in old oil or simply heat the dried nuts. The fried kernels are
then pounded or ground to a paste in a motorised grinder. The paste is mixed with a small quantity of water and heated to release the palm kernel oil. The released oil is periodically skimmed from the top. In Nigeria, most villages do not have stations that will accept well-dried kernels for direct extraction of the oil in mechanised, motorised expellers. Palm oil and palm kernel oil are the primary major products of the oil palm tree. These oils also are raw materials for the production of a variety of products such as cooking oils, margarine, biodiesel, edible fats in the confectionery and bakery trades, ice-cream, mayonnaise, toilet soap, powder detergents, pomades, candles, etc. The palm kernel cake is a major ingredient in livestock feed manufacture. Palm wine, an alcoholic beverage produced from the sap obtained by the tapping of the male inflorescence is sweet when fresh and sugar can be produced from it. It is an important source of yeast and vitamin B complex. Gin is distilled from the fermented wine. The trunk and the leaflet of the tree are also used for the production of various materials. The trunk is sawn into timber and used in the construction of fences, roofing, as pillar beams and in reinforcing buildings. It is also used as fuel for cooking and heating. The leaflet are used in making thatch for roofing houses, the leaf rachises are used for fencing, reinforcing buildings and in basket making. The mid-ribs of the leaflets are used for brooms while the palm cabbage, soft around the apical bud, serves as a delicacy. The fibrous pulp inside the bunch is used in making foot mat. The bunch refuse which is left after the fruits have been removed from the bunch is a rich source of potassium. The bunch is burnt and used in the manufacture of local soap. Bunch refuse is effective organic manure being very rich in potassium and is less expensive to apply as raw or composted refuse. The fibre residue left after the oil extraction from the fruits is used as fuel. The shell from the cracked palm nuts are used as aggregates in foundation of local buildings and for the flooring of houses.

Other uses of palm oil

African palm oils have non-edible uses which are of great economic value and can be used as a substitute for petroleum. Palm and kernel oils are used in the production of oleochemical products such as fatty acids, fatty esters, fatty alcohols, which all contain glycerol and fatty nitrogen. Recently, palm and kernel oils have been increasingly used as biodiesel fuel. Non-edible uses of palm oil include: Soaps and detergents, Candles, Cosmetics, Lubricating greases for machinery used in the production of edible foods, Grease for bread molds and bread making equipment, Grease used to protect tanks, pipelines and similar instruments which Remain uncovered and in the open air, Drilling mud for the petroleum industry, Epoxidated palm oil used to plastify and sterilize products in the plastics industry, in particular during the production of PVC, Glue, Printing inks, Biodiesel, Metallic soaps for the manufacture of lubricating grease and metallic dryers, Steel cold rolling processes, Tinplate rolling, and Acids to lubricate fibers in the textile industry. Palm oil contains much more saturated fat (around 40% palmitic acid) than other vegetable oils. Unlike other vegetable oils, it is a solid at room temperature and less susceptible to turning rancid. These properties make palm oil increasingly valuable edible oil for use in cooking and food processing. It is used as a frying oil, to make margarine, is a dairy substitute and is a component of many processed foods. Palm kernel oil is also used for frying and as a salad dressing. Both palm oil and palm kernel oil are sources of basic chemicals such as olefins (alkenes) and have uses in manufacturing lubricants and detergents. In 2005, Proctor and Gamble announced a substantial move towards greater use of palm oil as a source of surfactants for its detergents and shampoos. Palm oil is rich in anti-oxidants, such as carotenoids (vitamin A), giving it a reddish color, and tocopherols and tocotrienols (forms of vitamin E). It also has what is now generally considered a very valuable blend of saturated, monounsaturated and polyunsaturated fatty acids, which give it an important dietary role.

Nutrition experts now recognize three types of fats or oils detrimental to health if eaten in amounts in excess of normal requirements: saturated fats, cholesterol, and now, trans fats. Too much of these types of fat cause heart disease. Saturated fats and cholesterol are typically found in meat and dairy products. Vegetable oils contain mixtures of unsaturated fats which in appropriate amounts are known to be beneficial to health.

Biodiesel

The second most common liquid biofuel is biodiesel, which is made primarily from oily plants (such as the soybean or oil palm) and to a lesser extent from other oily sources (such as waste cooking fat from restaurant deep-frying). Palm oil is a very good source of biodiesel because of its very high yields. Biodiesel is produced by the trans-esterification of vegetable oils. This results in biodiesel (methylated fatty acids) and glycerol as a by-product. Many countries have mandatory targets for the inclusion of biodiesel as an additive to petroleum-derived diesel. Using the standard notation, B5, for example, refers to a fuel with 5% biodiesel added. Compared to regular diesel, biodiesel gives much lower emissions of carbon monoxide, carbon dioxide, aromatic (benzene-like) hydrocarbons, particulates and emits no sulfur. Oxides of nitrogen are similar if engines are fitted with catalytic converters. An oil palm plantation can produce more than 6000 liters/ha of biodiesel compared to only about 500 liters/ha of soybean and 1000-1500 liters/ha of other arable oilseeds. The Malaysian Palm Oil Council (MPOC) feels that palm oil will certainly qualify as second generation biofuel in reducing carbon dioxide emission by more than 80 per cent, with a little more fine-tuning in its processing technology. Using palm oil as a biofuel is more environmentally friendly and it’s more advantageous than other combustible fuels such as petrodiesel and standard petrol. Using palm oil as a biodiesel brings benefits and is environmentally friendly. It also generates employment and contributes to the demand for renewable energy sources. “Biodiesel markets are now opening up and it will help create more demand for palm oil. In doing so, palm oil planters will be blessed with good demand which will help prices to stabilise at a remunerative level.

Other Oil Palm Products

The oil palm has many uses, and is made into many things. The tree provides sap for wine. The sap is very sweet and contains
little alcohol in the morning when it is first taken from the tree. It then continues to ferment throughout the day. Marketing Palm Wine Tappers usually sell their sap to women who are in business. The palm wine continues to ferment through the whole day, so it is sour by afternoon, and not possible to save for the following day. Gin is usually distilled from the fermented sap. Oil palm is a tree of great antiquity, for in the most expensive method of embalming the dead, the ancient Egyptians used the sap of the tree, that is, palm-wine for rinsing the abdomen after the intestines had been extracted through an incision, five inches long, made in the left side of the body. The strips of branches can be used to make mats, skirts, fences, or drying racks to dry the cocoa, pepper, fish, etc or many other woven items. The string can be used to make palm skirts used by local masquerades and dancers or it can be used to tie together mats that are used to dry other farm produce. In fact the uses of this tree are many, supplying such necessaries as food, drink, clothing, timber for building, light, fuel, a powder similar to fuller’s earth, drugs, materials for roofing huts, and making baskets, mats, fishing-nets, brooms and ropes. In addition to oils extracted from the oil palm fruit, other parts of the tree can be used in industry. For example, leaf fibers and empty fruit bunches are used to produce chipboard and plywood. After plantations are cleared out, the trunks of old palms can be used to make furniture. Even after the tree is used to make palm wine by draining all the sap, it does not stop being productive. After all the sap is tapped, and all the branches removed, the tree is allowed to rot. In the rotting palm tree, a special kind of grub grows — it is the larval stage of the rhinoceros beetle. Harvested, the grubs can be fried, and alone they are delicious, tasting much like shrimp. They can also be put in soups and stews.

About the time of the first rains each year, a particular mushroom grows only in the rotting (usually red) soil left by the disintegrating tree. It is delicious, and highly prized. There is extensive information in the literature about medium- and large-scale palm oil processing, as well as about traditional technologies in Africa, but information on small-scale mills is scarce. Modern processing of oil-palm fruit bunches into edible oil in Africa is practiced using various methods, which may be grouped into four categories according to their throughput and degree of complexity. These are the traditional methods, small-scale mechanical units, medium-scale mills and large industrial mills. Generally, processing units handling up to 2 tonnes of fresh fruit bunches (FFB) per hour are considered to be small-scale. Installations that process between 3 and 8 tonnes FFB per hour are termed medium-scale, while large-scale refers to mills that process more than 10 tonnes per hour. At the outset it must be stated that small-scale palm oil processing in the sub-region has systematically acquired sophistication, efficiency and reliability. The traditional methods of extracting palm oil were inefficient and tedious for making oil for sale. Generally women in the villages are responsible for the processing and sale of farm produce. Small-scale agro-processing seems to hold the key to rural poverty reduction and the prolific oil palm tree provides the best raw material for starting rural industries.

A by-product of palm oil extraction is the palm nut which, when cracked, yields a kernel containing a completely different kind of oil which can be used as a valuable substitute for cocoa butter. Charcoal made with the inner kernel shells is very clean and hot burning, and is very popular with blacksmiths. Unfortunately not many palm oil processors include palm kernel extraction at the same location. It is more usual that a completely different group undertakes palm kernel extraction.

**Oil-Palm fronds as a roughage feed source for ruminants**

Oil-palm fronds are available daily throughout the year when the palms are pruned during the harvesting of fresh fruit bunches for the production of oil. Currently, oil-palm fronds are left rotting between the rows of palm trees, mainly for soil conservation, erosion control and ultimately the long-term benefit of nutrient recycling. The large quantity of fronds produced by a plantation each year make these a very promising source of roughage feed for ruminants. A major reason for the slow growth of the ruminant industry in Nigeria is the lack of good-quality feed resources. Oil-palm fronds can be used as a substitute for grasses in cases where forage or fodder is a limiting factor. The recommended level of oil-palm fronds in the total mixed rations (on a dry matter basis) are 50% for beef cattle, and 30% for dairy cattle and goats. The ruminant sector in particular is well suited to maintaining competitiveness through the use of plantation and processing by-products (Abu Hassan et al. 1995). Of the commercial plantation crops, oil palm produces the most abundant biomass, and oil palm fronds have been shown to be a very promising source of roughage feed for ruminants. Oil-palm fronds belong to the category of fibrous crop residues, which also includes by-products such as rice straw. Previous studies comparing oil-palm trunks as a roughage feed (Oshio et al. 1990) with rice straw supported the use of the oil-palm materials as a source of roughage for ruminants, as did a long-term feeding trial of oil-palm trunks for beef production (Abu Hassan et al. 1991).

There are numerous opportunities within the palm oil sector in which small-scale producers can add value to palm sap through product diversification, technology improvements and enhanced market access. Production of palm sap sugar is one of them. The income of oil palm tree farmers could be several times higher if they tap the tree and process the sap into sugar rather than depend only on its fruit and sap. Charcoal making, handicrafts are some of the large number of traditional products that could be derived from palm fruits and trees. It is a “no-waste tree” as even its waste products provide ample opportunity to augment farmers’ income. The midribs, twigs, spathe, leaves are also now being utilized in the manufacture of handicrafts which can form export products from developing countries.

**Social and Environmental impacts**

The social and environmental impact of oil palm cultivation is a highly controversial topic. There are multiple sources highlighting the positive and negative aspects of this industry. Oil palm is a valuable economic crop and provides a major source of employment. It allows many small landholders to participate in the cash economy.
Demand for palm oil has increased in recent years due to its use as a biofuel, but recognition that this increases the environmental impact of cultivation as well as causing a food vs fuel issue has forced some developed nations to reconsider their policies on biofuel to improve standards and ensure sustainability. Converting agricultural land to oil palm planting brings about many positive benefits for the environment such as reducing soil erosion.

**Treatment of solid waste products**

In a well run palm oil mill, it is expected that each 100 tonnes of FFB processed yields 20 to 24 tonnes of crude palm oil and about 4 tonnes of palm kernels. Thus between 72 to 76 percent of the FFB comes out at various stages of the process as waste. The solid wastes that result from the milling operations are: Empty fruit bunches, palm fibre, and palm kernel shell. In the large- and medium-scale mills these waste products are all put to economically useful purpose. They could therefore be referred to as by-products rather than waste products. Wet, empty bunches are partly dried in the sun and later used as fuel. Another economic use for the empty bunches is to return them to the plantation as a mulch to enhance moisture retention and organic matter in the soil. The palm kernel shell is also used as a source of fuel for the boilers. Unfortunately the shell contains silicates that form a scale in the boilers if too much shell is fed to the furnace, thus limiting the amount of shell that can be utilised in the boilers. Residual shell is disposed of as gravel for plantation roads maintenance. Blacksmiths also buy the shells to use as fuel material in their casting and forging operations. Palm nut shell is also used in the preparation of pozzolana, a cement substitute material that has been developed by the Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. The fibre recovered from the nut/fibre separation stage is a good combustible material and finds ready use as fuel to boil the fruit. Boiler ash is recycled as fertilizer and factory floor cleaning agent. The potash in the ashes reacts with the oil to form a weak potash soap that is washed away with water. Small-scale mills also use the fibre and bunch waste as fuel material. Most small-scale mills do not undertake the shelling of recovered palm nuts. The nuts are sold to palm kernel processors. Small-scale palm kernel processors use clay baths to separate kernels from shells. The shells are normally left in a pile to dry. Some of the shells are used for fuel but there are always residual amounts found around the palm kernel processing centres. Periodically the pile is removed and used as landfill. Wood consumption of small-scale operations is relatively small because of the recycling of the fibre and bunch waste as the main fuel source.

**CONCLUSION**

Oil palm is a versatile crop with many uses besides those of its two oils. These include wood for furniture and biomass for energy generation from the trunk; fiber for boards and paper, and animal feed and fertilizer from the remnants of the bunches after oil extraction. However, the oils themselves are the most valuable commodities. Despite being one of the world’s producers of palm oil, Nigeria has to spend a large chunk of its hard-earned foreign exchange on the import of edible oil every year. It is recommended that groups of willing farmers of oil palm should be sent to Malaysia on government expenses to provide them on job training regarding plantation, harvesting, oil extraction and other commercial use of oil palm. This is mainly intended for small farmers and identification of whom will be the joint responsibility of the society and concerned government department. In order to attract the land-less farmers, incentives are should be offered to them in the shape of land and seeds at an affordable price. They should also be provided road approach, drinking water facility, low cost sanitation, primary education, basic health facilities, oil extraction mill and market to the nearest township to enable them to sell the fruit, seed, oil and inter-cropped vegetables. These facilities if provided would be result oriented, functional and economically viable thereby eradicating poverty in the society.

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