



Impacts of Ebola on Supply Chains in MRB Countries: Using Liberia as a Case Study

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Abstract

The purpose of this paper is to present a science-based narrative of the impact of the Ebola Virus Disease (EVD) on the supply chains of the major commodities of Liberia. Scientific literatures from appropriate journals, newspapers, trade data of applicable ministries and governmental agencies, data on Ebola from websites of World Health Organization (WHO), Food and Agricultural Organization (FAO), Center for Disease and Control and Prevention (CDC), World Bank, the International Monetary Funds (IMF) and other relevant institutions are used extensively while also employing a market chain approach to represent the overall supply chains of these products. The review reveals, among others, the significant disruption to the flow of goods and the decrease in output of the main export commodities of Liberia. It also shows a fall in real GDP growth rate of the Mano River Basin (MRB) countries during the Ebola years. The paper identifies that the specific mechanisms through which the supply chains were disrupted were as a result of fear and government's regulation. Additionally, it provides a practical conduit for the diversification of the rubber industry. Given the complex web of supply chains of just a single product, this effort is in no way an exhaustive review on the impact of the EVD on supply chains of commodities dealt with herein, let alone the overall impact of EVD on the country as a whole. Obviously, this review is also limited in terms of scope and extent. This review is a useful introduction to investigators who might want to commit to research in this particular aspect of the impact of the EVD vis-a-vis its impact on supply chains in Liberia or on a broader level, the MRB Countries.

Key words: Liberia, Ebola, Supply Chain, GDP, Market Chain, Mano River Union

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Introduction

Many researches have been conducted on the Ebola outbreak of Mano River Basin countries including Liberia. Most have focused on the medical and health aspects of the disease (Gizelis et al. 2017; Elmahdawy et al., 2017; Painter et al., 2017, Gee & Skovdal, 2017; etc.) while some such as (Bowles et al, 2016; Adegun, 2014; Bonwitt et al., 2018, etc.) concentrate on the economies and livelihood. However, there are very few,

if any, publications on the impact of Ebola on supply chains of major products of any of the Mano River Basin let alone Liberia. With the abundance of raw materials, Africa is expecting a vibrant economy success evidenced by its rapid growth rate. However, due to the fact that economies in Africa have not matured enough to withstand severe shocks caused by natural disasters, it is no coincidence that the disease had a devastating consequence on the supply chains of the main products of the MRB. Therefore, this paper aims to present a concise but precise narrative of the disruption to the supply chains of the most important products from Liberia during the Ebola outbreak. This article focuses on and provides a vivid picture of the impact the virus disease had on the distribution of specific goods in the supply chains. This paper is one of the few that combines the keywords: Ebola Virus Disease and supply chains with respect to Liberia. The idea of supply chains and their disruptions is a whole lot complex and dynamic phenomenon and as such this paper does not claim to have the final sayings but rather it could serve as an introduction for any further investigations into this particular aspect of the impacts of the disease which are highly recommended. As (Webster and Watson, 2002) puts it “An effective review creates a firm foundation for advancing knowledge, facilitates theory development, closes areas where a plethora of research exists, and uncovers areas where research is needed”, this narrative is therefore a foundation that answers, in very few words, specific questions such as “What factors lead to the rapid spread of this particular EVD outbreak that became the most catastrophic EVD outbreak to date? What was the responses of the government, businesses and the general populace? How did these responses disrupt supply chains of the main products?” all of which, from supply chains risks management perspective, sum up to the more basic question “By what means was supply chains of major products disrupted in Liberia during the EVD outbreak?” Not only did this narrative answer this fundamental question but also it opens several research directions into supply chains disruptions caused specifically by the EVD, or in a broader sense, diseases which spread rapidly into urban areas.

Literature Review

The first known EVD outbreaks occurred in 1976 consecutively in the Democratic Republic of Congo (formerly Zaire) in a village near the Ebola River, which gave the virus its name and South Sudan with mortality rates of 88% and 53% respectively, with a total of about 500 cases (Muyembe-Tamfum et al., 2012). There have been recurrences of the outbreak since 1976, with over 25 occurring mainly in Africa with few cases in Europe and America as well (“Years of Ebola Virus Disease Outbreaks,” 2018). Even with donor’s support in terms of supplies and personnel, it has been difficult to control these outbreaks when they occur in Africa because of the lack of good health infrastructures coupled with factors such as population growth, encroachment into forested areas, and direct interaction with wildlife (such as bush meat consumption, including the African fruit bat (Goldstein et al., 2018; Li et al., 2016). For the Mano River Basin area, there were extra factors that exacerbated the EVD outbreak. Among others, there were the fact that some of the preventive methods were in direct conflict with prevailing cultural and traditional attitudes in West Africa towards friends and sick family members, the unprecedented circulation of EVD into crowded urban areas, and increased mobilization across borders. For example, direct contacts such as shaking hands, hugging, the ceremonial bathing of the dead were the culprits for main factors that lead to the rapid rise of infection rates during the 2014-2016 West Africa outbreak, as majority of transmission events (74%) were between family members (“History of Ebola Virus Disease,” 2018). Interestingly, it caused changes in behaviors related to mourning and burial, along with the adoption of safe burial practices, that were critical in controlling the epidemic (Baseler et al., 2017). In addition, as seen in Figure1, the disease started around Guekedou in the Republic of Guinea not far from the point where the territories of the three countries meet around March 2014 and by July the same year, it had already spread to almost every part of the MRB region due to the movement of affected persons into heavily populated centers and other reasons that have been expounded on.

Ebola virus outbreaks have been concentrated in Africa with the most recent being the one ongoing in the democratic Republic of Congo, which started in 2018 (“Ebola Virus Disease- Democratic Republic of Congo,” 2018). However, the largest Ebola virus outbreak to date in terms of cases and death is the 2014-2016 occurrence in the MRB countries (Guinea, Liberia, and sierra Leone). On March 23, 2014, the World Health Organization (WHO) reported cases of EVD in the forested rural region of southeastern Guinea and within few months the disease had spread to neighboring Liberia and Sierra Leone and became the largest in

history. In this outbreak, there were more than 28,600 cases and 11300 deaths (Coltart et al., 2017; "Years of Ebola Virus Disease Outbreaks," 2018). During the outbreak, the increasing rate of infection was alarming to the extent that governments instituted stringent measures to curb the menacing rise of deaths and new cases. However, these measures greatly had negative consequences in terms of supply chains activities with a pronounced effect on the economy of the MRB region. Some of these measures included the closure of borders. For instance, in July 2014, Liberia partially closed her borders while Senegal closed its border with Guinea completely disrupting the flow of goods and services. In addition, Sierra Leone and Liberia announced state of emergency further heightening the fear intensity. Furthermore, the rapid rate of infection instill fear in businesses which resulted into firms partially, or in some cases totally, halting their normal activities. For example, (Bowles et al., 2016) reported that 12.5% of firms that were surveyed closed during the Ebola outbreak. According to these authors, cyclic sectors were hit most with 30% of restaurants closed, and 15% of food and drink vendors closed between the pre- and post-Ebola surveys. They reported a closure rate in Montserrado of 20%; this seems very high as compared to Africa-wide business closure estimates of around 4-5% annually (Aga & Francis, 2015). In addition, there was a 47% loss of employees by firms in Montserado between the pre- and post-outbreak surveys and even in less severely affected areas, firms lost 24% of employees between rounds. Also, it was reported by (Adegun, 2014) that seminars and workshops scheduled to take place in the region were cancelled. This author reported that airlines such as the British Airways, Emirates and Asky airlines cancelled flights to Sierra Leone and Liberia and international businesses such as Caterpillar Inc., Canadian Overseas Petroleum Ltd, Dangote, ExxonMobil and Chevron Corporation either pulled out their staffs, suspended or seized work or were contemplating to withdraw.

Unfortunately, the actions taken by governments, firms and individuals together with the unprecedented nature of this specific outbreak greatly impacted on the supply chains of the Mano River Basin. Basically, supply chain consists of a network that provides a link between suppliers and firms for production and distribution of products, and the representation of strategies taken to eventually deliver the goods and services to end consumers/users. In addition, they are influenced by different types of risk including natural disasters (Sodhi & Lee, 2007; Wagner & Bode, 2006). Natural disasters may disrupt supplies and affect the transportation and distribution of goods and services (Sodhi & Lee, 2007). The Mano River Basin Ebola outbreak was a catastrophic event, an event that have a low probability of occurrence but has high impact on supply chain operations (Knemeyer et al., 2009). As a result of the severity of the outbreak and its devastating impacts on the supply chains, the growth rates of the economies in these countries were decimated to negatives in at least one of the Ebola years.

Research and Methodology

The methodology used in arriving at the aim stated above is to collect scientific literatures from appropriate journals, newspapers, trade data of applicable ministries and governmental agencies, data on Ebola from World Health Organization (WHO), Food and Agricultural Organization (FAO), Center for Disease Control and Prevention (CDC), World Bank, the International Monetary Funds (IMF) and other relevant institutions; and use them extensively while also employing a market chain approach to present an approximation of the overall supply chains disruption of these products.

Due to the difficulties in gathering data from the MRB region, there arise instances where discrepancies are observed. Some may not be considerable; however, in other cases they tend to be too significant to be ignored. Therefore, the utilization of multiple databases basically was use to serve two purposes. First, it identified relevant research efforts and helps acquire an extensive body of data. Secondly, it provided a means of correlating and corroborating data using several sources.

In addition, the use of market chains stems from the fact that it enables a better understanding of the mechanisms by which agricultural supply chains and trade have been affected by the EVD outbreak. This approach proves particularly relevant and useful to coherently organize different sets of information on production, trade flows, restriction measures, markets and consumer behaviors (Impact of Ebola, 2016). However, the use of market chains approach also works well for other commodities such as minerals and gemstones. For similar reasons, market chains approach is the option used in this narrative since Liberia's

main economic sectors are mining and agricultural. However, the emphasis is concentrated on outputs during the Ebola years more than any other parameters.

Furthermore, to gain a genuine appraisal of growth or decline in terms of production of a commodity, the method used in this paper is to place emphasis on volumes/quantities rather than actual fiscal values even though the latter is used in some cases where growth is not being projected.

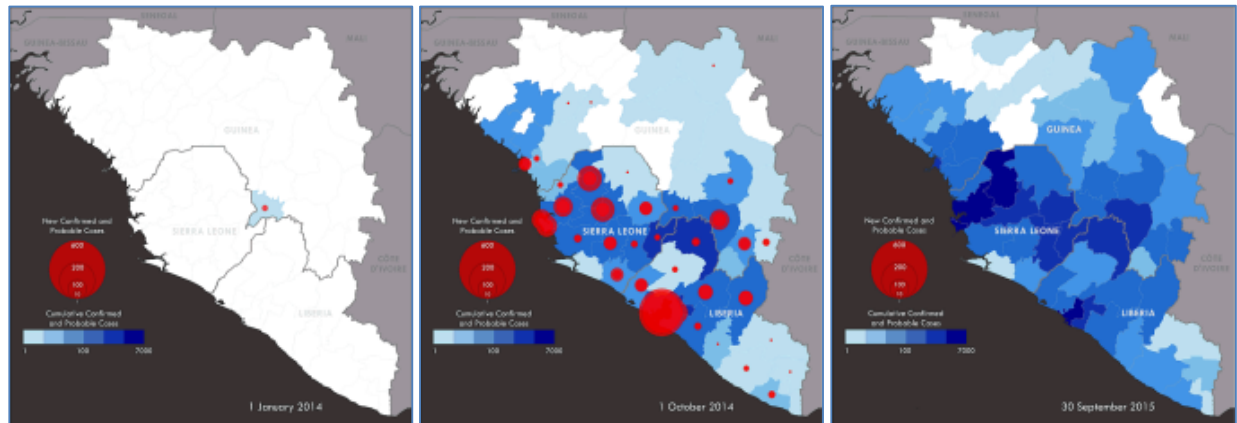


Figure 1: Propagation of the EVD throughout the MRB countries. (World Health Organization)

Result and Discussion

GDP Growth Rate of MRB Countries Before, During and After the EVD

Without extensive details, this section summarizes the real gross domestic product (GDP) growth rates of the Mano River Union countries excluding Ivory Coast for the obvious reason of this country being minimally impacted. The information presented here is to compare the GDP figures during the three periods (before, during and after the EVD outbreak). For detailed narratives on the economy growth of these countries, the reader is referred to reports from the world Bank and the International Monetary Funds.

Liberia

Figure2 shows the real GDP growth of Liberia, Guinea and Sierra Leone from 2008 to 2017 and projected growth rate for 2018 and 2019; this covers the period before, during and after the Ebola outbreak. Just before the outbreak in 2013, the Liberian economy grew at 8.7%, steered by increased production in the mining, construction and service sectors. However, with limited growth in the agriculture sector especially with lower price for the chief agricultural product, rubber, a reduction was expected in the growth rate in 2014. Even though real GDP was projected to expand by 6.8% in 2014 and 8.2% in 2015 (AfDB/OECD/UNDP, 2014), the advent of the Ebola outbreak initiated a downward trend in the growth rate of the GDP in 2014-2016 to a minimum negative value (CBL Annual Reports, 2010-2017; IMF/WEO, 2018; MFDP Annual Economic Review, 2014-2016). This can largely be attributed to the almost complete halt of economic activities in the country. Conversely, the economy rebounded to a growth rate of 2.5% in 2017 an increase of 4.1 percentage point. In fact, it is projected to continuously increase to about 4.7% in 2019. This robust enhancement of GDP growth rate was powered by mining export following a marked increase in gold production along with a buoyant manufacturing sector.

Sierra Leone

As depicted in Figure2, Sierra Leone had a consistent strong growth of an average annual rate of 8.7% over the period from 2008-2014 before the outbreak of EVD. However, in 2015 the economy experienced a sharp decline in GDP as low as minus 20.5% representing the largest decline for the three countries during the Ebola period. Nonetheless, there was a whopping 26.8% rise to 6.3% in GDP growth in 2016 followed by a fall to 3.5% in 2017 with a projected growth rate of 5.6% in 2019. This reduction is largely blamed on a weak recovery in mineral production. For instance, Iron ore production grew by only 5.6% to 6.5 million metric tons compared to an anticipated 9.0 million metric tons. Also, the non-iron ore sector growth rate was lower than

the overall growth rate due to a slowdown in public investments which resulted into drop in construction activities (World Bank-Sierra Leone, 2018).

Guinea

As can be seen in Figure 2, the average annual GDP growth rate of Guinea was lower than those of the two other countries for the beginning from 2008 to 2014 when the outbreak started. However, this average was more or less steady during the outbreak and rose in 2016. This was a surprise as the trends in Liberia and Sierra Leone were much more different with negative growth rate in that same period. Although Ebola stalled promising economic growth in the 2014-15 period and impeded several projects, the momentum in economic growth continued with GDP growth rate of 6.6% in 2016 and 6.7% in 2017, mainly due to agriculture output and public investment boosted economic growth, while the mining sector continued to play a prominent role in economic performance (Guinea Economy Profile, 2018). The projected GDP growth rate 2019 is 5.9%.

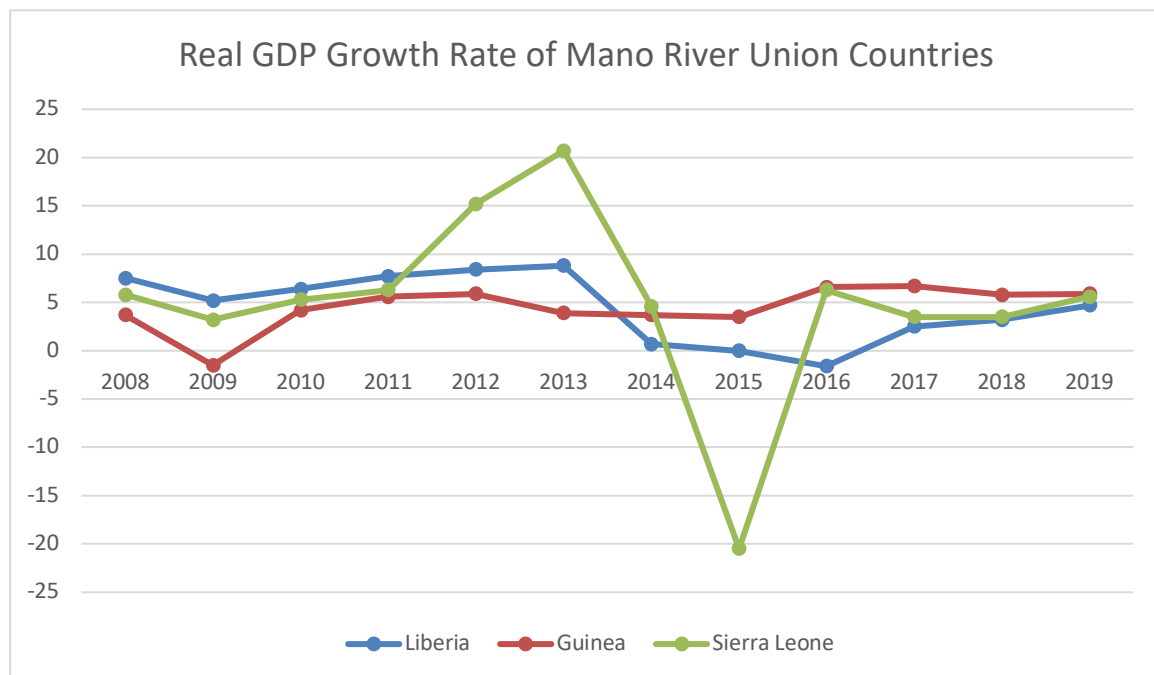


Figure 2: Real GDP growth of Mano River Basin Countries (IMF-WEO, 2018)

Export Products and Major Trade Partners of MRB Countries in 2013, Just Before the Outbreak

In this section, the main products that were exported 2013 from the countries in the MRB are summarized along with the countries to which these products are exported to. Before most African countries traded bulk of their products with their former colonial masters and the MRB countries were no exceptions. However, the situation has changed and now the MRB has a multiplicity of trade partners with the changing dynamics of international trade and geopolitical interests. Therefore, this summary is done on a country by country basis due to the variety in the amount and types of products and trading partners of these MRB countries. There is a significant amount of trade existing among the West African countries but our focus is on the commercial activities with the main raw materials importing countries of the world.

Guinea

The country of Guinea has had a robust trade relationship with France due to the latter being its former colonial master. Even up to today's date, this European country was still the largest trade partner of its former colony in terms of worth of export received in 2013 as revealed in Table 1a. This represented 29.6% of the total. Prominent among the products exported to France were rubber, gold and bauxite (aluminum ore). Next in line was Switzerland. This country was the main recipient of gold export from Guinea. Also, there was a

host of other countries (UAE, USA, Ireland, etc.) that had substantial trade with this West African republic. The total value of Guinea's export was US \$ 1,780,483,526.

Liberia

For its part, Liberia has always had a close economic and political ties with USA. However, China has become a major trading partner of Africa including Liberia. In fact, in 2013 in terms of fiscal value, China was the highest recipient of Liberia's export. This was 23.8% of all exports from the country. It is interesting to note that countries such as France, Poland, and Germany were ahead of the USA in terms of monetary worth of exports received from Liberia as illustrated in Table 2b. This is based on the fact that these countries are chief destinations of iron ore, Liberia's main export product. Nevertheless, America still received bulk of the rubber and rubber products exported from Liberia. The country accrued the total amount of US \$ 454,790,119.96.

Sierra Leone

Similar to its MRB neighbors, Sierra Leone is blessed with natural resources. Hence, it comes as no surprise that, like its MRB sisters, exports from this country are predominantly natural-resource dependent as portrayed in Table 1b. Its main products are iron ore, diamond, and bauxite. Besides having similar export products, the country has basically the same trading partners such as China, France, Switzerland, and USA. However, Great Britain, the colonial masters of this West African country has always had a special trading relationship with Sierra Leone. In fact, in 2013 the United Kingdom was surpassed only by China in terms of export values received from Guinea.

Table 1a: Export trading partners and products of Guinea (UN Comtrade database, 2013)

Guinea top export products and exporting partners in 2013

Country	Export Value (\$)US	Product	Trade Value(\$)\$US
France	526,889,486	Iron ore	26,725,940
Switzerland	456,986,092	Gold	942,278,139
UAE	147,314,733	Coffee	3,621,398
USA	74,025,875	Aluminum ore	432,484,187
Ireland	70,578,722	Rubber	21,427,386
Germany	50,852,285	Cocoa Beans	2,227,064
Ukraine	48,702,471		
India	43,208,882		
China	42,736,661		
Spain	106,170,615		
World Total	1,780,483,526		

Table 1b: Export trading partners and products of Liberia (MoCI, 2013 Annual Bulletin)

Liberia top export products and exporting partners in 2013

Country	Export Value (\$) (CIF Values)	Product	Trade Value(\$)\$US
China	108,254,486.13	Iron Ore	221,974,150
Poland	63,518,088.79	Rubber	54,319,348
France	58,934,518.95	Logs	20,324,412
Germany	43,657,607.00	Rubber Wood	2,830,490
USA	29,933,147.30	Cocoa Beans	2,667,250
Spain	28,088,932.55	Scrap Metal	1,751,850
Luxembourg	26,112,925.19		
Belgium	25,012,839.00		
Cote D'Ivoire	23,695,656.82		
Netherlands	11,347,334.00		
World Total	454,790,119.96		

Table 1c: Export trading partners and products of Sierra Leone (Foreign Trade Statistics Bulletin – 2013)

Country	Export Value (million Leones)	Product	Trade Value(million Leones)
China	3,340,856.51	Iron Ore	4,613,287.50
UK	287,474.76	Bauxite	59,860.66
Gambia	212,661.02	Diamond	804,293.34
Guinea	57,535.33	Cocoa	38,897.29
		Beans	
South Africa	21,226.21	Gold	15,921.95
Canada	12,381.30	Coffee	12,183.67
Holland	11,591.40		
Switzerland	7,425.07		
Belgium	5,974.68		
USA	4,308.25		

Impact

During the EVD all the major aspects of supply chains in Liberia were impacted considerably. There were devastating effects on the national healthcare infrastructure, economy, general population, and agricultural systems (Nyenswah et al., 2016). With government's restrictions and the fear of people to travel from one place to another, transportation of goods and services encountered serious strains. The fear of Ebola prevented both consumers and producers from entering markets, which caused increases in food scarcity, caused the price of food to rise sharply, and resulted in reduced caloric intake for many already food insecure families (USAID, 2016). In addition, a major source of supplies, the agricultural sector with about 50% of the work force in Liberia (AfDB/OECD/UNDP, 2014) was greatly affected with dwindling of agricultural supplies to the cities and spoilage of agricultural products. The fiscal cost of controlling the epidemic, combined with an increase in unemployment and a decrease in the export of rubber and iron ore brought economic growth to a near halt (USAID, 2016). Although, all sectors which contribute to the supply chains in the country were affected, the effect on some sectors were graver than other. For instance, the mining sector, a major bastion for the Liberian economy was hit hard with as much as 50% drop in some areas because of the afore mentioned reasons. Therefore, this section focuses on the main sectors that were affected than others.

Mining Sector in Liberia overview

The mining sector of Liberia came to prominence when iron ore was discovered and became to be mined. The iron ore industry was the backbone of the Liberian economy from the 1960's to the 1980's with a contribution of more than 60% of export earnings and about 25% of GDP (Boakye et al. 2012). Even up to today's date iron ore mining plays a significant role in the Liberian economy and accounted for nearly 30% of total export earnings in 2016 with five iron ore mining companies. The other major minerals featuring in the mining industry in Liberia are gold and diamond. After being mined by artisanal miners for many years, there are now 25 (twenty-five) or more mining (iron ore, gold, diamond and oil) companies which have operated or currently operating in Liberia since 2014. Some are listed in table 2. Even though, the long period of civil upheaval essentially rendered it non-existent, the mining industry rebounded at the end of the war with an operational mining concessional area of 113,256 ha, attracting massive foreign investment of USD 7.6 billion and creating about 10,000 jobs in 2014/2015 fiscal year (LEITI 2016; Ministry of Finance, 2013). In the same year, the sector faced a drop in demand, production level, investment, and loss of employment as a result of the twin shock—Ebola virus disease and the price of iron ore. Even during the Ebola years, the sector contributed more than any other in terms of government revenue; it provided more than 55% of said revenue as illustrated in Figure3. Even though oil provided a significant contribution to the real GDP growth of the country, it is not discussed here because this sector has not started production yet, in order words, oil has not been discovered in commercial quantity. In this section, the focus is placed on the impact of Ebola on the mining sector with respect to outputs; hence, for more information on the mining sector's current practice and challenges the reader is referred to (Wilson et al. 2017).

Table 2: Mining Companies in Liberia (LEITI, 2016)

Types of Mining Companies	Mining Companies
Oil Companies	African Petroleum
	Anadarko Liberia
	Exxon Mobil Exploration & Production
	Anadarko Block 10
	Chevron Liberia
	Hua Lee International Corporation
Iron Ore companies	Arcelor Mittal Liberia, , ,
	BHP Billiton
	Western Cluster
	Putu Iron Ore
	China Union
Gold and Diamond Companies	African Diam Company
	Golden Bar Trading
	Royal Company
	Bea Mountain Mining
	MNG Gold
	Golden Mass Trading
	The Diamond Star Plus
	Dibodo Import & Export
	Golden View Trading
	West African Diamond
	Earth Source Mineral
	Golden Vision Trading
	West African Gold &Diamond
	Global Diamond Company
	Lee Yam Diamond
Zwedru Mineral Business	
Hummingbird Resources (Liberia)	

Iron Ore

The iron ore sector experienced a huge investment from foreign companies. For example, ArcelorMittal invested \$800 million in its Nimba County iron ore project. The main features of the project included the redevelopment of the western iron ore deposits of an abandoned mine and related infrastructure in Nimba County; the reconstruction of a 240-km rail track, which connects the old Yekepa mine in Nimba County with the city of Buchanan in Grand Bassa County; and the dredging of the Buchanan Port (ArcelorMittal, 2015). In addition, there were other deals such as the acquiring of a 51% stake in Western Cluster Ltd. at a cost of \$90 million by Vedanta Resources plc. of India through its subsidiary Sesa Goa Ltd (Vedanta Resources, 2014), and those acquired by PAO Severstal of Russia (61.5% interest), through its subsidiary Severstal Liberia Iron Ore Ltd (PAO Severstal, 2011) and London-based Sable mining Africa Ltd which acquired an exploration license. It should be noted that some of these deals did not reach the production stage.

However, Bong Mines Company Ltd. (commonly known as China Union) and ArcelorMittal were the first companies to start production with Production of 'direct shipping ore' (DSO) commencing in in 2011 from the first of three deposits at Yekepa (Mount Tokadeh, Mount Gangra and Mount Yuelliton) in the 'Western Range Project' (WRP) operated by ArcelorMittal. At present iron ore is mined from two deposits, Mount Tokadeh in the WRP, which produced 4.9 million tonnes (Mt) in 2014 (ArcelorMittal, 2015), and the Bong Mines, operated by China Union, which recorded its first production of 50 000 tonnes in early 2014. This total of about 5.0 Mt was an increase from a little over 2.4 Mt in 2012. The almost 5.0 Mt in 2014 could not be maintained or augmented but rather iron ore output dropped to around 4.5 Mt in 2015 and further dropping to 1.4 Mt in 2016 as seen in Figure4. The main reason for this fall in production was in two folds: the outbreak of the Ebola virus in 2014 with the lag effect spilling over in 2015, and the drop in demand of Iron ore from China coupled with increases in new supply which precipitated price collapse of the commodity. The increase in rate of infection was so alarming that virtually every operation came to a standstill. Even though the outbreak

started in 2014, export was greater in that year than in the next probably due to the already existing stockpile. However, other factors cannot be ruled out because even after the end of the epidemic and with the resumption of mining activities, the sector was still faced with serious challenges due to the existence of the exogenous factors discussed earlier.

Diamond and Gold

As mentioned before, gold and diamond had been mined primarily by artisanal miners in Liberia. However, this took a dramatic trend with the introduction of industrial gold mining companies. Currently there are three large-scale industrial gold mines, Bea Mining Corporation a then subsidiary of the Aureus Mining Company, MNG Gold and Hummingbird Resource (Liberia), and a host of small gold and diamond mining companies. In addition to these companies in the gold and diamond market chains are the artisanal and small scale miners (ASM). These ASM sell their products to brokers who in turns trade with bigger buyers. There has been reports emanating from the camps of these artisanal miners of cross-border trade in these precious minerals due to the porous nature of the border, however, the extent and amount of this cross-country trade is anyone's guess. As for diamonds, the Kimberley Process Certification Scheme (KPCS) process makes it difficult for illicit cross-border trade to occur. Also, an insignificant amount of the gold is used domestically in making jewelries.

Gathering accurate data on gold and diamond production in Liberia is difficult due to the fact that artisanal mining, which employs hundreds of thousands of men and women directly and many millions more in the downstream industries it spawns in the Mano River Basin countries (Fanthorpe and Maconachie, 2010; Hilson and van Bockstael, 2012; Bolay, 2014) and is predominantly practiced in gold and diamonds, is traditionally carried out by unlicensed and illegal miners. Also, its lucrative mines are located in remote and inaccessible areas in forest regions, however, the government lacks the necessary resources or capacity to monitor mining activities ("Liberia - Mining & Minerals," 2017). Although the Ministry of Lands, Mines and Energy in Liberia is trying to formalize the artisanal and small scale mining (ASM) sector, this has yet to yield the intended result. However, the data collected from different sources all pointed to similar trends in the gold and diamond sector as was observed in the iron ore sector. From Figure 5, it is clear that the advent of the Ebola outbreak had a profound impact on gold and diamond mining in the country. For example, after a rise to approximately 20,000 ounces in 2014 there was a decrease in export to around 9,400 ounces in 2015 for gold, a decrease by 53%. However, there was a colossal increase in the output of gold in 2016 as well as 2017. This was the case because of the introduction of large scale hard rock gold mining by companies such as Bea Mountain Mining Corporation. In like manner to gold, the amount of diamond leaving the country was lower in 2015 about 66000 carats down from about 74900 carats in 2014. The data shows a drop in output for both iron ore and diamond in 2016 with marginal rises in 2017. Again, the main reason for these drops in 2016 was the spillover of the effect of the EVD from the previous year, that is, the decline is attributed to the shutting down of mining activities due to the outbreak of the Ebola epidemic coupled with weak demand on the world market.

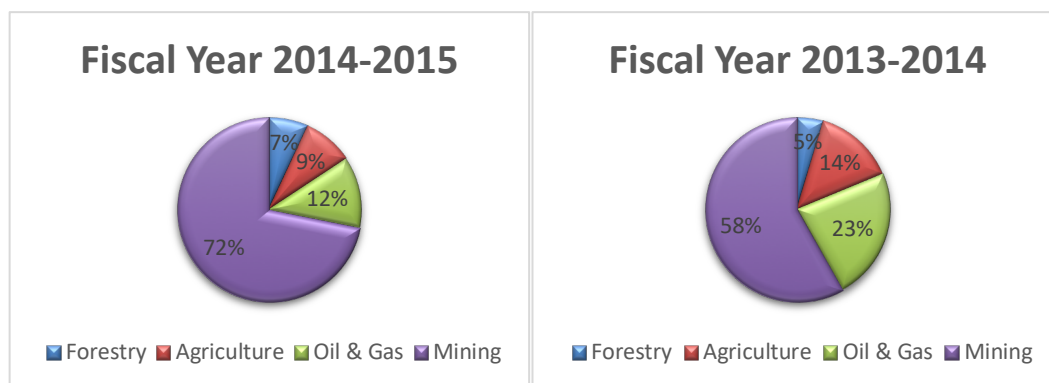


Figure 3: Sector comparison for two fiscal years in Liberia

Source: LEITI, 2016; Ministry of Finance, 2013; Wilson et al., 2017

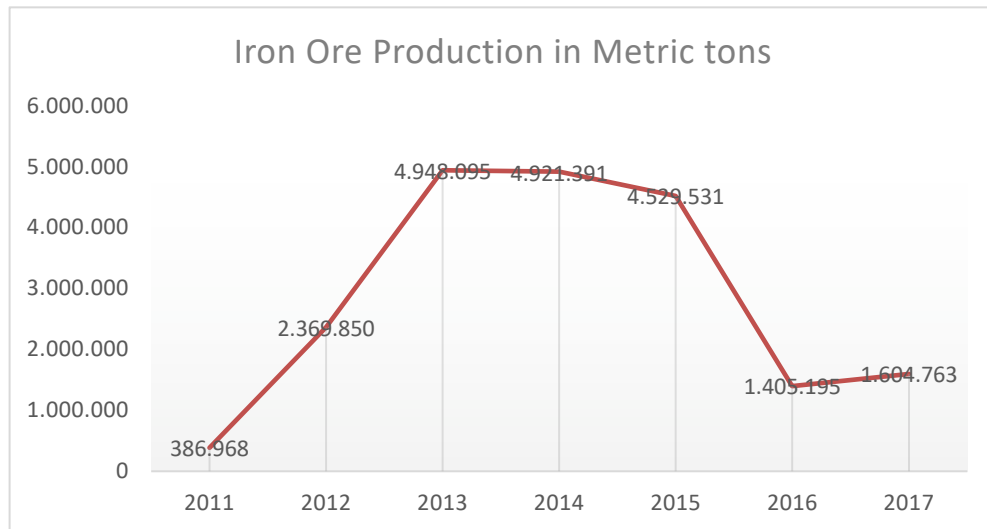


Figure 4: Production of iron ore in tonnes from 2011 to 2017 in Liberia (CBL Annual Report, 2010-2017)

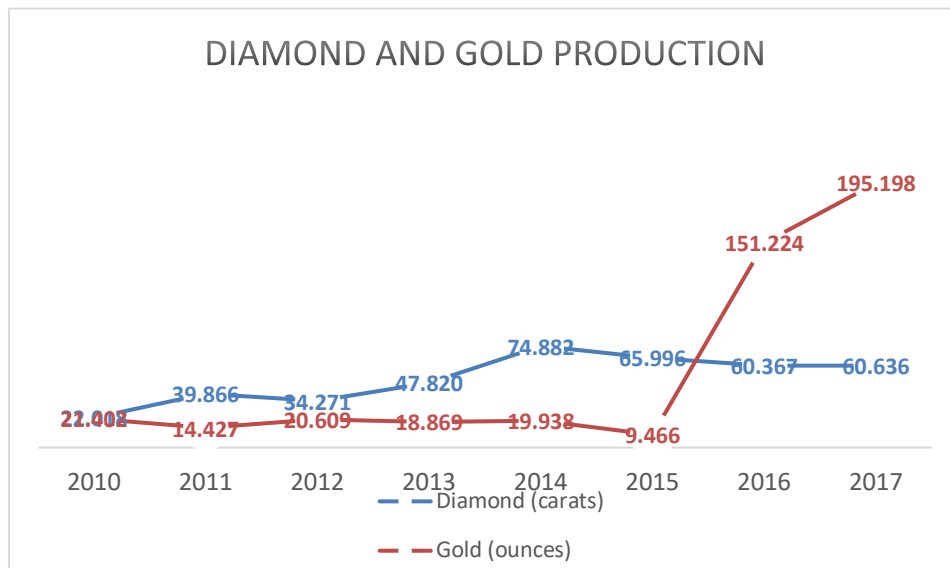


Figure 5: Production of gold and diamond from 2010 to 2017 in Liberia (CBL Annual Reports, 2010-2017)

Agriculture

Expectedly, most of the inhabitants of rural Liberia are farmers, the majority of whom are in smallholder agricultural activities, while on the contrary, in urban areas the dominant workers were wage work and non-agricultural self-employment activities. In fact, in 2015, agricultural activities made up an estimated 46 percent of the labor force especially in the formal sector, with around 70% of rural households involved in the small scale farming (LEITI, 2014-2015). However, in 2014, the EVD outbreak impacted on the agriculture and food sectors. For example, there was a 4% decrease in rice production in 2014 from an average production of 284,000 tons for the previous four years (FAO/GIEWS, 2018). In addition, the agriculture sector contributed an estimated 23.9% of the country's real GDP growth rate in 2015 which is a negligible 1.1% drop from 24.2% in the previous year. This can be attributed basically to the fall in rubber output by 9.2 percent, to an estimated 54,406 metric tons, down from 59,892 metric tons produced in 2014 and to the EVD (CBL Annual Report, 2015).

The major agricultural products in Liberia are rubber, rice, cassava, oil palm and cocoa (MoCI, 2015). On the whole, all the major cash crops experienced no real growth at all or contracted in 2014. As examples, with

the exception of oil palm which reported a 50 per cent real growth in 2014, there was no growth for both rubber and coffee during that period after rubber had seen a 20% contraction and a 3% expansion for coffee was witnessed in 2013. Cocoa, for its part, continues its 7% decline from the previous year. Even the two main food crops, rice and cassava, growth rate was shrunken by 6% down from an expansion of 3% in 2013 (MFDP, 2015), as the EVD epidemic hit the main food production counties during the height of the production season.

In this section focus is placed on rubber and rice. For rubber the emphasis is due to the fact that it is Liberia's foremost agriculture product contributing a considerably greater percentage to government's revenue than any other as shown in Table 2. Out of the first six largest contributors to government's revenue only Golden Veroleum was not in rubber exportation. Furthermore, most of the products under this category are exported similarly to rubber. In addition, the market supply chains of most of these products are not different from the rubber market supply chains. Consequently, a discussion on the impact of EVD on rubber production in Liberia is an able generalization for the cash crops.

In the case of rice, it is the staple food for Liberians with an annual consumption of about 570,000 tons of rice but usually around 2/3 of the rice is imported (Terneusen, 2018). Besides being the staple food in Liberia, rice is the most cultivated food crop among the small scale farmers in rural Liberia. It is so important that the term "farmer" traditionally meant rice farmer in many local languages. Almost every small scale farmer has a rice farm along with the other crops. The food products are usually sold together or separately to traders who deal in multiple products using similar market chains for their varied products; hence one would expect the market chains of the other food crops to be similar to the rice market chains. In fact, like rice, a majority of the food crops is consumed in the country. For these reasons, a treatment of the impact of the Ebola outbreak had on the rice market chains in Liberia is appropriate representative approximation of the overall food crop supply chains. For an extensive deliberation on market chains and trade of other agricultural products, the reader is referred to (Impact of Ebola, 2016).

Table 2: Agricultural Companies Contributing to government's revenue (LEITI, 2016)

Company	Total (USD)	Weight (%)
Firestone Liberia Incorporation	6,705,384	35.19%
Liberian Agricultural Company(LAC)	3,894,614	20.44%
Golden Veroleum Liberia	1,830,253	9.61%
Sime Darby Plantation	1,742,594	9.15%
Salala Rubber Corporation	1,702,505	8.94%
Cavalla Rubber Corporation	1,452,216	7.62%
Libinc Oil Palm Inc. (LIBINC)	820,877	4.31%
Maryland Oil Palm Plantation (MOPP)	355,163	1.86%
Equatorial Palm Oil (Liberia) Incorporated (EPO)	219,204	1.15%
The Lee Group of Enterprise	182,068	0.96%
Liberia Forest Products Inc (LFPI)	116,046	0.61%
Liberia Export & Import Enterprise (LEXIM)	19,948	0.10%
Morris American Rubber	11,916	0.06%
Total	19,052,786	100.00%

Rubber

From the advent of Firestone plantation in 1926, the mainstay of the Liberian economy had been rubber and even up to present it remains the most important cash crop of the country. Since then, the cultivation of rubber has grown to include a host of large company-owned plantations and small scale farms that belong to small families and individuals ("Rubber Production in Liberia," 2016).

The rubber market chain is simple in Liberia. Small rubber companies and individual farmers sell their semi-processed products to large companies such as Firestone Rubber company which export almost all the rubber abroad. At larger companies, after the rubber is brought to the field station it is sent for further processing where it is clean in several stages. The cleaning process is followed by heating and packaging into blocks awaiting exportation. In addition, most of the smaller farmers lack the capital to expand productivity. Therefore, in 2008, an agreement signed between Firestone Liberia and the Liberian government in which the company committed to continue increasing its support (which among others includes the purchasing their raw rubber) to small Liberian rubber farmers (FPA, 2017). There are calls from some quarters right or wrongly that this part of the agreement indirectly gives Firestone a monopoly over purchase of rubber from small farm holders.

Most of Liberia's rubber is exported to America. Even though the natural rubber is used to manufacture many products, around 50% is used in making tires and even though about 70% of the world's natural rubber (cis-1,3-polyisoprene) production goes into the manufacture of tires (Sethuraj & Matthew, 1992), it is not the main component of most tires; synthetic rubber such as styrene-butadiene rubber (SBR) is dominant in the composition of most rubber tires. In fact, synthetic rubber accounts for almost 70% of world consumption of rubber ("Rubber Faqs," 2019). This is despite natural rubber's environment-friendly nature, biodegradability, and lack of dependence on oil pricing. In addition, natural rubber is also produced in large plantations in Asia. For these reasons, the demand for natural rubber can sometimes decline leading to fall in rubber price which in turns influences rubber market chains and socio-economic well-being of rubber workers, farmers and the general citizenry in Liberia. For example, in 2016, after making around 500 of its employees redundant, Firestone Liberia announced that it will continue to implement a number of measures to cut costs in its operation, including streamlining of the company's business functions to reduce expenses, improving operational efficiencies, and discontinuing company employee-tapping operations in certain very old and low-producing areas of the concession (FPA, 2016). It had been reported earlier that Lee Group of Enterprise had allegedly laid off 50 of its employees (AllAfrica, 2015). These redundancies exacerbated the already dire economic situation faced by these workers and their thousands of dependents caused by the EVD.

The fall in demand coupled with the outbreak of Ebola would have had a severe negative consequence on the rubber supply chain in Liberia. The fact that the Ebola did not trigger a fall in rubber output in 2014 as seen in Figure 6 can be attributed to the lack of cessation of work at Firestone Rubber Company and other larger rubber companies which contribute a very huge portion of the rubber yield in Liberia. The main reason for the continuation of operation at these large firms was largely due to the fact that the regions in which they are located were more or less spared by the outbreak. Even though, Lofa, Margibi, Montserrado, Bomi and Bong were designated most affected counties based on Ebola cases per 1000 people in each county (Bowles et al., 2016) the actual plantation sites of the three largest exclusively rubber producing companies - Firestone and Salala Rubber Company of Margibi and Liberia Agricultural company of Grand Bassa County - were generally unscathed by the EVD. Eventually though, the twin effects of the EVD and the global fall in demand and hence price of rubber led to the decline in productivity 2015 which spill over to 2016 when the massive layoff of workers was experienced in the rubber industry. The fall in rubber production could also be attributed to aging rubber trees and the longevity in the gestation period of newly planted rubber trees. However, there was a resurgence in 2017 rubber output but the sector is still facing an uphill task as rubber price continues to remain low on the world market.

A Case for Diversification of the Rubber Industry

Rubber has been introduced in the country for almost a century ago; however, it is unbelievable that Liberia is still only an exporter of raw rubber which is obviously not a high value commodity. There are suggestions that secondary and tertiary rubber processing activities especially the manufacturing of tires in Liberia would be the catholicon for the industrial woes faced in the country given the country's high comparative advantage in the production of rubber. This would have undoubtedly precipitated a dynamic shift in the rubber market chain in the country from a simple to a more complex and diversified one; unfortunately, the prevailing conditions on the ground do not favor the case of the tire industry (Freeman, 2011). As was stated earlier, natural rubber is not the primary constituent of most tires. Secondly, there is an absence of market or demand in Liberia and the bordering Mano River Basin countries for original equipment manufacturer (OEM) or

replacement tires. Most importantly, tire making is very capital intensive and involves a sundry raw material resource base which the country lacks. All of these factors reduce investor's taste provided the diminished outlook for sound tire manufacturing investment in Liberia.

With this said, besides tire making the rubber market chain can still be giving added value by investment in other rubber products as natural rubber is a critical raw material essential for 50,000 or more secondary products such as industrial, consumer, engineering, medical, and military products (Cornish, 2017); however, another major product that could give an added value to the rubber market chain is the rubber wood itself. Rubber wood has a host of advantages over other species being used to produce many products ("Rubber Wood Products," 2015) including its production cost per cubic meter of which is only about 30 percent of the production cost of certain forest species (Kollert and Zana, 1994). It is currently being used to produce a plethora of products such as furniture and furniture parts, wood panels, pulp and paper, knife blocks etc. Actually, the diversification to include rubber wood products has already commenced at the Firestone Rubber Company with the construction of a plywood production factory at the plantation site. For further information on the advantages, application and the potential of rubber wood production in Liberia the reader is referred to (Freeman, 2011).

Rice

It has been stated before that the consumption of rice is considerably greater than any other food product in Liberia; however, due to low production in the country around 65% of domestic needs is satisfied by imported rice (WFP-Liberia, 2010; WFP-Liberia, 2011). It is no doubt that the livelihood of many small farm holders depends on the local market chain. On the other hand, the international rice supply chain serves as a means of obtaining accessible rice for millions of consumers. Therefore, the disturbances in the supply chains of rice and trade flows caused by the Ebola outbreak had an adverse effect on food security and the socio-economic condition of the people.

Lofa County, known as the "Food Basket" of Liberia, due it being the main food-production area, was hardly hit by the EVD because of its proximity to the origin of the West African Ebola epidemic. The outbreak reached Liberia via Lofa in March, and continue throughout the rice-farming season. Because of this, a decrease in rice production was expected with estimates as high as 25% in worst affected areas (FAO-WFP-Liberia, 2014). However, the undesirable impact on rice production was mainly to fear and the restrictions on gatherings that created labor shortages thus negatively affecting the collective farming activities which are the core of small scale farming in Liberia. Even though, there was an anticipation of low productivity because of the EVD, this decrease was very marginal in terms of national paddy rice production in 2014 from the previous year as illustrated in Figure7. In fact, there was an increase in 2015 over the value in 2013. This was partially attributed to the planting season not being intensely interrupted (FAOWFP CFSAM, 2015). The collective farming method used by the farmers had already being carry out and by the time Ebola awareness was in full bloom in 2014 it was almost harvesting period. In addition, the loss in communal labor at this time was appreciably compensated by the use of family labor. Although, this was not as efficient as the mutual assistant group, it went a long way in mitigating risky decline in production. Consequently, it was at the marketing level where the brunt of the EVD was felt.

There was a serious disruption in the marketing of local rice. This was due to fear of traders to collect rice from the affected areas and the stringent restrictions to movement. Locally, the surplus of rice produced is generally traded in nearby markets. Also, cross-border trade in rice has been in existence howbeit on a limited and variable scale. The existence of this cross-border rice trade is blamed on periods when the exchange rate makes imports from neighboring countries more profitable than from the international market. For instance, for the reason just given rice is imported from Liberia to remote Pujehun District of south-eastern Sierra Leone via Bo-Waterside market while imported rice from Guinea could be seen in Nimba and Bong Counties in Liberia (WFP-Liberia, 2010). However, during EVD, this cross-border trade was almost completely halted though there were some cross border trades continuing all through the Ebola outbreak due to the very porous and difficult-to-man borders. In addition, because of the lower number of rice traders coming to buy rice, the producers' power to bargain was reduced and this led to low rice price (FAO-WFP-Liberia, 2014). On the other hand, due to the limited amount of trucks coupled with the restrictions,

transportation was high thereby leading to moderate high price of local rice on the markets in Monrovia. It should be noted here that even though imported rice is seen in the markets in the City, local or “country” rice is the sole raw material certain local but widely consumed products and therefore its price is usually higher than the price of imported rice. Also, it is always the case that during harvesting period locally produced rice is cheaper than during other periods.

Having said this, there was no hikes in the general price of rice even in the midst of these little fluctuations. This can partly be attributed to the regular importation of rice. There had been fear that import would have dropped due to the disease. Had this occurred, there would have been shortage of this precious commodity on the market which would have resulted in dangerous price hike which subsequently would have led to civil unrest as seen in 1979. However, this was not the case as rice importation in 2014 and 2015 remained fairly constant and even a little more than 2013 the year immediately before the EVD outbreak as depicted in Figure 8. Even though there were some marginal increases in price in Ebola affected areas, this was partly attributed to the increase strength of the United States dollar against the Liberian dollar (FAO-WFP-Liberia, 2014) and not due to acute shortage of rice.

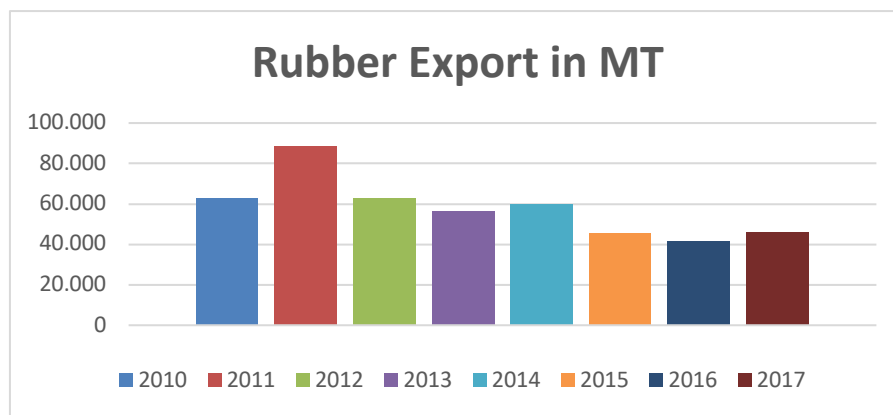


Figure 6: Rubber export from Liberia in metric tons (CBL, 2010-2017)

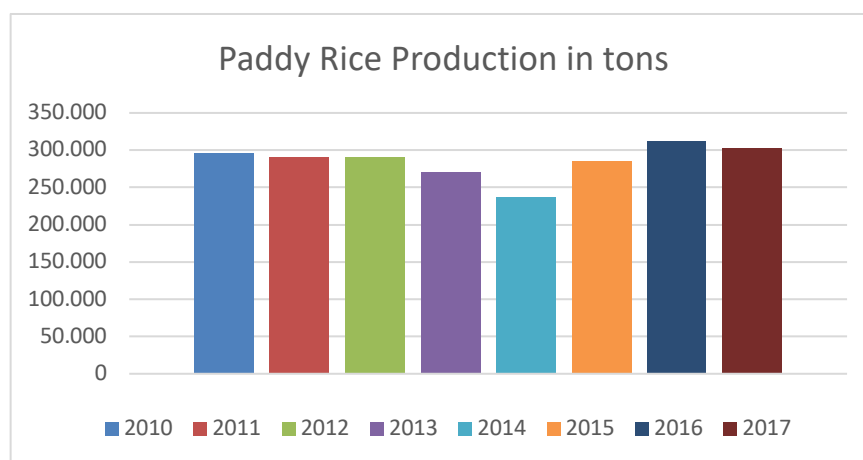


Figure 7: Liberian Paddy Rice Production in tons (FAO/GIEWS, 2018)

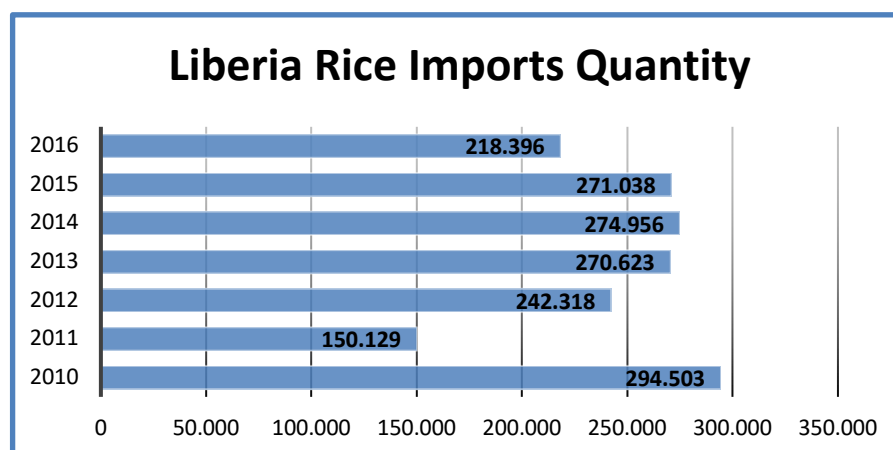


Figure 8: Liberia rice Import in tons (Liberia-Rice imports quantity, 2016)

Conclusions

The objective of this review was to present an unbiased science-based summary on the impact the EVD outbreak had on the supply chains of the primary mining and agricultural commodities produced in Liberia. To this end, the overwhelming and disastrous impacts of the disease were enumerated. The results indicate that among others:

1. there were significant disruptions to the flow of goods and decrease in outputs of the main export commodities of Liberia.
2. the GDP growth rate of the three countries in the Mano River Basin experienced a drastic decline during the Ebola years.
3. the specific mechanisms through which the market chains were interrupted were as a result of fear and government's regulations.
4. there is need to for a more feasible diversification route for the rubber industry from raw-rubber-only export to manufacture of latex products other than tires, and the production of rubber wood as a means of ensuring value added products to the industry.

When concluding his review, Van Hoek intentionally omitted the term conclusion. Instead, he opted for closing remarks, suggesting that researchers on a particular topic in his field of studies were not yet in a position to make conclusions (Van Hoek, 2001). Based on the nature and limitations of this review, I concur and also decided to use closing remarks indicating that more research needs to be conducted on the impact on supply chains in MRB region caused by the most widespread and deadly EVD outbreak ever in the history of mankind. The understanding of the of mechanisms of the disruption will enable supply chains risks managers to craft more robust strategies in remediating these interruptions in supply chains.

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