

Assessing Transportation Logistics for White Shrimp (*Nematopalaemon hastatus*) Marketing Using ArcGIS Network Analysis

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Abstract – This study assessed transportation logistics for prospective consumers and marketers of white shrimp (*Nematopalaemon hastatus*) within a 500 km buffer to processing and marketing areas in Ondo State, Nigeria using ArcGIS network analyst tool. The result indicated that shorter routes between the towns and major shrimp market at Igbokoda provided buyers with a lower budget for logistics and product cost compared with higher budget computed for longer routes between the towns and Ugbonla waterside, Nigeria. However, due to lower price of smoked shrimp at processing areas, shrimp product would get to the towns/cities within the buffer per kilogramme at a lower cost compared to products directly sourced from marketing areas (Igbokoda). Thus a typical consumer/marketer within the buffer was expected to budget an average of \$42-\$110 (~~₦12,810-₦35,500~~) and \$59-\$123 (~~₦17,995-₦37,515~~) for 10.42kg of smoked shrimp from processing areas in a typical peak and off-peak month respectively. In the alternative, they are expected to budget an average of \$50-\$110 (~~₦15,250-₦33,550~~) and \$60-\$125 (~~₦18,300-₦38,125~~) to source same quantity of the species from Igbokoda in a typical peak and off-peak month respectively. Developing a shrimp market at Ugbonla waterside, Nigeria would open the community for more economic development and attraction due to easy accessibility to shrimping and processing areas. Therefore, prospective shrimp marketers and consumers within the 500km buffer who are interested in accessing this highly nutritional species and other aquatic products from the processing and marketing areas could be guided by this information for effective trade and marketing.

Keywords: white shrimp, logistics, buffering, network analysis, shortest route, and budget.

1. Introduction

The special needs of landlocked areas especially those related to the need to improve their accessibility to marine aquatic resources have been recognized for a long time by policymakers and developmental institutions; some of these special needs are very specific and focused which include the development of efficient transit corridors to connect areas with abundant aquatic resources with areas with low abundance[1]. Nigerian coastal zone of about 835km sprawls over a total of nine states (out of the thirty-six states) of the federation, namely: Akwa-Ibom, Bayelsa, Cross River, Delta, Edo, Lagos, Ogun, Ondo and Rivers. Economic activities in the coastal zone include Oil and Gas exploration and exploitation, fishing industries, shipping,



agriculture and tourism [2]. In 2015, 398, 428 metric tonnes representing 38.8% of the total fish production (1,027,058) in Nigeria were products of marine environments while 30.4% and 30.8% are from the inland fisheries and aquaculture respectively [3]. Ondo State, Nigeria is one of the States endowed with abundant aquatic fisheries resources including shrimp; thus, it is expected that landlocked areas must devise means of accessing aquatic products from such area.

Shrimp of the family *Palaemonidae* is one of the most important components of the aquatic resources of Nigeria. White shrimp (*Nematopalaemon hastatus*) is a prominent member of this family [4]. It is widely distributed in the continental shelf of Nigeria; they inhabit the freshwater, saltwater including lakes, coral reefs, and the depth of the sea [5]. It is of great economic importance in Nigerian territorial waters and the exploitation has been on the increase due to increasing population and increase in demand for protein sources in coastal communities and beyond [6]. In coastal communities of Ondo State, Nigeria, *N. hastatus* is widely distributed along the over 180 km coastline where it serves as a source of food, job, trade and investment [7]. It is highly cherished in food majorly in the Southern part of the country because of their excellent taste and flavour [8].

Transportation of shrimp products to the consumer markets from areas of abundance could entail passing routes on water and land. Hence, for prospective marketers, information on transportation logistics (routes distance and cost) is one of the major prerequisites for trade and investment. Managing the material flows of smoked shrimps from coastal areas to different geographical locations is a key task of supply chain management [9]. Basic information on logistics is the most important factor in business feasibility [10]. Equally, the length of the route covered by an actor in shrimp marketing to get/sell their material/product is expected to influence profitability and dispersal of the product respectively. Sreenivas and Srinivas [11] opined that the key element in a product supply chain is the transportation system, which joints the separated activities. Thus, transportation occupies one-third of the amount in the logistics costs while transportation systems influence the performance of logistics system hugely [12].

One of the ways by which food products have been supplied to consumer markets in Nigeria is via road [13]. However, bad roads significantly increase transportation cost for distributors and the cost is further increased whenever a fragmented market is not connected to the major road networks; thus, the distribution challenges are heightened when the consumers are not all within the production areas [14]. Hence, the state of most Nigerian roads has necessitated the need to provide scientific methods of determining the best or route to source product from a particular area. ArcGIS network analysis platforms have for some time, supported transport planning by analysis of spatial patterns, such as calculating the shortest path between two points on a network [9]. It has been said to provide information best /shortest route to assess products with the overall aim of reducing logistic costs (including travel time and cost) as well as equally assist prospective traders and investors to assess logistics for new markets [15].

Despite the effectiveness of GIS in logistics studies, there is a paucity of information on the utilization of network analysis to estimate the shortest routes between cities and processing/marketing areas and using such information to project budget for sourcing smoked

white shrimps in coastal areas of Ondo State, Nigeria. Therefore, this study assesses transportation logistics for white shrimp (*Nematopalaemon hastatus*) marketing using ArcGIS network analysis. It would provide prospective traders/investors within and outside the study area with requisite information on developing logistical strategies for white shrimp trade and investment.

2. Study Locations

The study was carried out in Ilaje Local Government Area, Ondo State, Nigeria (6.2585° N and 4.7692° E). The study area was located at the extreme southern part of the State. A preliminary survey was done to have information on processing sites, shrimps market and the business environment. Ugbonla was the major town on the hinterland to access processing areas while the major shrimp market was identified in Igbokoda.

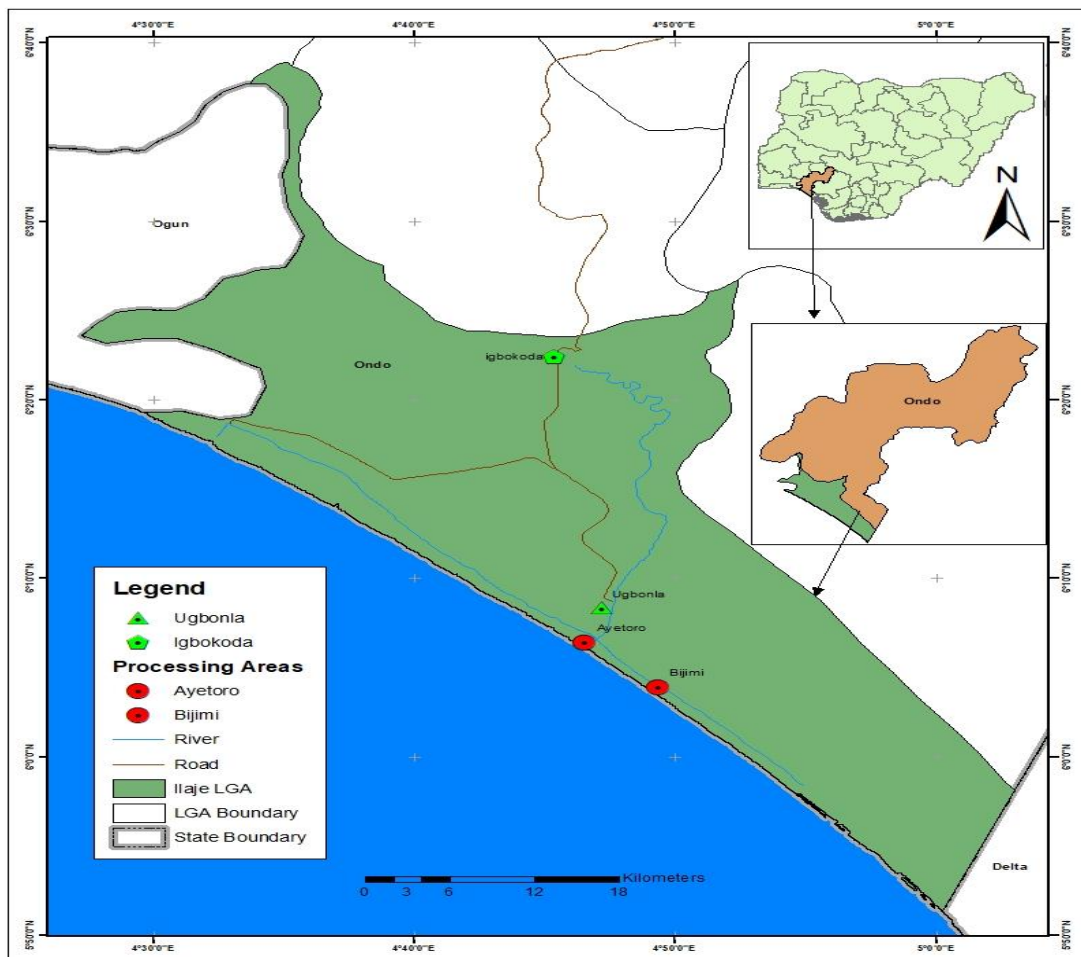


Figure 1: Map showing areas of Locations of Processing and Marketing Areas

3. Materials and Methods

3.1 Source of Data

Data used for this research can be broadly divided into primary and secondary data. Primary data on the cost of shrimp were collected from processors and marketers using focus group discussion. GPS coordinates of Ugbonla waterside and major shrimp market in Igbokoda were traced and captured using a handheld global positioning system (GPS) (Garmin eTrex) receiver. The secondary data includes satellite imagery from Google Earth Pro, Nigerian roads and inland water shapefiles. Missing roads on the Nigerian roads shapefile were digitized using Google Earth Pro 7.3.1 application. A 500 km buffer was created around the major shrimp market (Igbokoda) and Ugbonla to target majorly landlocked areas. States that were captured after buffering and randomly selected towns/cities are presented in Table 1a.

Table 1a: States Captured and Selected Towns/Cities within the Buffer

Zone	State	Towns/Cities
North Central	Kogi	Ayetoro-Gbede, Kabba, Lokoja, Okene
	Anambra	Awka, Ifite-Ogwari, Nnewi, Onitsha
	Enugu	Awgunta, Enugu, Nsukka, Ogbede
South-East	Imo	Oguta, Okiqwe, Orlu, Owerri
	Bayelsa	Sagbama, Kenan, Yenogua, Amasama
	Delta	Asaba, Warri, Agbor, Kwale
	Edo	Auchi, Akoko-Edo, Benin
South-South	Rivers	Ebuguma, Egbolom, Omoku, Port Harcourt
	Ekiti	Ado-Ekiti, Aramoko-Ekiti, Omuo-Ekiti, Otun-Ekiti
	Ogun	Abeokuta, Ijebu-Ode, Sagamu, Odeda
	Ondo	Akure, Ikare-Akoko Ondo, Ore
	Osun	Ile-Ife, Osogbo, Iwo, Ila-Orangun
	Oyo	Ibadan, Saki, Oyo, Ogbomosho
South-West	Lagos	Ajah/Lekki, Egbeda, Ikeja, Victoria Island

Source: United States Geological Survey (2019).

3.2 ArcGIS-Based Route Analysis

ArcGIS 10.5 network analyst tool was used for this research. Coordinates of the study sites, digitised towns, administrative map of Nigeria; digitized administrative road map of Nigeria and satellite imagery were stored in the Geodatabases. Network dataset was created in Geodatabases within ArcCatalog. Route solver was then used to determine the shortest routes between towns within the buffer and point of access to processing areas by road and marketing sites respectively [16].

3.3 Estimated Cost for Transportation and Shrimp Using Shortest Route

This was determined by multiplying the length (km) of the shortest route from the cities to processing and marketing areas by the standard cost transportation/kilometre (₦20)(\$0.07) used for estimating duty tour allowance for public service engagements in Nigeria [17] according to the formula in equation i. The estimated budget for sourcing smoke-dried shrimp study areas was determined by the addition of the cost of transportation and the cost of sourcing a measure of the product in a typical peak and off-peak months respectively (equation ii). An average selling price of \$31.15 and \$48.38; \$36.07 and \$53.32 per measure of smoke-dried *N. hastatus* in processing and marketing areas in the different periods were used for this estimation respectively. This was derived by monitoring/averaging the price at which five (5) processors sold to marketers/consumers and the rate five (5) marketers sold to other market agents/consumers in the peak (June-October) and off-peak (November-May) months in 2018. Estimated price at which a kilogramme of smoke-dried white shrimps would get to the cities from the processing and marketing areas was determined by dividing the estimated budget by the number of kilogrammes in one measure (10.40kg)

$$PTC = \$0.07 \times LSR \quad 1$$

$$PB = PTC + (ASC \times Q) \quad 2$$

$$PPkg = \frac{PB}{Quantity (kg)} \quad 3$$

Where:

PTC = estimated transportation cost (\$), TR = transportation rate/kilometre, LSR = length of shortest route (kilometre), PB = estimated budget, ASC = average shrimp cost, Q = number of units bought. PPkg = estimated price per/kilogramme. Surface maps of estimated budget were interpolated according to methods described by Environmental Systems Research Institute [16].

4. Results

4.1 Shortest Routes between South-westerns Townsend Study Areas

Table 1b provides information on the shortest routes and the corresponding cost of transportation between selected South-western towns and processing as well as marketing sites respectively. It shows that Ore in Ondo State had the shortest route (104.16 km and 160.68 km) to Ugbonla and shrimp major market in Igbokoda respectively while Saki in Oyo State, Nigeria was the farthest Towns (867.80 km and 924.32 km) to Ugbonla and marketing sites in Igbokoda respectively. Shrimp buyers going to processing and marketing sites from other Towns such Iwo, Odeda, Oyo and Ogbomoshu are expected to cover a shortest route that ranges between 627.56km – 637.97km and 571.04 km – 581.45 km respectively. Equally, marketers and consumers from Abeokuta, Ibadan, Ikare-Akoko, Ikeja, Ila-Orangun, Omuo-Ekiti and Ota, Osogbo, Otun-Ekiti and Victoria Island would get smoke-dried shrimp from processing areas and Igbokoda on an estimated shortest route that ranges between 513.25km – 597.34

km and 456.78km -540.83km respectively. Marketers and consumers travelling from Ado-Ekiti, Aramoko-Ekiti, Ijebu-Ode, Ikare-Akoko and Sagamu, was estimated to travel through a distance of that ranges between 405.33 km–496.65 km and 348.81-440.13km to the towns bordering the processing areas and Igbokoda respectively. Similarly, consumers and marketers from Akure, Ile-Ife and Ondo were estimated to travel through a distance of 241.44-369.60 km and 184.92 km (Figure 3).

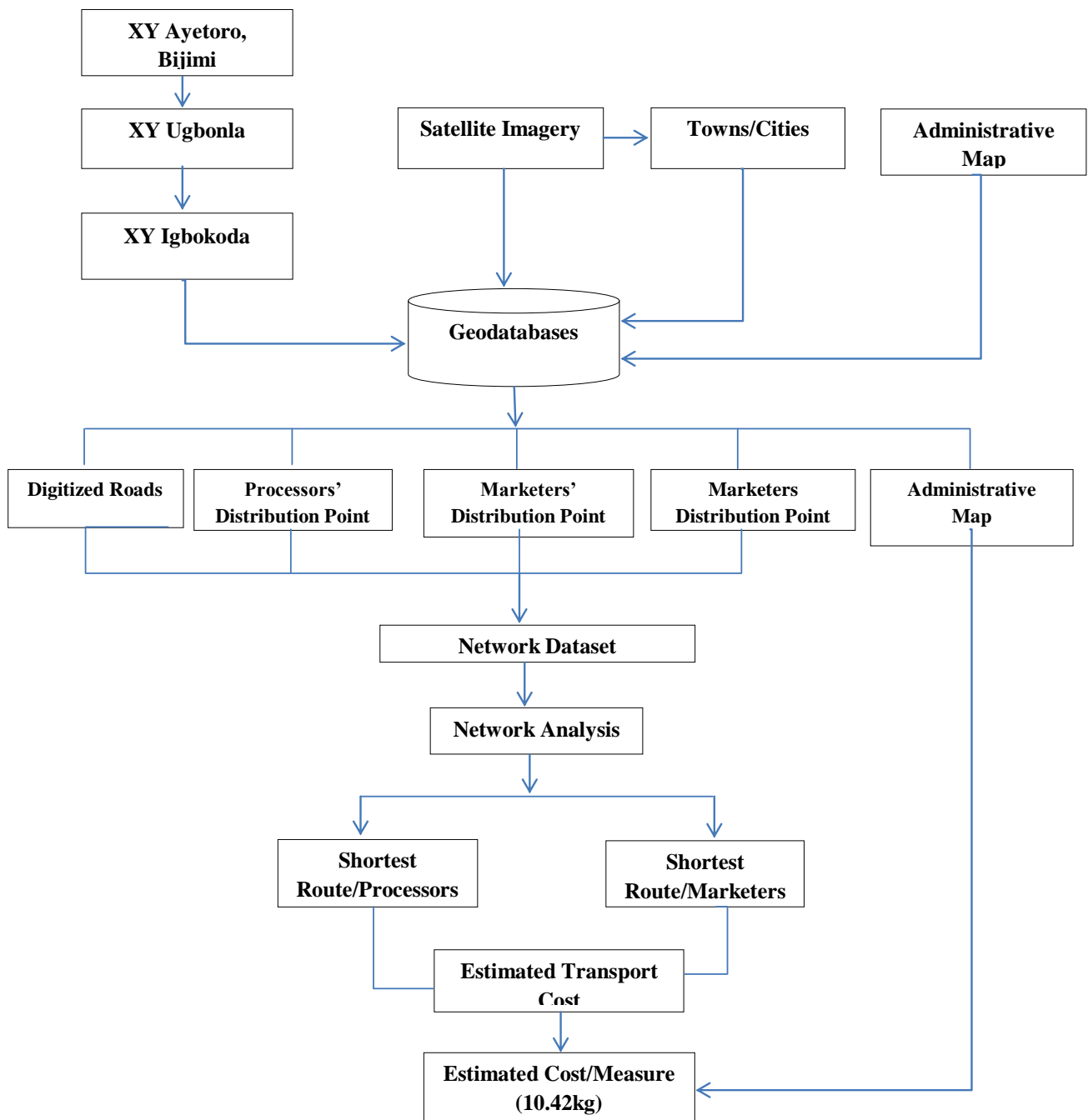


Figure 2: Methodology Chart

Table 1b: Shortest Routes and Estimated Cost of Transportation between Processing and Marketing Areas and Some Towns in South-West, Nigeria

Towns	Segment	Shortest Route (km)	Transportation Cost (₦)	Transportation Cost (\$)
Abeokuta	Processing	567.77	11355.36	37.23
	Marketing	511.25	10224.93	33.52
Ado-Ekiti	Processing	442.17	8843.40	28.99
	Marketing	385.65	7712.96	25.29
Aja/Lekki	Processing	624.04	12480.82	40.92
	Marketing	567.52	11350.52	37.21
Akure	Processing	349.56	6991.26	22.92
	Marketing	293.04	5860.83	19.22
Aramoko- Ekiti	Processing	496.65	9933.00	32.57
	Marketing	440.13	8802.57	28.86
Ibadan	Processing	529.37	10587.46	34.71
	Marketing	472.85	9457.02	31.01
Ife	Processing	369.60	7392.06	24.24
	Marketing	313.08	6261.63	20.53
Ijebu-Ode	Processing	405.33	8106.56	26.58
	Marketing	348.81	6976.12	22.87
Ikare-Akoko	Processing	566.80	11336.03	37.17
	Marketing	510.28	10205.60	33.46
Ikeja	Processing	555.46	11109.27	36.42
	Marketing	498.94	9978.84	32.72
Ila-Orangun	Processing	571.63	11432.60	37.48
	Marketing	515.11	10302.20	33.77
Iwo	Processing	627.56	12551.27	41.15
	Marketing	571.04	11420.83	37.45
Odeda	Processing	628.47	12569.40	41.21
	Marketing	571.95	11439.00	37.50
Ogbomosho	Processing	637.97	12759.40	41.83
	Marketing	581.45	11629.08	38.13
Omuo-Ekiti	Processing	590.02	11800.34	38.69
	Marketing	533.50	10669.90	34.98
Ondo	Processing	241.44	4828.79	15.83
	Marketing	184.92	3698.35	12.13
Ore	Processing	160.67	3213.50	10.54
	Marketing	104.15	2083.07	6.83
Osogbo	Processing	513.25	10265.00	33.66
	Marketing	456.73	9134.56	29.95
Ota	Processing	597.34	11946.71	39.17
	Marketing	540.82	10816.40	35.46
Otun-Ekiti	Processing	547.79	10955.92	35.92
	Marketing	491.27	9825.48	32.21
Oyo	Processing	632.48	12649.56	41.47
	Marketing	575.96	11519.12	37.77
Sagamu	Processing	476.98	9539.68	31.28
	Marketing	420.46	8409.24	27.57
Saki	Processing	924.32	18486.40	60.61
	Marketing	867.80	17355.96	56.90
Victoria Island	Processing	588.19	11763.89	38.57
	Marketing	531.67	10633.45	34.86

Source: United States Geological Survey (2019).

4.2 Shortest Routes between South-South Towns and Study Areas

Information on the shortest routes between marketers and consumers from some selected towns within the buffer from the Niger-Delta region of the country and processing and marketing areas is presented in Table 2. Benin-City in Edo State, Nigeria had the shortest route (352.59 km and 409.11km) to these areas respectively while Ebuguma River State was the most distanced (1151.23 km and 1094.71 km) city from the processing and marketing areas respectively. Other Towns such as Amamasa, Egbolom, Kenan, Port Harcourt, Sagbama and Yenagoa had a distance that ranged between 1003.46 km – 1103.99 km and 1003.53 km – 1046.67 to Ugbonla waterside and the marketing area under study. Kwale and Omoku had a distance to Ugbonla and Igbokoda that ranged between 776.22 km –985.40 and 719.70 km – 928.88 km. Areas such as Akoko-Edo, Asaba and Auchi had the shortest route that ranged between 628.06 km-699.08 km and 561.54 km-642.56 km respectively while the estimated length of routes between Agbor, Ekpoma and Warri was between 506.37 km-589.80 km and 449.85 km-533.28 to these areas (Figure 3).

Table 2: Shortest Routes and Estimated Cost of Transportation between Processing and Marketing Areas and Some Towns in South-South, Nigeria

Towns	Segment	Shortest Route (km)	Transportation Cost (₦)	Transportation Cost (\$)
Agbor	Processing	506.37	10127.51	33.20
	Marketing	449.85	8997.07	29.50
Akoko-Edo	Processing	699.08	13981.58	45.84
	Marketing	642.56	12851.14	42.13
Amassama	Processing	1060.05	21200.92	69.51
	Marketing	1003.53	20070.52	65.80
Asaba	Processing	637.31	12746.29	41.79
	Marketing	580.79	11615.89	38.08
Auchi	Processing	618.06	12361.23	40.53
	Marketing	561.54	11230.83	36.82
Benin	Processing	409.11	8182.22	26.83
	Marketing	352.59	7051.82	23.12
Ebuguma	Processing	1151.23	23024.67	75.49
	Marketing	1094.71	21894.27	71.78
Egbolom	Processing	1066.44	21328.81	69.93
	Marketing	1009.92	20198.41	66.22
Ekpoma	Processing	509.18	10183.50	33.39
	Marketing	452.66	9053.10	29.68
Kenan	Processing	1103.19	22063.85	72.34
	Marketing	1046.67	20933.45	68.63
Kwale	Processing	776.22	15524.40	50.90
	Marketing	719.70	14394.00	47.19
Omoku	Processing	985.40	19708.06	64.62
	Marketing	928.88	18577.66	60.91
Port Harcourt	Processing	1036.66	20733.30	67.98
	Marketing	980.14	19602.90	64.27
Sagbama	Processing	1094.32	21886.40	71.76
	Marketing	1037.80	20756.00	68.05

Warri	Processing	589.80	11796.04	38.68
	Marketing	533.28	10665.64	34.97
Yenogua	Processing	1059.95	21199.56	69.51
	Marketing	1003.46	210069.16	65.80

Source: United States Geological Survey (2019).

4.3 Shortest Routes between South-Eastern Towns and Study Areas

Table 3 provides information on the shortest routes between Towns in the South-Eastern parts of the country within the buffer, Ugbonla waterside and Igbokoda. Okigwe was the most distanced (1064.88 km and 1121.35 km) city while Onitsha had the least short route (610.54 km and 667.06 km) from this part of the country to marketing and processing areas. Marketers and consumers from Awqunta, Ifeti-Ogwari and Nsukka would have to travel through shortest routes that ranged between 918.84 km–976.88 km and 862.32km–920.37 to these areas respectively. Similarly, white shrimp buyers from others Towns such as Enugu, Ogbede, Orlu and Owerri would travel an estimated distance that ranged between 861.37 km–898.82 km and 804.85 km–842.30 km to Ugbonla and Igbokoda respectively while buyers from Awka, Nnewi and Oguta were estimated to travel through a route that ranged between 749.67km–783.15km and 693.13 km–726.63 km to these areas respectively (Figure 3).

Table 3: Shortest Routes and Estimated Cost of Transportation between Processing and Marketing Areas and Some Towns in South-East, Nigeria

Towns	Segment	Shortest Route (km)	Transportation Cost (₦)	Transportation Cost (\$)
Awqunta	Processing	918.84	18376.85	60.25
	Marketing	862.32	17246.45	56.55
Awka	Processing	758.78	15175.70	49.76
	Marketing	702.26	14045.30	46.05
Enugu	Processing	861.37	17227.35	56.48
	Marketing	804.85	16096.95	52.78
IfiteOgwari	Processing	976.89	19537.85	64.06
	Marketing	920.37	18407.45	60.35
Nnewi	Processing	749.67	14993.43	49.16
	Marketing	693.15	13863.03	45.45
Nsukka	Processing	942.78	18855.55	61.82
	Marketing	886.26	17725.15	58.12
Ogbede	Processing	898.82	17976.32	58.94
	Marketing	842.30	16845.92	55.23
Oguta	Processing	783.15	15663.07	51.35
	Marketing	726.63	14532.67	47.65
Okigwe	Processing	1121.35	22426.91	73.53
	Marketing	1064.83	21296.51	69.82
Onitsha	Processing	667.06	13341.23	43.74
	Marketing	610.54	12210.83	40.04

Orlu	Processing	864.96	17299.18	56.72
	Marketing	808.44	16168.78	53.01
Owerri	Processing	877.48	17549.60	57.54
	Marketing	820.96	16419.20	53.83

Source: United States Geological Survey (2019)

4.4 Shortest Routes between North Central Towns and Study Areas

Result of the buffering analysis indicated that only Kogi State was captured from the central region of the country (Table 4). Buyers from Lokoja, Okene, Ayetoro-Gbede would have to travel through a distance of 826.01km, 750.05km, 707.05km, 670.67km and 769.49km, 693.53km, 650.60km and 614.15km to these areas (Figure 3).

Table 4: Shortest Routes and Estimated Cost of Transportation between Processing and Marketing Areas and Some Towns in the North Central, Nigeria

Towns	Segment	Shortest Route (km)	Transportation Cost (₦)	Transportation Cost (\$)
Ayetoro-Gbede	Processing	707.12	14142.33	46.37
	Marketing	650.60	13011.93	42.66
Kabba	Processing	670.67	13413.36	43.98
	Marketing	614.15	12282.96	40.27
Lokoja	Processing	826.01	16520.24	54.16
	Marketing	769.49	15389.84	50.46
Okene	Processing	750.05	15001.04	49.18
	Marketing	693.53	13870.64	45.48

Source: United States Geological Survey (2019).

4.5 Estimated Budget for Sourcing Smoke-Dried from Processing Areas in the Peak Period

Figure 4 provides information on the estimated budget for sourcing smoke-dried *N. hastatus* from processing areas in a typical peak using the shortest route from towns, estimated cost of transportation and an average cost of shrimp based on the assumption they would source one measure (10.42kg) of the product. Thus, buyers from Ondo and Ore sourcing white shrimp from processing areas in a typical peak month should have an estimated budget that ranged between \$42 and \$52. Other cities and their estimated budget include Benin-City, Ile-Ife and Ijebu-Ode (\$53-59); Ado-Ekiti, Aramoko-Ekiti and Sagamu (\$60-\$64); Agbor, Ekpoma, Ibadan, Ikare-Akoko, Ila-Orangun, Osogbo and Otun-Ekiti (\$65-\$68); Abeokuta, Ajah/Lekki, Auchi, Egbedalkeja, Iwo, Odeda, Ogbomoso, Omuo-Ekiti, Oyo, Victoria Island and Warri (\$69-\$73). Also, buyers from Asaba, Ayetoro-Gbede, Kabba and Onitsha, (\$74-\$79); Awka, Kwale, Nnewi and Oguta (\$80-\$85); Ogbede, Orlu and Owerri (\$86-\$90); Ifite-Ogwari, Nsukka and Omoku

(\$91-\$96); Amasama, Ebuguma, Kenan, Okiqwe, Port Harcourt, Sagbama, Saki and Yenagoa (\$97-\$110).

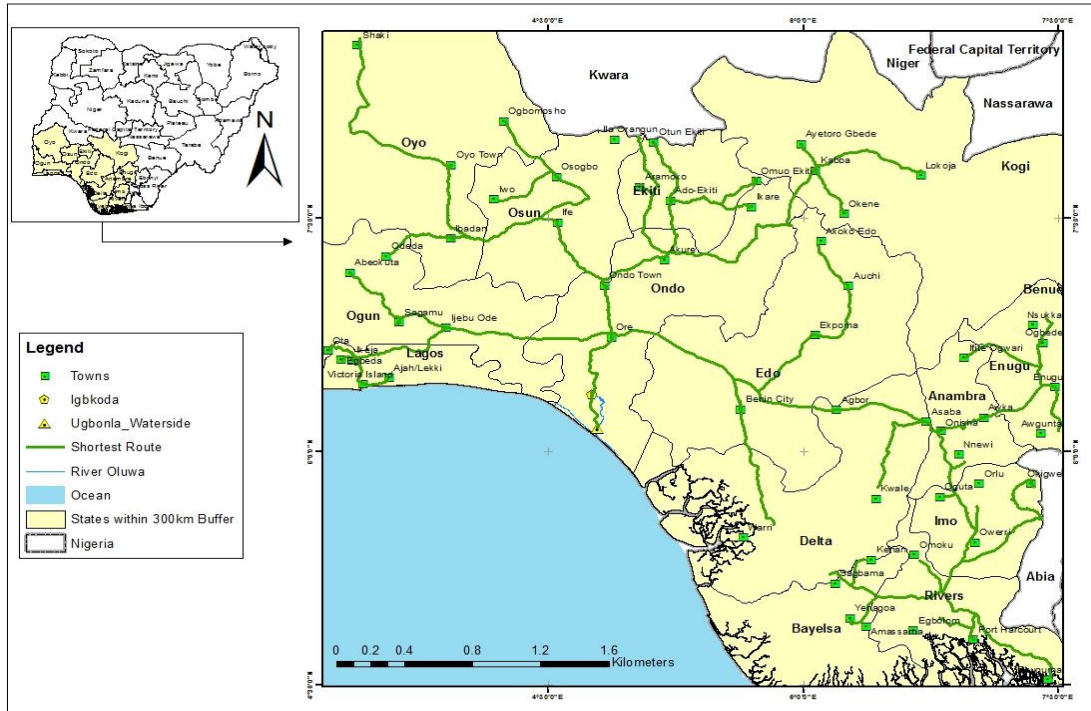


Figure 3: Map of Shortest Routes between Processing, Marketing and Some Towns.

Source: United States Geological Survey (2019).

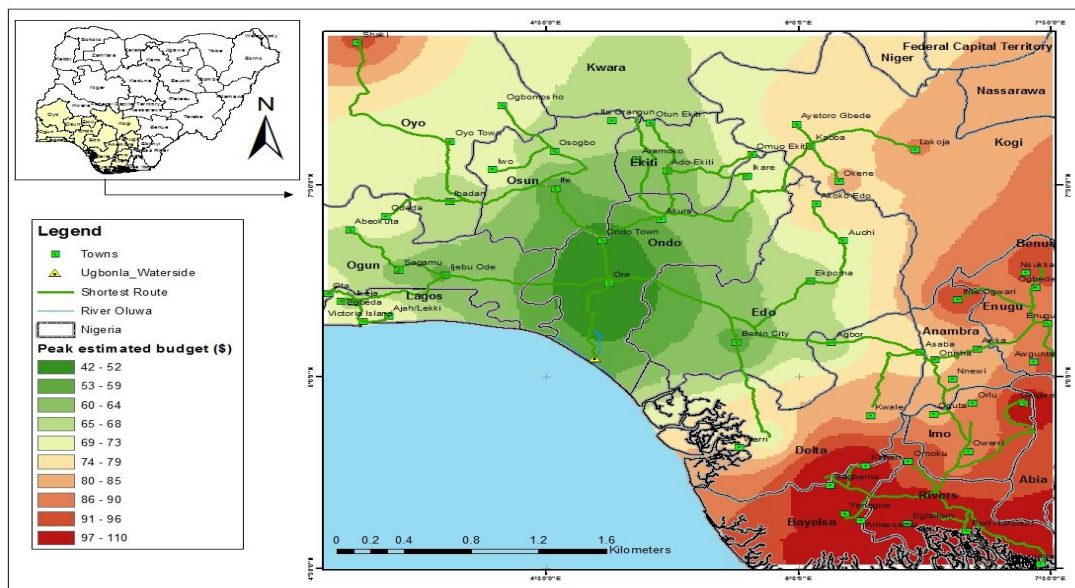


Figure 4: Estimated budget for smoke-dry white shrimp in Towns from Ugbonla waterside in a typical peak month. Source: United States Geological Survey (2019).

4.6 Estimated Budget for Sourcing Smoke-Dried from Processing Areas in Off-peak Period

In a typical off-peak month, dried white shrimp buyers from Ore and Ondo should estimate a budget that ranged between \$59-\$65 and \$73-\$78 to buy 10.42kg of shrimp from processing sites (Figure 5). Equally, buyers from Towns such as Ado-Ekiti, Akure, Benin, Ijebu-Ode and Ile-Ife are expected to budget between \$79 and \$85. Other estimated budgets were Agbor, Aramoko, Ekpoma, Ibadan, Osogbo, Otun-Ekiti and Sagamu (\$86-\$91); Abeokuta, Ajah/Lekki, Asaba, Auchi, Egbeda, Ikare-Akoko, Ikeja, Ila-Orangun, Iwo, Odeda, Ogbomosho, Omuo-Ekiti, Oyo, Victoria Island and Warri (\$92-\$98); Onitsha, Akoko-Edo, Okene, Kabba and Ayetoro-Gbede (\$99-\$105) while marketers and consumers coming from Akwa, Amasama, Egbolom, Eguluma, Enugu, Ifite-Ogwari, Kenan, Kwale, Nnewi, Nsukka, Ogbede, Oguta, Okiqwe, Omoku, Orlu, Owerri, Port Harcourt, Sagbama, Saki and Yenagoa were estimated to spend between \$106-\$123 on transportation and buying a measure of smoke-dried white shrimp from shrimp processing areas in coastal areas of Ondo State, Nigeria in a typical off-peak month.

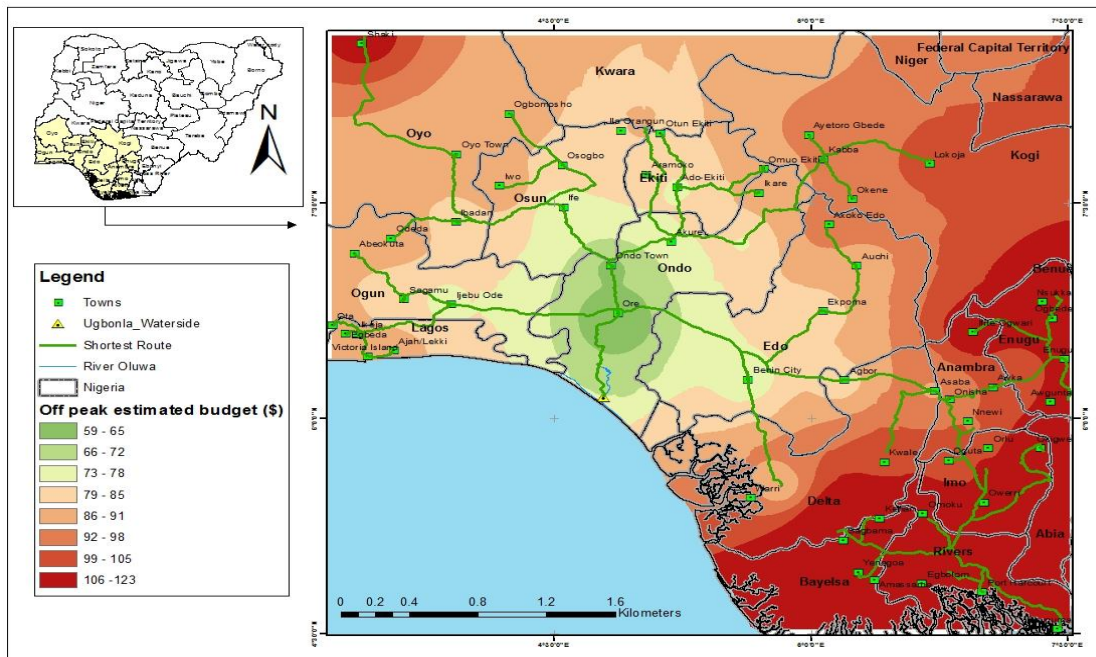


Figure 5: Estimated budget for smoke-dry white shrimp in Towns from Ugbonla waterside in a typical off-peak month. Source: United States Geological Survey (2019).

4.7 Estimated Budget for Sourcing Smoke-Dried from Marketing Area in the Peak Period

Results further indicated that shrimp marketers and consumers travelling from Ore and Ondo to source smoke-dried shrimp in Igbokoda fish market (Figure 6) were expected to budget between \$43 and \$49 in a typical peak month. Information on the estimated budget for buyers from others Towns includes Ado-Ekiti, Akure, Benin-City, Ijebu-Ode and Ile-Ife (\$50-\$56); Agbor, Aramoko-Ekiti, Ibadan, Osogbo, Otun-Ekiti, Owo, Ekpoma and Sagamu, (\$63-\$69); Abeokuta, Ajah/Lekki, Auchi, Egbeda, Ikare-Akoko, Ikeja, Ila-Orangun, Iwo, Odeda, Ogbomosho, Omuo-Ekiti, Oyo, Victoria island and Warri (\$70-\$75); Akoko-Edo, Asaba, Ayetoro-Gbede,

Kabba, Okene and Onitsha (\$76-\$82). Others include Akwa, Kwale, Lokoja, Nnewi and Oguta (\$83-\$88); Enugu, Nsukka, Ogbede, Orlu and Owerri (\$89-\$95); Port Harcourt and Omoku (\$96-\$100) while buyers from Amasama, Ebuguma, Egbolom, Ifite-Ogwari, Kenan, Okiqwe, Sagbama and Saki are estimated to spend between \$101 and \$110 on transportation and cost of buying a measure of smoke-dried *N. hastatus* in a typical peak month.

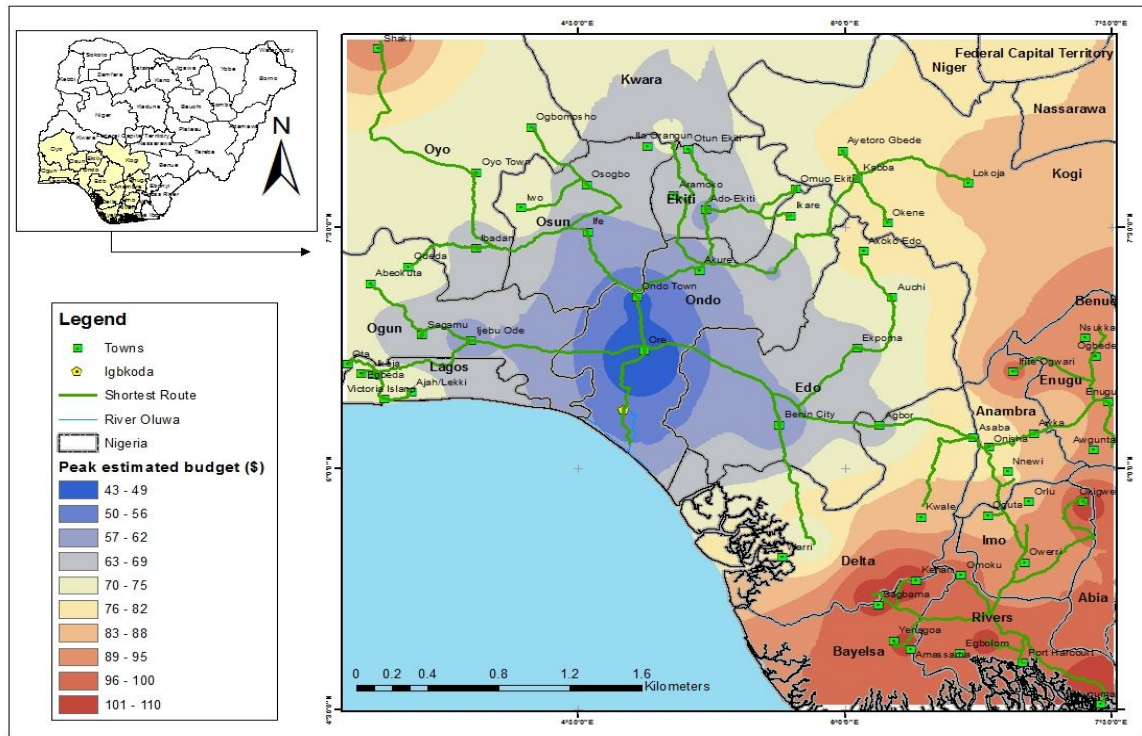


Figure 6: Estimated budget for smoke-dry white shrimp in Towns from Igbokoda in a typical peak month. Source: United States Geological Survey (2019).

4.8 Estimated Budget for Sourcing Smoke-Dried from Marketing Area in the Off-peak Period

Figure 7 provides information on the budget estimates for sourcing a measure (10.42kg) of smoke-dried *N. hastatus* from the major fish market at Igbokoda in a typical off-peak month. The estimated budget for buyers from Ondo and Ore ranged between \$60 and \$67; Ado-Ekiti, Akure, Benin-City, Ijebu-Ode and Ile-Ife (\$74-\$80); Agbor, Aramoko-Ekiti, Ekpoma, Ibadan, Ila-Orangun, Osogbo, Otun-Ekiti and Sagamu (\$81-\$86). Shrimp marketers and consumers coming from Abeokuta, Ajah/Lekki, Auch, Asaba, Egbeda, Ikare-Akoko, Iwo, Odeda, Ogbomosho, Omuo-Ekiti, Oyo, Victoria Island and Warri (\$87-\$93); Akoko-Edo, Ayetoro-Gbede, Kabba, Okene and Onitsha (\$94-\$99); Awka, Kwale, Lokoja, Nnewi, Oguta, Orlu and Owerri (\$100-\$105) while buyers from Amasama, Awqunta, Ebuguma, Enugu, Ifite-Ogwari, Kenan, Nsukka, Ogbede, Okiqwe, Omoku and Sagbama are expected to budget between \$106 and \$125 to source smoke-dried white shrimps from Igbokoda in off-peak periods.

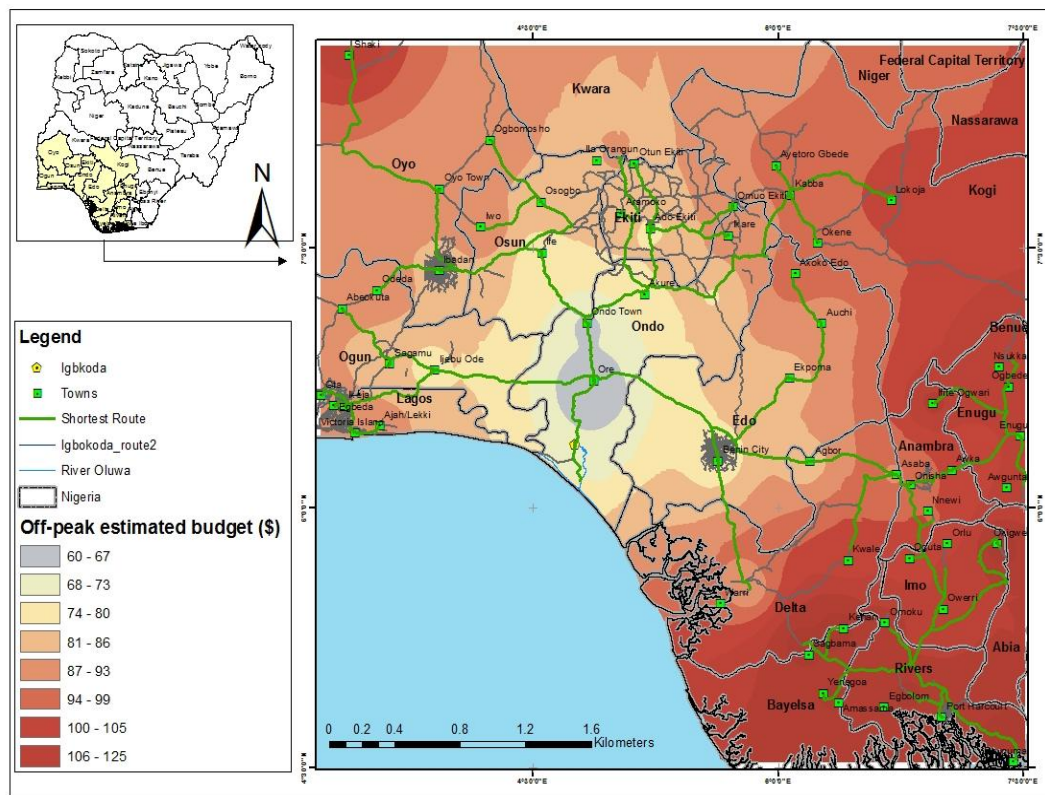


Figure 7: Estimated budget for smoke-dry white shrimp in Towns from Igbokoda in a typical off-peak month. Source: United States Geological Survey (2019).

5. Discussion

Results of this study showed that eight (Anambra, Edo, Ekiti, Enugu, Imo, Kogi, Osun and Oyo) States out of the fourteen (14) States captured in the 500 km were landlocked while the remaining six States (Bayelsa, Delta, Lagos, Ogun, Ondo and Rivers) shared borders with the Gulf of Guinea [18]. For State bordered by the Atlantic Ocean, there exists abundance and distribution of marine aquatic species including penaeid shrimps. Various authors such as Agbo and Usoroh [5]; Ngodigha, Gbarabe [19]; Olawusi-Peters and Ajibare [4]; Ajani, Bello [20] and Okayi and Solomon [8] have reported a high frequency of occurrence and abundance of shrimp most especially *N. hastatus* in these areas. Hence, the result of this research is of primary importance to States that are landlocked and low in aquatic food production.

The result of the study was equally important to the findings of [21] who stated that majority of secondary and tertiary marketers who sourced white shrimp from the coastal marketing areas were from South-Western and South-Eastern parts of Nigeria. Majority of participants sourcing white shrimp from processing areas or transporting them from processing sites to Igbokoda market were involved in two modes of transportation. The first mode involved moving smoke-dried *N. hastatus* from Ayetoro to Ugbonla (5.05km) and Bijimi to Ugbonla (10.43km) while the

second node involves transporting shrimp via road from Ugbonla to Igbokoda (28.26km). Though, there was an inland waterway prospective consumers/marketers/processors could access processing areas and Igbokoda; however, assessing these areas via water transportation from Igbokoda to Ayetoro (43.53km) and Igbokoda and Bijimi (51.31km) was longer than assessing these areas via a stop on road at Ugbonla and using boats from there to Ayetoro or Bijimi on a distance of 5.05km and 7.78km respectively. Water transportation from Ugbonla to Igbokoda, however, provides better logistic for processors and marketers transporting/sourcing larger volume of shrimp to Ayetoro and Igbokoda respectively. The distance on water from Ugbonla to Igbokoda on water (38.48km) makes transportation of shrimp via road from Ugbonla to Igbokoda (28.26 km) a better choice for small scale actors in the shrimp marketing chain. [22] described road and water transportation as the two modes of transportation that incur a relatively lower cost with the latter being more effective for significantly larger quantities of goods.

Shortest route analysis between towns within the buffer and marketing areas as well as point of access to processing areas are important to marketers' sales volume and their ability to deliver the proper levels of customer service in a cost-effective manner [23]. Hence, shrimp buyers are expected to pass through routes that could reduce transportation cost as well as makes smoked shrimp available to retail outlets and consumers at a reduced price. Shorter routes between the towns and major shrimp market at Igbokoda provides buyers with a lesser estimated budget for transport logistics compared with higher values computed from longer routes between the towns and Ugbonla waterside. The shortest route between the towns and Igbokoda fish market as well as the easy accessibility to the area might be attributed to the reason the market was a preferred destination for sourcing aquatic products [7].

However, despite the shorter routes from the towns to the marketing site, sourcing shrimp from processing areas via Ugbonla provided buyers with an estimated budget that was lesser than the values recorded for Igbokoda. The differences in the estimated budget for sourcing shrimp from the two facilities could be attributed to the differences (28.26km) between the point of access to processing areas by road (Ugbonla) and the major fish market at Igbokoda. This implies that the total return difference for a typical participant in the shrimp marketing in the study area was 56.52km. Therefore, retail marketers and consumers were expected to get smoked *N. hastatus* at lower prices in towns within the buffer when the origin was from the processing areas while buyers in the towns would get the shrimp species at higher due to higher cost of shrimp at Igbokoda market. Generally, taking a product through a longer/shorter route would increase/reduce transportation cost and ultimately increase/reduce the price at consumers get the product.

Furthermore, the result of this study implies that marketers would get the product from Ugbonla waterside to Ondo and Ore by road in a typical peak month at an estimated budget that ranges between \$4.03 and \$4.99/kg; in Benin-City, Ile-Ife and Ijebu-Ode (\$5.09-\$5.66/kg); Ado-Ekiti, Aramoko-Ekiti and Sagamu (\$5.76-\$6.14/kg); Agbor, Ekpoma, Ibadan, Ikare-Akoko, Ila-Orangun, Osogbo and Otun-Ekiti (\$6.24-\$6.53/kg); Abeokuta, Ajah/Lekki, Auchi, Egbedalkeja, Iwo, Odeda, Ogbomosho, Omuo-Ekiti, Oyo, Victoria Island and Warri (\$6.62-\$7.01/kg). Also, buyers from Asaba, Ayetoro-Gbede, Kabba and Onitsha, (\$7.10-\$7.58/kg);

Awka, Kwale, Nnewi and Oguta (\$7.68-\$8.16/kg); Ogbede,Orlu and Owerri (\$8.25-\$8.84/kg); Ifite-Ogwari, Nsukka and Omoku(\$8.73-\$9.21/kg); Amasama, Ebuguma, Kenan, Okiqwe, Port Harcourt, Sagbama, Saki and Yenagoa (\$9.31-\$10.56/kg).

Equally smoked *N. hastatus* would get to Ore and Ondo in the off-peak period from processing sites between \$5.66-\$6.24 and \$7.01-\$7.45 per kilogramme. The same quantity was estimated to get to Ado-Ekiti, Akure, Benin, Ijebu-Ode and Ile-Ife are expected to budget between \$7.58-\$8.16/kg. Marketers would get the product to Agbor, Aramoko, Ekpoma, Ibadan, Osogbo, Otun-Ekiti and Sagamu at an estimated cost of \$8.25-\$8.73); in Abeokuta, Ajah/Lekki, Asaba, Auchi, Egbeda, Ikare-Akoko, Ikeja, Ila-Orangun, Iwo, Odeda, Ogbomosho, Omuo-Ekiti, Oyo, Victoria Island and Warri (\$8.82-\$9.40/kg); in Onitsha, Akoko-Edo, Okene, Kabba and Ayetoro-Gbede (\$9.50-\$10.07/kg) while the product was estimated to get to Akwa, Amasama, Egbolom, Eguluma, Enugu, Ifite-Ogwari, Kenan, Kwale, Nnewi, Nsukka, Ogbede, Oguta, Okiqwe, Omoku, Orlu, Owerri, Port Harcourt, Sagbama, Saki and Yenagoa at \$10.17-\$11.80 per kilogramme by road from Ugbonla waterside.

Also, marketers would get the product from the fish market at Igbokoda via the road at an estimated cost/kg slightly lesser than the value recorded for Ugbonla waterside by the same mode of transportation. Therefore, a kilogramme of this estuarine shrimp would get to Ore and Ondo in a typical peak period at an estimated budget that ranged between \$4.13 and \$4.70/kg in a typical peak month while same quantity was estimated to get to Ado-Ekiti, Akure, Benin-City, Ijebu-Ode and Ile-Ife at (\$4.80-\$5.37/kg); Agbor, Aramoko-Ekiti, Ibadan, Osogbo, Otun-Ekiti, Owo, Ekpoma and Sagamu,(\$6.04-\$6.62/kg); Abeokuta, Ajah/Lekki, Auchi, Egbeda, Ikare-Akoko, Ikeja, Ila-Orangun, Iwo, Odeda, Ogbomosho, Omuo-Ekiti, Oyo, Victoria island and Warri (\$6.72-\$7.20); in Akoko-Edo, Asaba, Ayetoro-Gbede, Kabba, Okene and Onitsha (\$7.29-\$7.87). in Akwa, Kwale, Lokoja, Nnewi and Oguta (\$7.97-\$8.45); Enugu, Nsukka, Ogbede, Orlu and Owerri (\$8.54-\$9.12); Port Harcourt and Omoku (\$9.21-\$9.60/kg) while the product was estimated to get to Amasama, Ebuguma, Egbolom, Ifite-Ogwari, Kenan, Okiqwe at a cost that ranged between \$9.69 and \$10.56/kg in a typical peak month.

Estimated cost for buyers from Ondo and Ore ranged between \$5.76 and \$6.43/kg; Ado-Ekiti, Akure, Benin-City, Ijebu-Ode and Ile-Ife (\$7.10-\$7.68/kg); Agbor, Aramoko-Ekiti, Ekpoma, Ibadan, Ila-Orangun, Osogbo, Otun-Ekiti and Sagamu (\$7.77-\$8.25/kg); Abeokuta, Ajah/Lekki, Auchi, Asaba, Egbeda, Ikare-Akoko, Iwo, Odeda, Ogbomosho, Omuo-Ekiti, Oyo, Victoria Island and Warri (\$8.35-\$8.93/kg); Akoko-Edo, Ayetoro-Gbede, Kabba, Okene and Onitsha (\$9.02-\$9.50); in Awka, Kwale, Lokoja, Nnewi, Oguta, Orlu and Owerri (\$9.60-\$10.08/kg) while the product was expected to get to Amasama, Awqunta, Ebuguma, Enugu, Ifite-Ogwari, Kenan, Nsukka, Ogbede, Okiqwe, Omoku and Sagbama from Igbokoda at an estimated cost that ranged between \$10.17 and \$11.20 per kilogramme.

Generally, increasing the volume of Q in equation II would lead to a reduction of the rate at which the product gets to the towns within the buffer per kilogramme. This implies that consumers and other retail agents stand a chance of buying at a much-reduced price (USD/kg) when marketers transport higher volume of shrimps from the study area to towns/cities within the buffer as well as allow marketers to cover their marketing expenses and earn a profit on a

wider window. However, consumers would buy at an increased price and marketers' window for recovering expenses would become narrow when smaller quantities of the product are transported using the same shorter routes and transportation cost.

6. Conclusion

This research provides information on the length of routes and estimated budget requirements for sourcing smoked white shrimp from marketing and processing areas from states/towns within the buffer; most especially areas that were landlocked or have less abundance of the species under study. It indicated that Igbokoda had the shortest routes to towns/cities within the buffer than the Ugbonla waterside. However, the lower price of smoked shrimp at processing areas led to lower estimated cost at which the product would get to the towns within the buffer per measure/ kilogramme. The result provides prospective actors in shrimp marketing with estimates of shortest routes, transportation cost and estimated budget for sourcing white shrimps and other aquatic products from the coastal areas of Ondo State, Nigeria in the peak and off-peak seasons respectively. Developing a shrimp market at Ugbonla waterside would open the community for more economic development and attraction due to easy accessibility to shrimping and processing areas. Therefore, prospective marketers and consumers interested in accessing this highly nutritional species from these areas could be guided by this information for effective and profitable shrimp trade and marketing.

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