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SUMMARY

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RESEARCH ARTICLE OPEN ACCESS

CATCHMENT SCALE ASSESSMENT OF RIVER-WATER QUALITY IN AN UNGAUGED ENVIRONMENT

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ABSTRACT

This paper examines the application of coupled integrated model SWAT with emphasis on dynamic, physically-based modelling approaches that integrate the effects of different environmental processes across catchment scales in characterising and quantifying river water quality status. The plan is to address morphological and ecological impacts on streams and by extension, the creation of a link to correctly assess river water quality based on the attributes of the delineated catchment in ungauged and data-poor environments. The resultant pollutions are conditioned on the heterogeneity of the landscape features that control both hydrology and pollutant export coefficients which are variably distributed across catchment. The study area was delineated into five (5) landuse, land cover attributes: forest, cultivation, impervious, urbanisation and industrial within the following settlements, Ita-Iku, ABUAD farm, Ago-Aduloju, Igbemo, Ogbese-Ise and Ita-Ogbolu. A total of twenty-nine quality parameters were invesigated with the results indicating that the regions with with close proximity to emerging urbanisation and industrial development were most impacted. This serves as a policy guiding tool for water resource managers to incorporate different management scenarios in the surface water pollution abatement and control.

I. INTRODUCTION

Human developments in all facets and associated environmental vices have continued to exert great and diverse pressures on both the quality and quantity of water resources which in turn impact conditions fostering water-associated diseases [1]. A conformist estimate designated that 4.0% of global deaths and 5.7% of the global disease burden in disability adjusted life years – DALYs [2-3] were attributable to a small subset of water and sanitation related infectious diseases. [4] goes beyond the evaluation of damage to the ecosystem by reason of pollution sources by extending the scope to the dynamic nature of land use and persistence changes in the environmental factors as a strong influence on the non-point pollution source to streams and other water bodies. The resultant pollutions are conditioned on the heterogeneity of the landscape features that control both hydrology and pollutant export coefficients which are variably distributed across catchment. A classical example of the delineated catchment impact on a stream is represented in Figure 1.

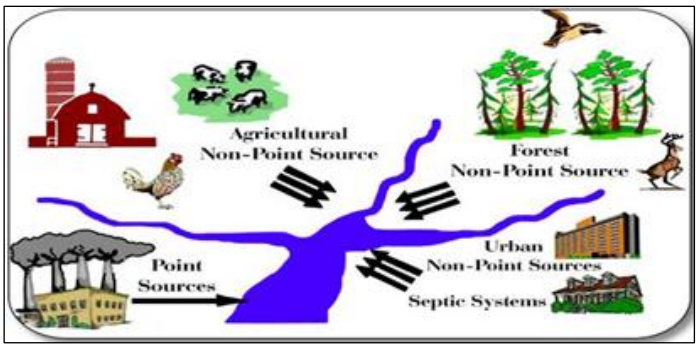


Figure 1: Schematic diagram of Non-point pollution sources in a typical catchment.
Source: [5].

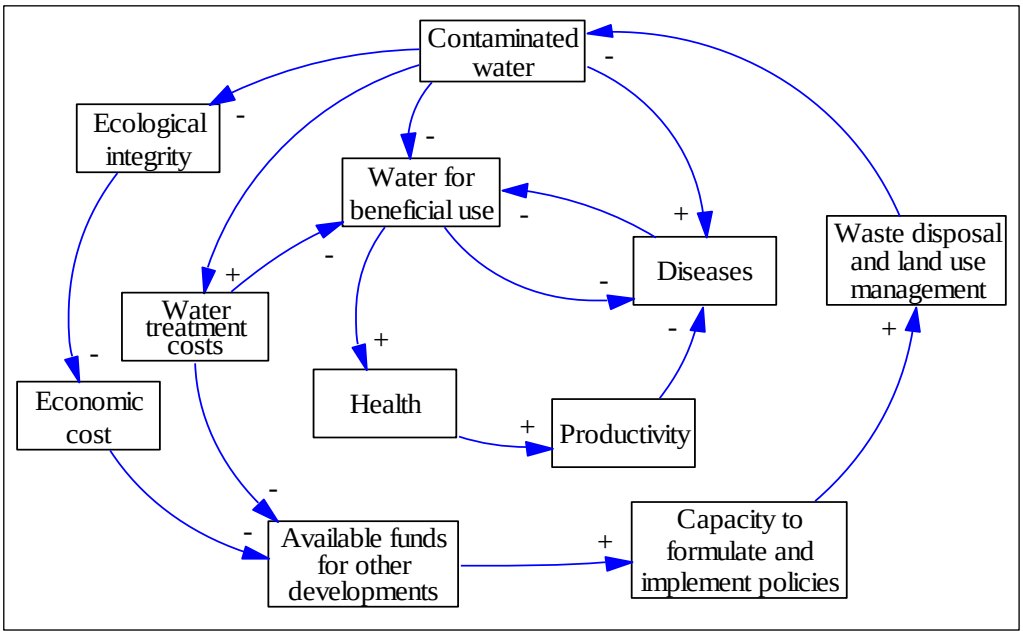
Thus, catchment scale hydrology and non-point source pollution evaluation is better addressed by a distributed-system modelling concept that accounts for all part of the catchment simultaneously and incorporates spatial and temporal variability due to the catchment attributes [1]. The concept of evaluation, by extension, consists of the methods, procedures and agents required for the transportation of pollutant from the source end to the receiving ends. Following this concept is direct to using a simulation method but as a prelude to verification of the expected result of the simulation, it is essential to make on the spot assessment of the water quality on location specifics, stemming from the delineation of the catchment at points through which the principal stream passes.

II. THEORETICAL REFERENCE

II.I THE SIGNIFICANCE OF POLLUTION

Generally, changes in biotic factors such as water nutrients and bacteria loading occasioned by anthropogenic activities, have been identified to interfere negatively with the food chain and life distribution in the water bodies which prove to be very useful for evaluating the impacts on the water status and probable effects of various measures on the environment [6]. Many environmental pollutants are hazardous to human health with the resultant effect in reducing life expectancy. This measure of life is recognised as an index to quantify the health impact of environmental pollution, especially stream pollution, in the assessment of diseases burden in larger part of today's communities. It is, therefore, relatable to note that many disease causative agents have their route and pathway in the water body at one point or the other. This informed the general framework of the diseases classification as water-borne, water-based, water-related, water-washed and water-dispersed [1]. For example, waterborne diseases, such as typhoid and cholera, are typically caused by enteric microorganisms such as Vibriocholerae, which enter water sources through faecal contamination and cause infections in humans through ingestion of contaminated water [6]. Evaluation of this pathway of transforming pollution data into disease data becomes fitting requirement on a data collection or data source and analysis of quantifying diseases burden in an ungauged environment.

Because of the level of development and poor hygiene conditions, sub-Saharan African countries is laddened with many of these water-borne problems and the consequent effects of casualties are often not recognized, reported or documented [1]. These effects and measures are captured in the health and productivity causal loop HPCL presented in Figure 2.



**The concept of adaptative sytem dynamics depicting impact of waste disposal and land management on health and economic security.*

Figure 2: Causal loop on Environmental health and Economic security.
Source: [1].

III. MATERIALS AND METHODS

III.I THE STUDY AREA

The domain of the study area with the drainage network shown in Figure 3 is a typical rainforest covering a land area of 2475 km^2 with a population density of 265 per km^2 computed based on the 2009 National population census with an assumed growth rate of 2.8 percent [1]. The catchment elevation ranges from 550 masl near the source at Igede-Ekiti (7º46'00.67"N; 5º16'00.50"E) to 307 masl at the gauge station Ayede-Ogbese (7º12'56.04"N; 5º20'51.54"E). The river is of the second order type with major tributaries at the upper and the lower courses. The upper bound of the catchment is much larger with few tributaries which may increase the downstream flow by more than twice with respect to the upstream value. The slope of the stream is more pronounced in the upper stream part of Ago Aduloju than at the middle course at Ogbese-Ise up to Ita-Ogbolu, and then increases in the final part [1]. This, together with the major tributaries located in the downstream part, makes the final part of the river much richer in flow and speed contrary to what obtains in most rivers where the upstream parts are steeper with fast flow. Nonpoint source pollution from agriculture is expected to make a measurable contribution to the river pollution. The upstream and the downstream are relatively unspoiled with densely vegetated riparian zones and sparse human settlements. In these sections, the photosynthetic action is considerable given the high nutrient content of the influent flow and attendant self-purification is very potent.

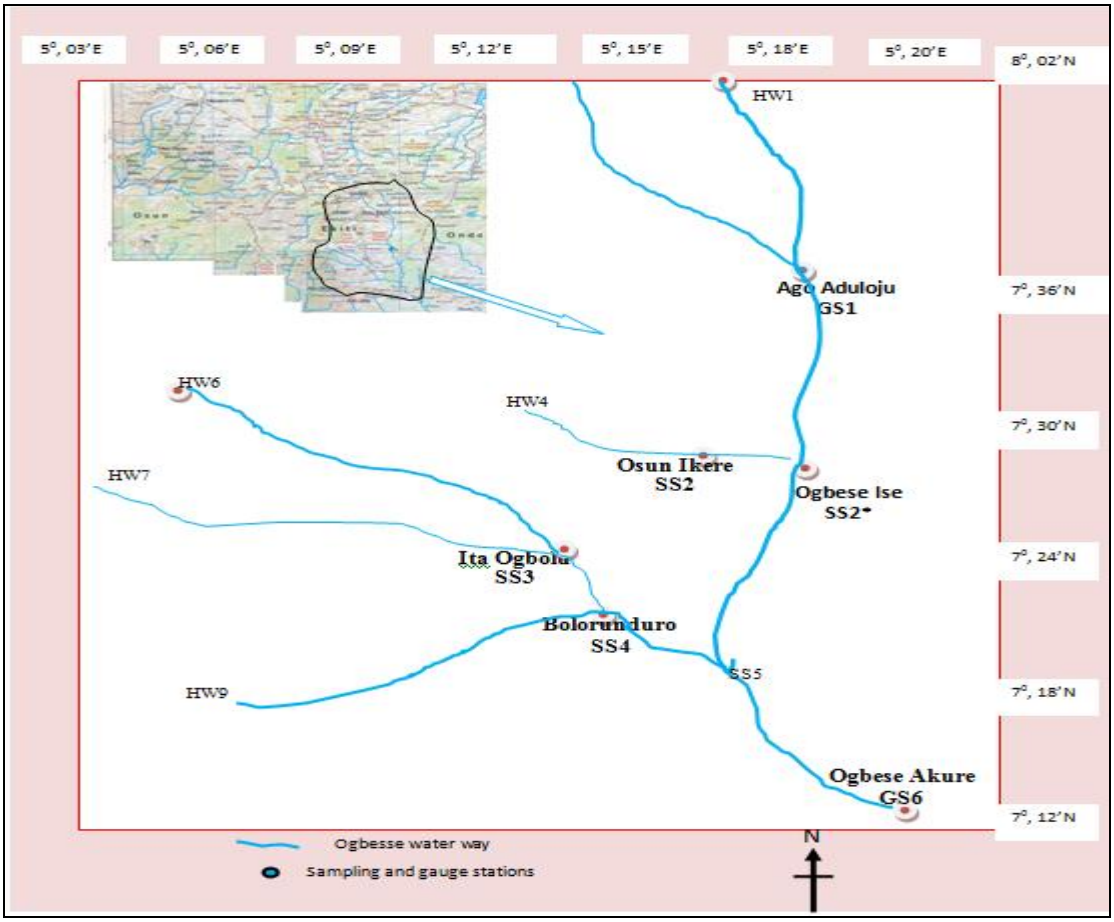


Figure 3: Extract from the Map of Nigeria showing drainage of the study área.
Source: Authors, (2021).

This paper incorporates Soil and Water Assessment Tool (SWAT), a catchment-scale model developed by [7] for the USDA Agriculture Reserve Service (ARS) primarily to predict the impact of land management and non-point source pollution on water, sediments and nutrients yield in large ungauged river catchments. The model concept framework, as expressed in Figure 4, stresses the environmental factors that impact water quality, flexibility in basin discretisation and continuous time simulation.

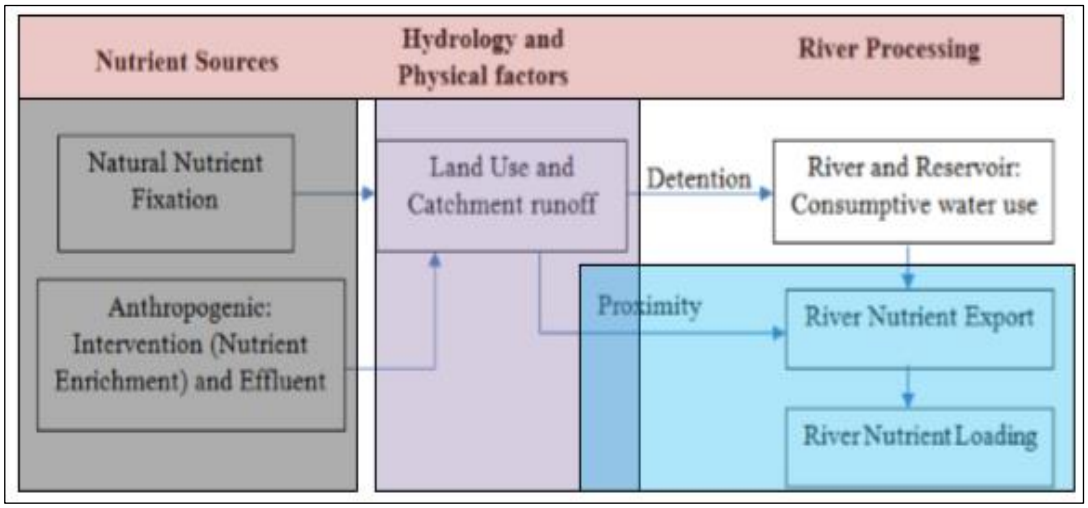


Figure 4: Catchment-Nutrient Export and Loading Scheme for Rivers: Sources and Sink.
Source: Authors, (2021).

The model integrates soil moisture replenishment, depletion and redistribution for the dynamic variation in areas contributing to direct runoff and in effect, the resulting river-water quality. Regardless though the limitation in data-feed, it provides a platform to evaluate the relationship between land use and in-stream water quality. It operates on a daily time step that allows the catchment to be subdivided into grid cells through which hydrologic components and their interaction are simulated as realistically as possible. Based on this concept, the study area was delineated into five (5) landuse sections, Table 1, for the purposes of capturing the relative contribution of each section into the stream load.

Table 1: Descriptive information of LULC for hydraulic load.

Sub-catchment code	Area (Km^2)	% Forest	% Cultivation	% Impervious	% Urbanisation	% Industrial	Reach Length (km)
1	446	41	45	1.75	12.5	0.05	18.700
2	403	30	57	3	9	1	20.320
3	220	25	42	5	25	3	15.230
4	144	12	52	7.5	27	1.5	13.720
5	378	25	60	5	10	0	25.610
6	226	20	50	22	8	0	17.800
7	125	15	62	15	8	0	14.600
8	56	15	62.5	10	12	0.5	11.180
9	195	21	52	10	15	2	22.720
10	125	22	45	5	25	3	8.810
11	157	20	28	10	37	5	12.820

Source: Authors, (2021).

III.2 SAMPLE COLLECTION AND ANALYSIS CAMPAIGN

III.2.1 Selection of the Sampling Point

The consideration for selecting the sampling points were based on the catchment delineation and the landuse landcover of the catchment area. Therefore it was important to see the water quality as a reflection of this delineation, especially where the rivers are flowing through the regions of special activities or have a close proximity to such areas. Therefore, six different locations along the course of Ogbese river were chosen based on designed criteria. These areas are Ita-Iku, ABUAD farm, Ago-Aduloju, Igbemo, Ogbese-Ise and Ita-Ogbolu.

III.2.2 In-situ Analysis

Representative water sampling was carried out from each location during the dry and rainy seasons of the year 2020 within the constraint of COVID-19 protocols. For in-situ water quality parameters, samples were collected in accordance with (SOP: 1040R01 Water Sampling.doc) and analysed in duplicates. The average values of the samples were used for graphical illustration. In-situ collection and analysis follows the standard protocols and methods of American Public Health Organization (APHA) [8] and American Society for Testing and Materials (ASTM) using different calibrated standard instruments [9]. Variables analysed are chemical components of collected water samples, dissolved oxygen (DO), pH, total suspended solids (TSS), total dissolved solids (TDS), turbidity, and electrical conductivity. The pH of the water samples was measured by using a pH meter (model HI 98130 HANNA, Mauritius, Iramac Sdn. Bhd). The temperature ranges between 27°C and 33°C for the duration of the water sampling seasons of the year. This region has been known for a marginal difference in seasonal temperatures over the years. Each of the duplicate samples were analysed for a number of parameters in the laboratory to determine their overall compliant with the WHO standard and the local regulating unit. Conductivity meter, model HI 98130 HANNA, Mauritius, Iramac Sdn. Bhd was used to assess the conductivity of the samples with its probe calibrated using a standard solution of a known conductivity. Care was taken to prevent cross contamination among different samples by rinsing the probe with deionized water at the close of each sampling. The water sample turbidity was measured using a turbidity meter (model 2100P Turbidimeter HACH, Colombia, USA, Arachem (M) Sdn. Bhd.).

III.2.3 Laboratory Analysis

The measurements of the laboratory-based water quality parameters, mainly the chemical and some of the physical parameters, were carried by using DT–3900 Multi-parameters Water Quality Analyser with accuracy to determine turbidity and suspended solids in accordance with DIN EN ISO. The instrument uses the infrared duo scattered light method Solitax sc to provide a unique colour independent measurement of solids and a reliable sludge analysis. A blank water sample is normally set as a standard to calibrate the machine prior to and a water sample to be tested according to the experimental procedure attached to the reagent manual corresponding to the item. When the instrument is working, the absorbance of the sample liquid and the standard solution/control liquid are first deected, and then the state of the substance to be tested in the sample liquid is determined through the analysis and calculation. The instrument is used together with with the water quality testing reagents, and the water sample is quantitively determined by photoelectric colorimetry. The results were recorded automatically on the machine visual display unit. Values of the parameters are presented in Table 2.

Table 2: Quality Parameters of selected locations along the River course.

No	Parameters	ITA-IKU	ABUAD FARM	AGO ADULOJU	ITAOGBOLU	OGBESE ISE	IGBEMO
1	Colour	Whitish	Brownish	Brownish	Greenish	Brownish	Brownish
2	Temperature	27ºC	27ºC	27ºC	27ºC	27ºC	27ºC
3	Turbidity	6NTU	45NTU	22NTU	8NTU	15NTU	18NTU
4	DO	5.7 mg/L	3.4 mg/L	3.9 mg/L	4.6 mg/L	4.3 mg/L	4.1 mg/L
5	TSS	180 mg/L	530 mg/L	450 mg/L	230 mg/L	310 mg/L	360 mg/L
6	TS	240 mg/L	710 mg/L	560 mg/L	360 mg/L	420 mg/L	480 mg/L
7	TOC	6.45 mg/L	11.6 mg/L	13.55 mg/L	12.3 mg/L	7.1 mg/L	11 mg/L
8	Calcium	2 mg/L	12 mg/L	10 mg/L	8 mg/L	10 mg/L	9 mg/L
9	Org. Nitrogen	0.6 mg/L	2.8 mg/L	1.9 mg/L	1.2 mg/L	2.1 mg/L	1.7 mg/L
10	PH	7.29	7.10	6.92	6.84	7.02	6.93

No	Parameters	ITA-IKU	ABUAD FARM	AGO ADULOJU	ITAOGBOLU	OGBESE ISE	IGBEMO
11	Acidity	16.81 mg/L	18.4 mg/L	20mg/L	8.81 mg/L	23.2 mg/L	18.4 mg/L
12	Alkalinity	10 mg/L	160 mg/L	95 mg/L	45 mg/L	75 mg/L	70 mg/L
13	Ammonia	0.9 mg/L	16.0 mg/L	10.6 mg/L	4.0 mg/L	9.1 mg/L	8.6 mg/L
14	Nitrogen	1.6 mg/L	9.0 mg/L	4.1 mg/L	2.2 mg/L	4.2 mg/L	3.7 mg/L
15	Phosphate	2.4 mg/L	64.5 mg/L	18.7 mg/L	5.6 mg/L	18.2 mg/L	14.3 mg/L
16	Sulphate	8 mg/L	35 mg/L	17 mg/L	13 mg/L	20 mg/L	18 mg/L
17	Zinc	0.4 mg/L	7.4 mg/L	4.8 mg/L	0.6 mg/L	2.6 mg/L	0.6 mg/L
18	Magnesium	4.01 mg/L	20 mg/L	13 mg/L	3 mg/L	7 mg/L	3 mg/L
19	Hardness	9 mg/L	38 mg/L	27 mg/L	6 mg/L	15 mg/L	5 mg/L
20	Lead	0.017 mg/L	0.02 mg/L	0.02 mg/L	0.02 mg/L	0.02 mg/L	0.02 mg/L
21	Iron	0.25 mg/L	1.80 mg/L	0.89 mg/L	0.30 mg/L	0.75 mg/L	0.55 mg/L
22	Oil & Grease	54.7 mg/L	75.3 mg/L	66 mg/L	57.3 mg/L	60.7 mg/L	63.3 mg/L
23	BOD	8.6 mg/L	11.8 mg/L	17.6 mg/L	14.7 mg/L	8.9 mg/L	11.8 mg/L
24	COD	20 mg/L	36 mg/L	42 mg/L	38 mg/L	22 mg/L	34 mg/L
25	EC	256 us/cm	138.9 us/cm	114.6 us/cm	55.5 us/cm	106.8 us/cm	86.1 us/cm
26	TVC	6	57	43	28	47	34
27	TCC	0	15	10	5	12	8
28	E.coli	0	4	2	0	3	2
29	MPN	0	18	14	6	16	10

**Note: TVC = total variable count: TCC = total coliform: MPN = most probable number.*

Source: Authors, (2021).

Table 4: Correlation coefficient of some of the water quality parameters in the study.

	Temperature	Turbidity	Do	PH	Hardness	Zinc	Discharge	TDS	BOD	COD	E coli
Temperature	1										
Turbidity	0.81	1									
Do	-0.77	-0.83	1								
PH	-0.31	0.02	0.49	1							
Hardness	0.61	0.88	-0.67	0.14	1						
Zinc	0.66	0.91	-0.76	0.04	0.99	1					
Discharge	0.19	0.45	-0.49	-0.10	0.43	0.49	1				
TDS	0.88	0.82	-0.86	-0.39	0.60	0.68	0.61	1			
BOD	0.50	0.15	-0.44	-0.70	0.25	0.27	-0.22	0.29	1		
COD	0.77	0.41	-0.65	-0.71	0.35	0.40	-0.08	0.58	0.92	1	
E coli	-0.37	-0.10	0.59	0.95	0.08	-0.02	-0.34	-0.55	-0.52	-0.62	1

Source: Authors, (2021).

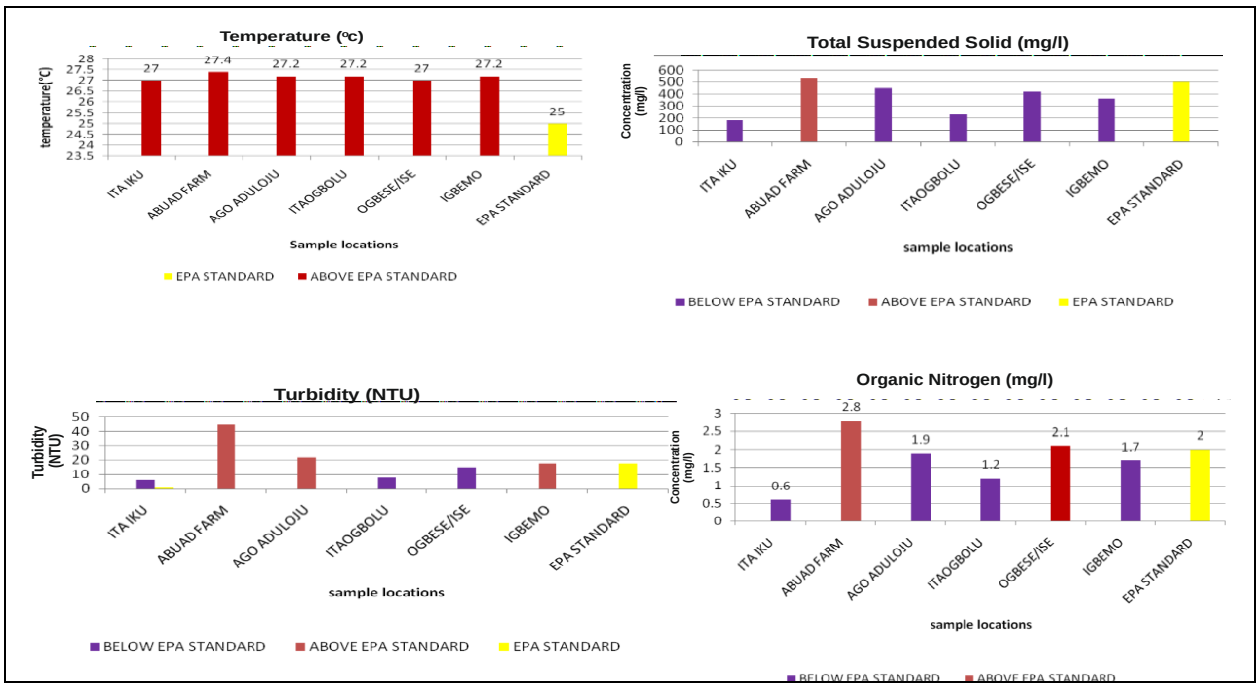


Figure 5: Some water quality parameters concentrations at various sites and in comparison with EPA standard.
Source: Authors, (2021).

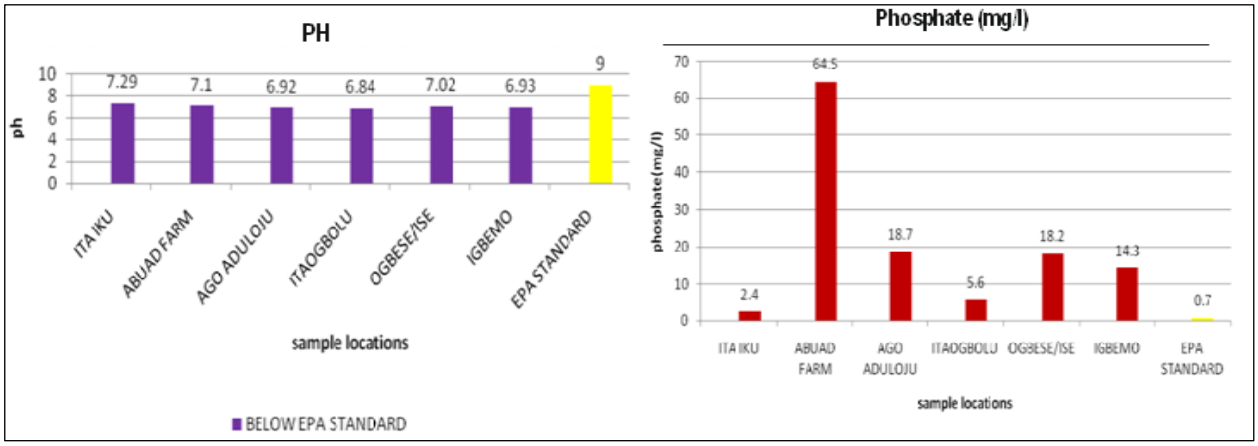


Figure 6: pH and Phosphate concentrations at various sites and in comparison with EPA standard.
Source: Authors, (2021).

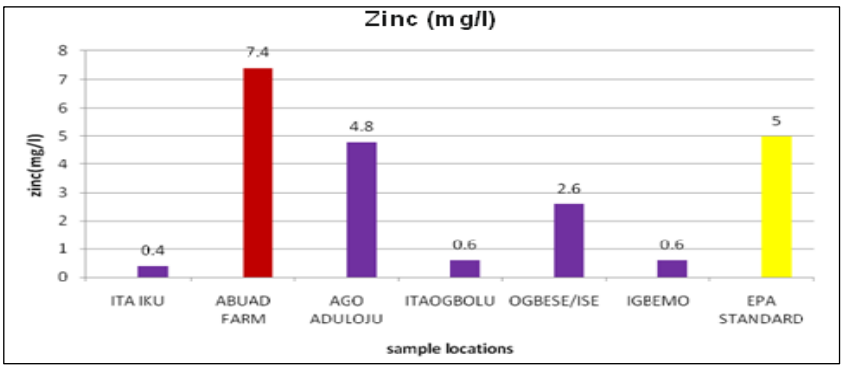


Figure 7: Zinc concentrations at various sites and in comparison with EPA standard.
Source: Authors, (2021).

IV. RESULTS AND DISCUSSIONS

IV.1 PH

The pH ranged between 6.93 and 7.29 with with Ita-Iku and ABUAD having the highest values 7.29 and 7.10 respectively There were no significant differences in the values of the pH although the values are, however, within the acceptable limits of the WHO. This is acceptable because the water would unlikely cause ailments such as acidosis. The pH is an indicator of the presence of microorganisms as it controls.

IV.2 TURBIDITY

The turbidity ranged between 6.0 to 45 NTU with ABUAD farm and Igbemo axis of the water stretch leading. There were significant differences in the values of turbidity as a reflection of development and farming activities around the river course where the samples were taken. This is understandable and acceptable because the water would likelybe imparted by the debries carried by the runoff from these riparian zones.

IV.3 ELECTRICAL CONDUCTIVITY (EC)

This is a measure of the dissolved ionic component and total dissolved substitution in water [10]. There were significant differences in the values of the electrical conductivity, although the samples were within the permissible limits of 1000 µs/cm of WHO maximum permissible limits for conductivity. The values of the electrical conductivity ranged between 86.1 us/cm and 256 µs/cm with Ita-Iku and ABUAD farm having the largest concentrations. The results indicated that the water samples are not salty as the concentration of salts dissolved in the water is as little as possible. The consumption of the water, which has values above the permissible limits over a period of time, has harmful effects on the health of man as it can defect the endocrine functions and cause total brain damage [11].

IV.4 TOTAL SUSPENDED SOLIDS (TSS)

The total dissolved solids ranged between 180 and 530 mg/L with the highest value coming from the water from ABUAD and Ago-Aduloju. These are the mid upstream sections of the river respectively where scouring and erosive actions are prominent owing to the steep topograhy coupled with the anthropogenic activities within the area. The soil layer in this region has for ages been disturbed by deforestation occasioned by cut and slash in farming process. The portion is often overgrazed by the cattle herders. Although, there were noted significant differences in the values of the TSS of the water samples they fall within the permissible l.

IV.5 CALCIUM

The value for the calcium ranged between 2 and 10mg/L with the water samples from ABUAD farm having the highest value of 12 mg/L and the least from Ita-Iku. There were significant differences in the values although the values were within the WHO permissible limits of 75 mg/L. imits of 500 mg/L.

IV.6 TOTAL HARDNESS

From the values obtained from the analysis, the total hardness ranged between 6.0and 38.0 mg/L higher at the region

around the ABUAD farm and a downward trend towards the downstream of the river. All the values were within the limits of the WHO permissible limits of 150 mg/L. There was no significant difference in the value of total hardness for all the samples; therefore, the total hardness could not have been said to pose any danger to the health of the populace who live around the area.

IV.7 CHEMICAL OXIDATION DEMAND (COD) AND BIOLOGICAL OXIDATION DEMAND (BOD)

The value for the COD ranged between 20 and 36 mg/L The values were at close proximity with each other indicating the presence of chemical oxidants in the water or better still, the self purification capacity of the water owing to its velocity of flow, the cross-sectonal area of the river and the veetation cover within ghe riparian zone. The BOD is an index of oxygen required for the biotic degradation of organic matter in bodies of water. The value for the BOD follows the same trend ranging between 8.6 and 17.6 mg/L showing a close proximity in the environmental impact on the water.

IV.8 SULPHATE

The value for the sulphate ranged between 8and 35 mg/L with the water There were significant differences in the values of the sulphate between the study locations although it has been reported that there is no guideline value based on human health; however, the recommendation of WHO is that any concentration higher than the permissible limits of 100 mg/L is termed un-hygienic [11].

IV.9 MAGNESIUM

Magnesium is a nutritional component for human beings, one of the micro-elements which is accountable for functioning of the membrane, stimulation for the transmission of nerves, construction of muscles and DNA duplication [12]. Values were within the WHO permissible limits of 50 mg/L with the range between 3.0 mg/Land 13.0 mg/. There were significant differences in the values of the magnesium in the sample; it has been reported that high values of magnesium could result in the hardness of water [13]. Nigerian Standard for Drinking Water Quality (NIS 554:2007) recommended magnesium concentration of 0.2 mg/L in drinking water.

IV.10 ZINC

The value for the detected zinc ranged between. Although the values fall within the WHO permissible limits of 3.0 mg/L, there were significant differences in the values of the zinc between the study areas. Zinc may have accumulated in the river from the environment from both natural processes e.g. weathering and erosion. It has been shown that acute zinc effect on people includes nausea, lack of moisture, tiredness, weariness, abdominal pain, inability to coordinate the muscles, and kidney failure. Chronic doses of zinc increase the risk of developing deformation of blood cells and could also damage the pancreas [14].

IV.11 IRON

The value for the copper ranged between 0.25 and 1.80mg/L with the water samples from ABUAD Farm region having the highest value of 1.8 mg/L.

IV.12 LEAD

The average values for the lead ranged between 0.01 and 0.02mg/L. The values were above the WHO permissible limits of 0.015 mg/L. Lead as a contaminant is a well-documented issue. It accrues with time in bones, blood vessels and other internal organs. It can access the human body through the consumption of food, water and air [15]. Lead, aside being a carcinogen, also impacts the central nervous system of the exposed individual and could lead to delayed mental and physical growth in children and could affect the attention span and learning abilities of children [16].

IV.13 AMMONIA

The presence of ammonia at higher than geogenic levels is an important indicator of faecal pollution. Ammonia is the most common forms of nitrogen in aquatic systems. It often occurs as a component of Nitrate which predominates in unpolluted waters. Nitrogen can be an important factor controlling algal growth when other nutrients, such as phosphate, are abundant. If phosphate is not abundant it may limit algal growth rather than nitrogen. Ammonia is excreted by animals and produced during decomposition of plants and animals, thus returning nitrogen to the aquatic system. There is highest concentration of 16 mg/L at ABUAD farm section with a corresponding 35 mg/L of sulphate and 64.5 mg/L of Phosphate concentrations. The detection can undoubtedly be the practicing of mechanized farming, the effluent of which is washed to the stream.

Zinc salts cause a milky turbidity in **water** in higher concentrations. In higher concentration about 2 mg / L, it may add an unwanted flavour to **water.** Solubility of **zinc** and **zinc** compounds. The solubility of **zinc** depends on temperature and pH of the **water** in question. At a fairly neutral pH, **zinc** in **water** insoluble. It is noted that the higher doses of Fe ranging from 25 to 75 mg inhibits the uptake of zink-sulphate [ZnSO4] in the human plasma. Elementary zink does not constitute health hazard but some zinc compounds, such as zinc arsenate and zinc cyanide, may be extremely hazardous.

IV.14 MICROBIAL ANALYSIS OF WATER SAMPLES

The value for total coliform as shown in Table 3.1ranged between 6 and 18cfu/mL with the water samples from ABUAD having the highest value while Ita-Ogbolu had a record for the lowest value. The presence of coliform indicates growth and possible biofilm contamination which usually occurs when there is contact with sewage and natural wastes from human and animal feces [17] The values were all above the WHO value of zero.

V. CONCLUSIONS

This paper is able to present a unique new technical model that captures the main features of real situation for river water quality assessment. The developed framework is capable of predicting at a whole catchment scale and over a long term span, the effect of LULC on the quality of the river. Moreover, the framework is capable of characterising water quality under the different catchment scale. The author is able to develop methods for collecting and assessing input data, including LULC for data-poor and ungauged regions and to demonstrate this approach with reference to a specific catchment. He is equally able to demonstrate how the data collection can serve as a tool for water resource managers by incorporating different management scenarios in the surface water model.

VI. AUTHORS'S CONTRIBUTION

Conceptualization: Toyin Omotoso.
Methodology: Toyin Omotoso.
Investigation: Toyin Omotoso and Justina Nwaeze Falana.
Discussion of results: Toyin Omotoso.
Writing – Original Draft: Toyin Omotoso.
Writing – Review and Editing: Toyin Omotoso and Justina Nwaeze Falana.
Resources: Toyin Omotoso and Justina Nwaeze Falana.
Supervision: Toyin Omotoso.
Approval of the final text: Toyin Omotoso.

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COUNT OF BACTERIA AND YEAST IN MICROBIAL BIOPRODUCT USING DIGITAL IMAGE PROCESSING

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ABSTRACT

The count of microorganisms in substances from different industries, like the count of bacteria and yeasts, is a necessary and important process since long time ago. Traditionally, in the industries this process is performed by experts observing the samples in the microscopes, which is time-consuming and varies depending on the degree of expertise of the experts. Currently, the use of digital images of the samples to be analyzed is a variant widely used for such count task. In that sense, several methods have been created in recent years to make this process, but none of them covers the wide range of diversity that can be found in the real microbiological world. With these ideas as premises, a new method for count bacteria and yeasts in microbial bioproducts using digital images is presented in this paper, in order to provide to experts the approximate number of those microorganism. The method involves basic operations of digital image processing like contour detection, morphological operations and statistical analysis; and it was developed in Python language using the OpenCV library. The results obtained were evaluated by microbiological experts proved to have an acceptable performance for the context of use.

I. INTRODUCTION

Due to the importance of the microorganisms in society, the detection and count of those small organisms has long been a task of vital importance in the laboratories of different industries such as chemical, pharmaceutical, agricultural, food and environmental [1], [2], as it allows to know the status and properties of microorganisms themselves, the substances and environment where they live.

Depending on the application where the sample is analyzed, is the degree of accuracy required for detection and count the microorganisms. In some scenarios, such as medical sciences, it is necessary to know the classification of the microorganisms present in a sample [3], while in others it is necessary to know the quantity of microorganisms [4]. On certain occasions, as in the detection of diseases, it is required that such information is present in a relatively short time, and with the least margin of error [5], [6] because it can be the cause of the late application of treatment in sick patients; or even if it is possible that information can be used to prevent diseases in the persons [7].

For the count of microorganisms and their colony forming units (CFUs) [8], [9] there are several methods. One of the most widely used are the observation of samples of the substances under microscopes by trained persons, usually called experts.

This counting task requires a great effort and time for part of the experts, sometimes becoming inaccurate when the volume of samples analyzed is large and eye fatigue appears [10], or the counting performed among different specialists may also vary [11], especially when the number of microorganisms involved in the counting process is high [12].

The morphological change in the structure of the microorganisms and their characteristics along their growth and

development, constitutes other factors that can cause difficulties in the identification and count task. The process of sample preparation is also other factor that could be lead a number of impurities than can cause the apparition of many false positives during this process.

Trying to eradicate these adverse situations and looking for the humanization in the counting of microorganisms, in recent years the use of digital images of the samples has been increased to perform this counting process. The use of images of the samples also provides additional possibilities, since they can be stored for future investigations, training, verification, audits and legal processes, among others.

Computer vision and digital image processing techniques have been one of the fields that have given an impulse to this variant, trying to achieve a high, consistent and fast repeatability, free from the subjectivities that inevitably arise due to fatigue or the degree of experience of experts [2].

Different software's have emerged for the analysis of bacteriological and other cell culture images, counting of microorganisms and their colonies. Some of those are proprietary or sometimes require the purchase of specialized equipment to perform an accurate count, as reported by some researchers [9], [13], making them highly expensive solutions.

As alternative to these difficulties, open source software has emerged, such as OpenCFU [13], COVASIAM [14], NICE [15], ImageJ [16] or the new project surged from that software: Fiji [17]; but their results, such as accuracy, versatility and speed, varies depending on the context where they are applied, as demonstrated in the research presented in [18] for different software with this functionality.

That is why several studies have tried to improve or extend the use of those software's, such as the research presented in [11], [19]; but until now, due to the wide range of characteristics and circumstances that can be found on the different microorganisms to be counted, such as shape, size, texture and overlap between them [20], it has been difficult to have general methods to carry out this task.

There is also another wide spectrum of changing parameters that affect the detection and count such as the physical media to take the image and the way that are acquired it, in which environment the microorganisms are placed, the rotation of the microorganisms, the scale at which the images are taken, the illumination, the angle at which the image is taken, the quality of staining, among others.

With this complex scenario, the settings parameters of those algorithms are tuned for specific experiments and scenarios; leaving the usefulness of algorithms with a restricted field of action [5], because in this count variant the steps to do are simple but the way to perform it could be diverse. Ideally, the microorganisms or their colonies should be isolated from the background [21], and then, if they are clustered, they should be separated from each other [13]. This makes the techniques employed in these processes diverse, especially when try to separate the clusters.

Generally, the techniques used to detect and count microorganisms in images can be grouped in two main groups: "classical techniques" of computer vision (CV) and digital image processing (DIP), and machine learning (ML) techniques, which differ in the way the counting is performed. While conventional techniques can achieve a detection and count that depends only on the characteristics of the image analyzed, ML techniques can drastically increase the efficiency compared to classical techniques but require large amounts of data from experiments, especially in the most advanced trend of ML, called deep learning (DL).

CV and DIP techniques can include the use of methods such as: multilevel threshold [14], morphological operations [7], edge detection [20], watershed algorithm [8], [12], [22], distance transform [8], and active contours [23] among others. Usually these algorithms are preceded by a series of steps in the preprocessing stage, which may include conversion between color spaces, image filtering and contrast adjustment.

The watershed algorithm with applied threshold, usually in conjunction with other techniques, has been one of the most used variants due to the possibility of divide and classify in different regions objects that are grouped in an image, in this case different microorganism. Examples of research using this algorithm can be seen in [24] where the H-Dome algorithm is also used whit images that are captured under different lighting conditions.

In [8] they also use the watershed algorithm to separate the colonies that form clusters. In this case, the images were acquired from samples placed in Petri dishes. For their method, the authors propose to work in two regions: one in the center of the disk and another in the periphery where they report that counting is much more difficult.

Those methods of segmentation using watershed could cause an over segmentation of the components in the image, that is the reason that in some cases that technic is combined whit technic to mark the regions to detect, as the work reported in [25].

In [20] propose a method composed of several processing techniques such as morphological operations, edge detection (Canny and Laplacian of Gaussian) and threshold, for counting microorganisms in a general way in digital images. Although the method returns 11 possible variants of microorganism detection, it requires user intervention to obtain good results. The author himself recognizes that the method may fail when the microorganisms are tightly clustered or the area of contact between them is large, as well as when the microorganisms have a color similar to that of the substance in which they are placed.

Other less commonly techniques reported in this context that have demonstrated acceptable accuracy are the circular Hough transform [10], [26], or the use of granulometry based on the morphological characteristics of the microorganisms [9], [27]. There are also reports of less general techniques such as the Chan-Vese algorithm [28], which is a variant of active model contours.

Inside the ML techniques used for this task, the convolutional neural networks (CNN), support vector machines (SVM), k-nearest neighbors (K-NN), decision trees and random forest (RF) are the most widely used techniques, demonstrating a superiority in obtaining results compared to classical techniques.

With the use of such methods, the detection, classification, count or analysis become very effective because they can learn patterns from the images. In many cases, as in [4], these more advanced techniques are combined with classical techniques to achieve greater accuracy or to save time in training the models.

Examples of the use of CNN can be seen in [3] where they use a deep convolutional neural network (DCNN) applying the transfer learning paradigm when employ a pre-trained network for the classification of bacteria, as in [29] for environmental microorganisms. CNN are also used in [4], [5].

The same technique, CNN, but for yeast segmentation is employed in the research presented in [30] where they use the watershed algorithm and the distance transform algorithm along with known CNN architectures.

The same purpose of bacterial classification is reached in [31] where three ML techniques are used: SVM, K-NN and Random Forest.

In [32] employ the RF algorithm and two variants of SVM: linear SVM (LinSVM), and Cross-Validation SVM (CVSVM) for the classification of bacteria causing tuberculosis disease.

With a need to automate the counting of microorganisms in microbial bioproduct obtained by fermentation, specialists from the Instituto de Biotecnología de las Plantas (IBP) [33] of the UCLV joined efforts with researchers from the Departmento de Automatica of the Universidad Central "Marta Abreu" de Las Villas (UCLV), to develop a method using digital images for bacteria and yeasts counting in the microbial bioproduct where microorganisms of both groups form a consortia. Until now, the detection and count of microorganism of different characteristic in the same image, as in [34], has been poorly covered, and there is not evidence that yeast and bacteria was detected and counted in the same image.

The main objective of this research was to develop a method to determine the number of bacteria and yeast in these microbial suspension, using DIP technics and digital images taken under different magnifications and conditions. This is the first step to establish, in later stages of the research and which are out of the scope of this article, relationships between the amount of that microorganisms and other properties measured by specialists such as pH and conductivity in these microbial bioproduct.

The structure of this paper after the Introduction follow as: Section II describes the proposed method for bacteria and yeast counting, Section III presents an analysis of the results obtained using the proposed method in images of different experiments and discusses circumstances that may cause the method fail, while Section IV presents the conclusions reached during the research.

II. MATERIALS AND METHODS

For the detection and count of bacteria and yeasts in this research, it were used samples of microbial bioproduct, which are under investigation in the IBP for agricultural use. These bioproduct present a composition where coexist bacteria of the coccus type and yeasts, in which bacteria are the great majority.

The process of sample preparation is out of the scope of this work, starting from the point of image acquisition. This image acquisition process was made changing the color of the illumination source, the suspension and the magnification of the microscope lens-ocular assembly, so that images were obtained with different sizes of microorganisms and under different conditions.

The images were taken with an Olympus BH series (Japan) microscope and a digital camera coupled. Under the objective for 40x magnification (PL40, 0.65 numerical aperture and 0.17 working distance) the scale factor was 2.3 px/ µm. In the case of 100x (HI plan 100/1.25 with immersion oil) it was 6.0 px/ µm.

The camera used to obtain the images was a HDCE-X camera [35] with a ½" CMOS sensor, with a resolution of 2592 pixel by 1944 pixels (5 Mp), where the pixel size is 3.2µm X 3.2µm and adjustable exposure time. This camera is coupled via a USB cable to a desktop computer with Ubuntu 18.04 LTS operating system, producing an output RGB image of 640 X 480 pixel with 24-bit depth (8 bit per channel).

The method code was written in Python 3 language, using the digital image processing library OpenCV in its version 4.0.0.

II.1 PROPOSED METHOD

The method proposed in this research to count bacteria and yeasts in digital images is composed of three fundamental stages, which were denominated: Primary Operations or Stage I, Statistic Operations or Stage II, and Classification or Stage III, as its show in Figure 1.

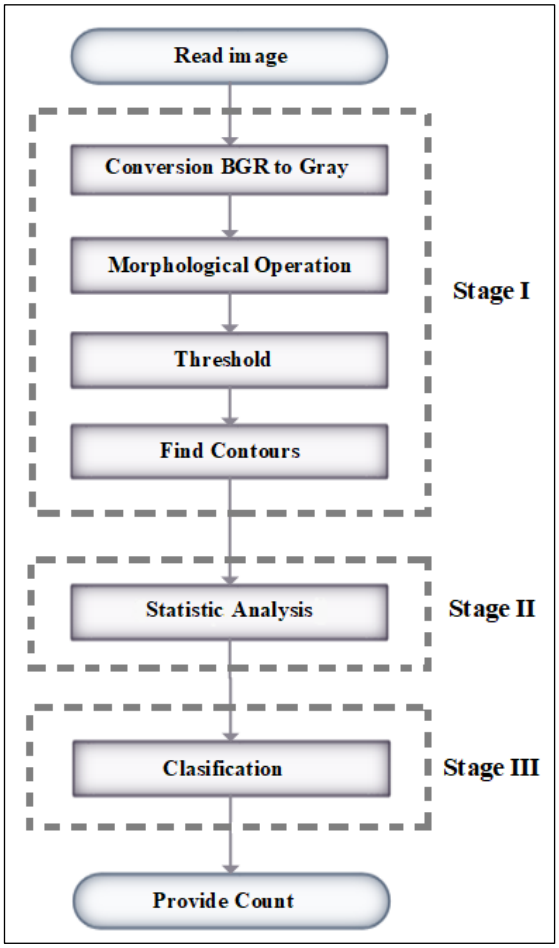

Figure 1: Flow of the proposed method.
Source: Authors, (2021).

The first step is read the image as a 3-channel image (BGR format, by default in OpenCV). Once the image is read, "Stage I" begins, which aims to delimit the possible microorganisms that appears in the image. In this stage the image is converted to grayscale, and to this new image is applied a process of morphological operations as filter, consisting of the "Black Top-Hat" method [36] whit the intention to highlight the visible contours of the microorganism.

This morphological operation consists on the difference between the process of making a morphological closing on the grayscale image and the grayscale image itself [37] as defined in Equation (1).

Black Top-hat morphological operation

$$\text{blackhat (img)} = close\ (img) - img \qquad (1)$$

Due the first part of the Black Top-Hat method is make an image "closing", the closing operation in gray scale images remove objects, relative to the size of the structuring element, that are more dark than their neighbors [38]; the effect of the Black Top-Hat method reveals areas more darker in the surrounding area of the objects of the image [36].

For this process, a square structuring element was used composed of a flat top with value of 1 in all its positions and size of nine pixel. The selection of the structuring element size was adjusted empirically, by applying the same operation in different

experiments, observing which was the most suitable size to cover the range of the experiments. The result of those steps can be seen in Figure 2.

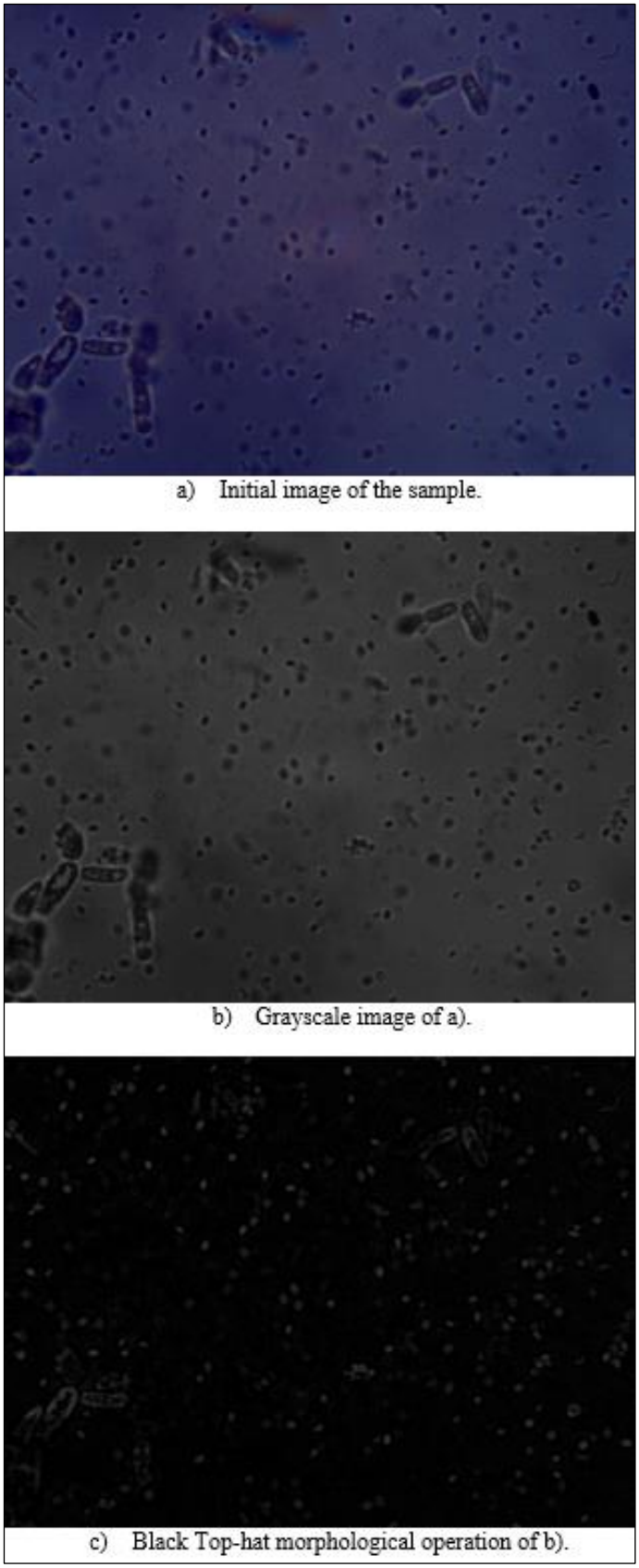

Figure 2: Example of Stage I in a microscopic image of microbial bioproduct (40X objective): a) Original image, b) Grayscale image, c) Black Top-hat morphological operation.
Source: Authors, (2021).

Once the image with the morphological operation is obtained a threshold is applied to it, selecting the Otsu method to apply a global binarization process, resulting in a binary image as shown in Figure 3.

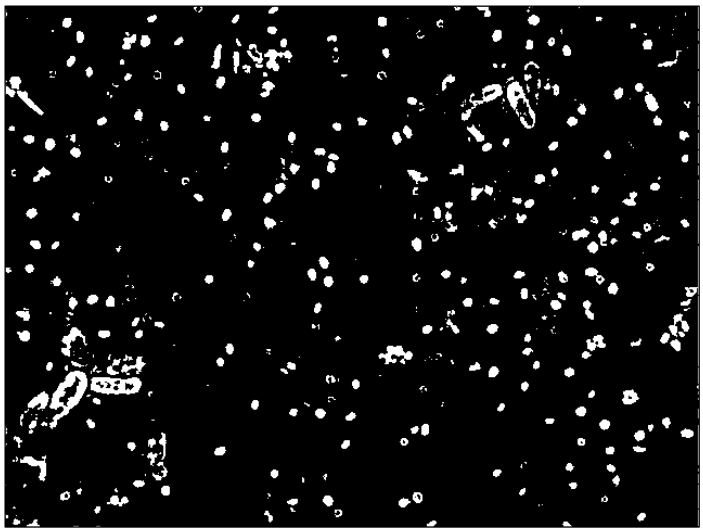

Figure 3: Image obtained after a threshold process on the image resulting of the Black Top-hat morphological operation.
Source: Authors, (2021).

After obtaining the binary image, as part of Stage I, is applied a process to obtain the contours present in the image. In this case, only the external contours that appear in the image were considered valid for the analysis, because sometimes microorganisms, especially yeasts, could project certain contour in the image that could be classified as internal, as illustrated in Figure 4. In this figure the external contours are drawn with a white line and the internal contours with black lines.

In order to avoid incorrect classifications, only the external contours are selected.

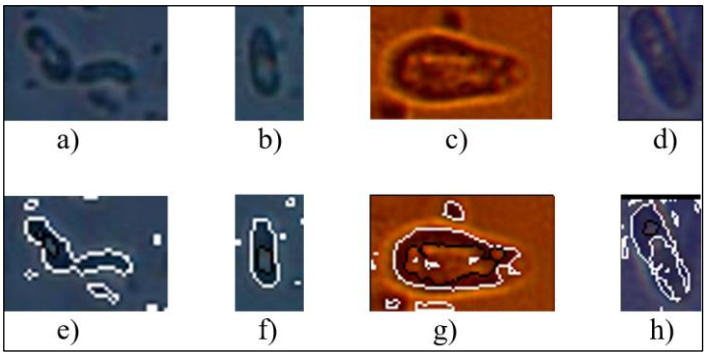

Figure 4: Example of classifications of internal and external contours in different microorganisms: a), b), c), d) image segments with different microorganisms, e), f), g), h) Internal and external contours detected in those image segments.
Source: Authors, (2021).

Once all the external contours of the microorganisms present in the image have been determined, “Stage II” begins. The main objective of this phase is determinate the mode of the size of the contours of the bacteria present in the image, as shown in Algorithm 1.

For achieve that objective, for each external contour found, the convex hull shape (cHS) of that perimeter is determined: that is

the convex polygon with the smallest area containing all the points of the contour [36].

The idea of the cHS of a contour is a figure to contain the entire area of that contour, all their points, within a polygon that is fully convex at any point on it.

Algorithm 1 Estatistic Analysis

```
for all external contour in image do
    find convex hull shape of contour
    find area of convex hull shape
    if area of hull contour > 0.01 then
        find area of contour
        calculate solidity factor
        if solidity factor is > 0.90 then
            find radius of mEC of contour
            take radius in consideration for determine mode
        end if
    end if
end for
extract mode of radius of minimal enclosing circle
```

As the scenario of this type of samples is high diverse, sometimes small contours appear after all preceded steps that can be ignored because they are too small. That is the reason to employ an adjustable parameter, using the area of the convex polygon, to discriminate or select the contours for subsequent analysis. In this case, if the area is less than 0.01 pixel it is not taken into account in the Stage II because such small areas may belong to noise in the images, or impurities in the environment where the microorganisms are placed [20]. This parameter was adjusted based on observations made during different iterations, and is applied in the Stage III too.

If the cHS has an area that must be taken into consideration, then the area of the set of internal binary pixel encapsulated by the analyzed contour is determined in order to calculate the contour solidity factor using Equation 2.

Solidity factor:

$$solidity = \frac{encapsulate\ area\ of\ contour}{area\ of\ convex\ hull\ shape} \quad (2)$$

The goal of the solidity factor in this research is to determine how regular are the pattern analyzed, which should correspond to well defined, non-clustered, bacteria or yeast, considering when more regular is the analyzed contour it solidity factor will be higher due the concordance between the areas.

Similar ideas to the solidity factor has been handled in other investigations like [12], but with a different formula.

At this point of the method, the comparison factor for the solidity of a contour was set to 0.90, using expert knowledge, thus considering for the statistic analysis to obtain contours as regular as possible.

If the analyzed contour satisfies the solidity criteria then the minimum enclosing circle (mEC) of that contour [39] is calculated; in other words, the circle of minimum area containing all the points of contour, as can be seen in Figure 5.

The integer part of the radius of the mEC are stored to take in account to determine, once all contours were analyzed, the mode of the radius size of the regular contours, otherwise it is not taken in consideration.

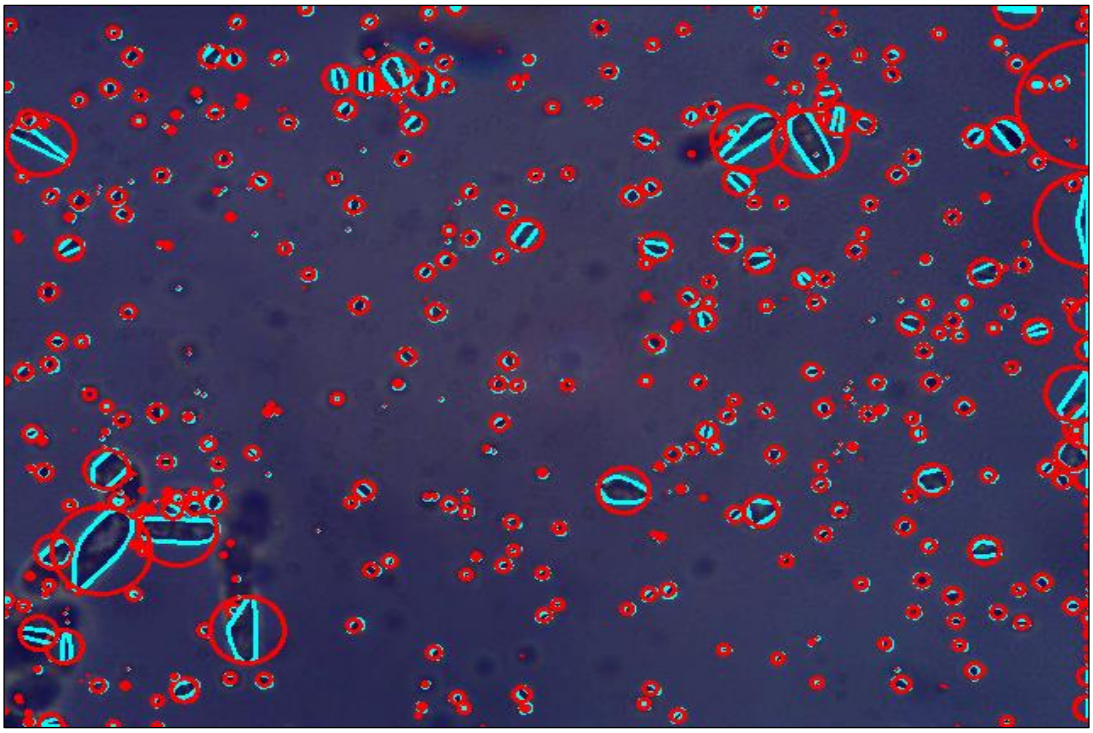

Figure 5: Determination of convex hull shape (cyan) and minimal enclosing circle (red).
Source: Authors, (2021).

After stored the integer part of the radius of mEC of contours, the first and second modes of these radius measurements are determined. One characteristic to employ these method whit this kind of samples is that always the number of bacteria have to be greater than the number of yeast. In case that property don't can established the method could achieve bad results, or even could fail. In the case that the number of bacteria is greater than yeast, was confirmed during the experiments realized, that can be

assumed that the first mode calculated, and in many times the second mode too, always going to belong to bacteria, due to the high number of them.

Once the second phase of statistic analysis is completed, the "Stage III" is carried out with the objective of classifying the microorganisms, bacteria or yeasts, that produce the contour detected and finally provide a count of them to the users.

To perform this task, all previously external contours determined are reanalyzed, as shown in Algorithm 2.

Algorithm 2 Clasification

```
for all external contour in image do
    find convex hull shape of contour
    find area of convex hull shape
    if area of hull contour > 0.01 then
        find radius of mEC of contour
        if radius of mEC> 0.5 then
            if radius is < 3 * maximun mode of radios then
                calculate solidity factor
                if solidity > 0.7 then
                    classify contour as bacteria
                else
                    classify contour as unknown
                end if
            else
                obtain coordinates of contour
                call function find_yeast for that contour
            end if
        else
            discard
        end if
    else
        discard
    end if
end for
```

For each of those external contours, the encapsulating cHS and its area are determined again, and the same criteria used in phase two are used to discriminate between the contours, being the very small contours excluded from the classification process. If the contour encapsulates a minimum established area, then the radius of the encapsulating mEC is calculated.

At this point in the method is placed a condition that allows ignore small contours for classification, those contours whit the radius of mEC is less than 0.5 pixel; otherwise the analysis of contour continue. That criteria were adjusted based on the experiments carried out using expert criteria.

When the contour satisfies that selection criteria, is used another condition that allows distinguish if the analyzed contour has a higher possibility of being a bacteria or not. This condition is based on compare the radius of the mEC of the contour with the mode of the radius. If the mEC radius is less than 3 times the mode, then it is more probably that the contour could be a bacteria; otherwise it is more probably to be a yeast or a union, cluster, of several microorganisms.

If the contour classifies to be analyzed as bacteria, its solidity factor is calculated again and this time if it is greater than 0.7 it is classified as bacteria; otherwise it is classified as unknown due to the irregularity of the shape.

Larger contours, those where the radius of the mEC is greater than three times the maximun of two modes of the radius, require another process for better classification as described in Algorithm 3. These contours can be composed of yeasts, or clusters of bacteria and yeasts, which is why another analysis is required for their classification. In that last case the contour is passed to a new function called "Find yeast", which is shown in Algorithm 3.

In this process, an empty image is created and the contour under study is drawn and filled. Two morphological operation processes are applied to this new image whit the intention to discover and separate, if it is necessary, the microorganism that are clustered.

Algorithm 3 Find yeast function

```
for specific contour in image do
    create a black image to draw contour
    draw and fill contour in black image
    apply erosion process to new image
    apply dilation process to new image
    find externals contours in new image
    for all new external contours do
        find radius of mEC of contour
        if radius of mEC > 0.5 then
            if radius of mEC < maximun mode of radios
then
                classify contour as bacteria
            else
                classify contour as yeast
            end if
        end if
    end for
end for
```

The first morphological operation consists of an erosion process who have the intention to erode the new figure seeking if this new figure is compose by different microorganism. To make that operation the size of the structuring element to be used is selected according to the mode of the radius of the mECs: if this mode is less than two, the size of the structuring element is set in 2, and if it is greater than 2 then the size of them is equal to the integer part of the mode of the radius.

The second morphological operation applied is a dilation process. That operation is applied whit the intention of increase the area of the shapes remaining from the erosion process, but preventing that the segments that were separated from each other coming back to be in touch again. In this operation the size of the structuring element to be used decreases by one unit with respect to the size of the structuring element used in the erosion process.

Once these two processes have been carried out, the new external contours that appear in this new image are determined. For each of these contours the radius of the mEC is calculated.

In this point of the method, the condition used previously is used again: if the radius of the mEC is greater than 0.5 pixel, it is classified, otherwise the contour is discarded for being too small.

If the radius of the new contour meets the requirement for classification, then it is compared to the higher value of the two most representative modes of the radius of the mECs determined in the statistic phase. If this new radius is smaller than the greater value of the two modes of the radius, then it is classified as bacteria, otherwise it is classified as yeast.

Finally, the count is provided to the specialists, highlighting bacteria in green circles, unknown forms in red circles and yeasts in magenta rectangles.

III. RESULTS AND DISCUSSIONS

For the development and test of the proposed method, several experiments were carried out in which the microbial suspension, the magnification of the camera-lens set, the focus, among other characteristics, were different; trying to capture a wide range of real characteristics and operations in this process.

As can be seen in Figure 6, the method is able to detect bacteria and yeasts in microbial bioproduct. In that image, bacteria were highlighted with a green circle and yeasts in purple rectangle. Microorganisms or microbial detritus that were classified as unknown are marked in red.

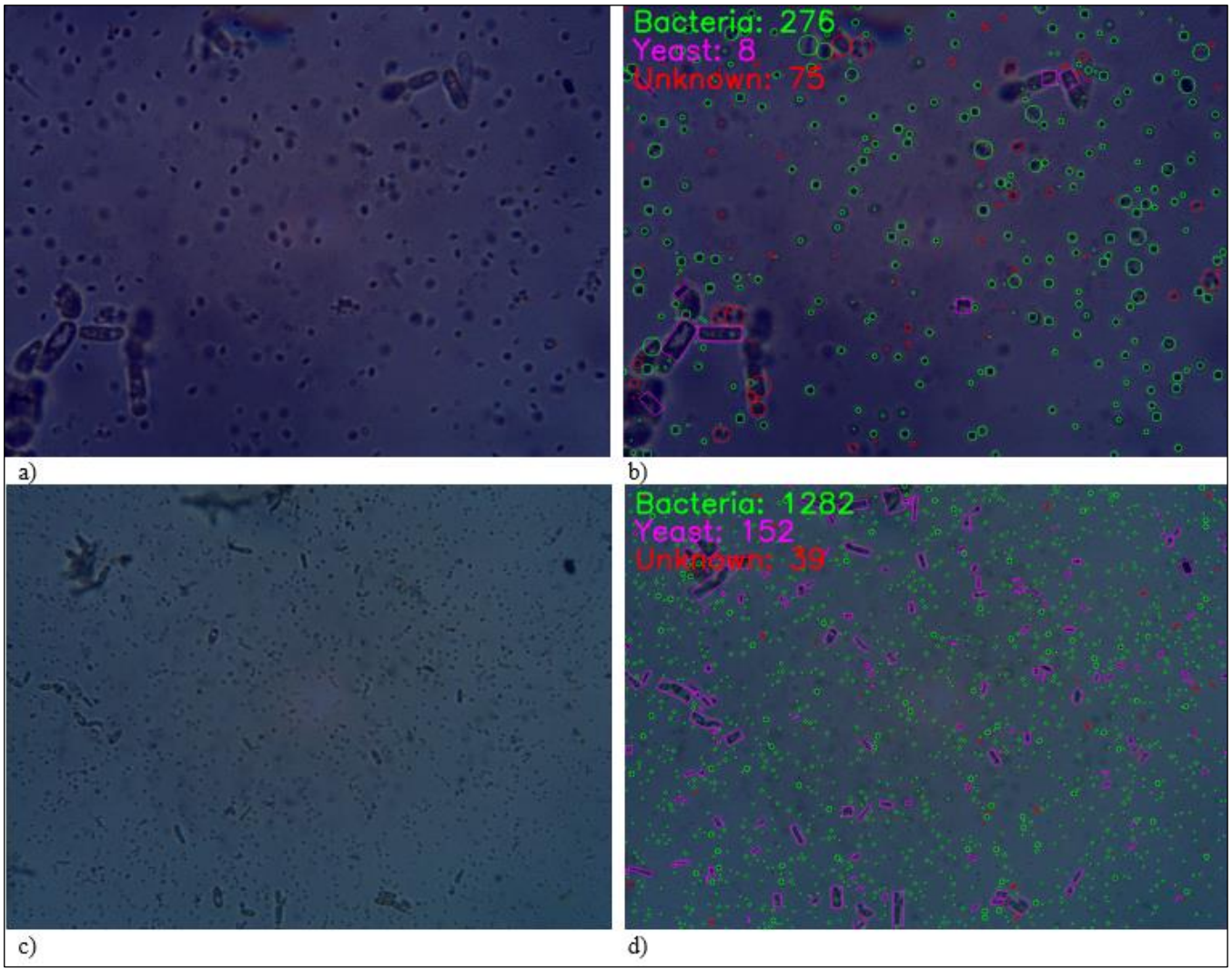

Figure 6: Count of bacteria and yeast in microbial suspension by the proposed method in experiments with different conditions: a) Experiment 1, b) count on the a) image, c) Experiment 2, d) count on the c) image.
Source: Authors, (2021).

Analyzing the results obtained through the observation of the images, it can be seen that the detection and counting of bacteria was achieved with acceptable accuracy, but not in the case of yeasts, whose precision is considerably lower. In this case the user should discern in those contours marked as unknown which is its possible classification, or if it should be discard.

The method was able to separate cluster of bacterias or yeast with a few microorganism touching between them, in large concentrations of those microorganism the accuracy is lower.

This issue is closely related to the small regular shape characteristic of bacteria, which don't present great variation in their color or in their shape, whereas the larger size of yeasts and their changes in color can result in a detection not precisely after image processing.

Other aspect that can also observed in the images are shadows that belong to microorganisms that are below the analysis surface or that are poorly focused, which can cause many false positives to be classified as bacteria because at least a part of the microorganism contour meets all the selection criteria, and in most cases this contour does not appear visibly clear.

There are also contours and shapes that do not meet the established matching criteria and were not classified.

III.1 FAIL CASES

As result of the wide range of experimental conditions, it was observed different scenarios where the method can make an incorrect classification.

One of common problems than can cause poor results have already been reported in similar investigations, such as the low contrast between the microorganisms and the background.

Other condition that can cause classification errors as it was mentioned before, is the shape itself of the figures of microorganisms in the image, especially the larger ones: yeast.

The non-homogeneous shape characteristics, especially in the color, can result in the fact that during the image processing, part of their shape is removed from the images by the different operations, resulting in a partition of the same microorganism into several sorting regions.

This two conditions make very difficult the process of detection and count as can be observed in Figure 7.

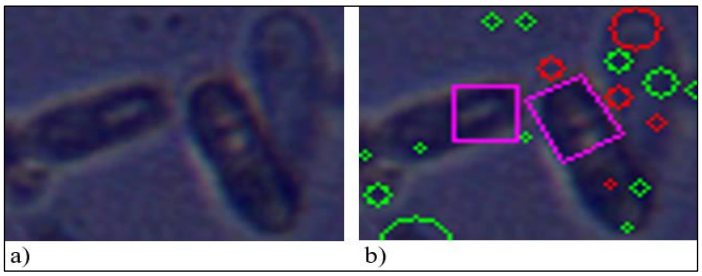

Figure 7: Example of misclassification of a yeast due to the irregularity in its shape structure in the image and poor contrast between the microorganism and the bacground: a) segment of an image of the sample and b) results obtained after processed the image in a).
Source: Authors, (2021).

In addition, sometimes the silhouette of the microorganism in the image cannot be observed completely, or there are clusters of bacteria and yeasts, in which it is very difficult to separate them, as can be seen in Figure 8 where is visible misclassification or bad count of microorganism, more accentuated in the classification of yeasts.

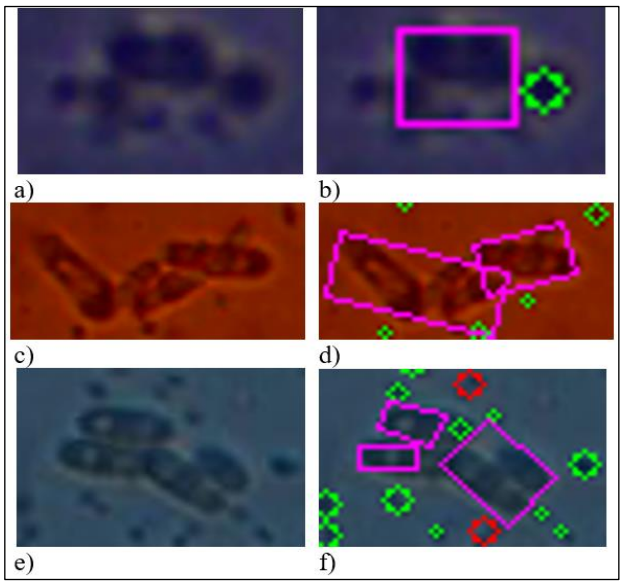

Figure 8: Clustering of several microorganisms causing misclassification: a) segment of an image of the sample and b) results obtained after processed the image in a); c) segment of an image of the sample and d) results obtained after processed the image in c); e) segment of an image of the sample and f) results obtained after processed the image in e).
Source: Authors, (2021).

Other great difficulty in obtaining good results with the method is the degree of focus with which the image is acquired, a condition that can be challenging for any computer vision algorithm. In this case the focus over the sample of the microscope-camera has a great influence on the results that can be obtained. Figure 9 shows this problem in different frames of a video taken on the same sample where the degree of focus varies.

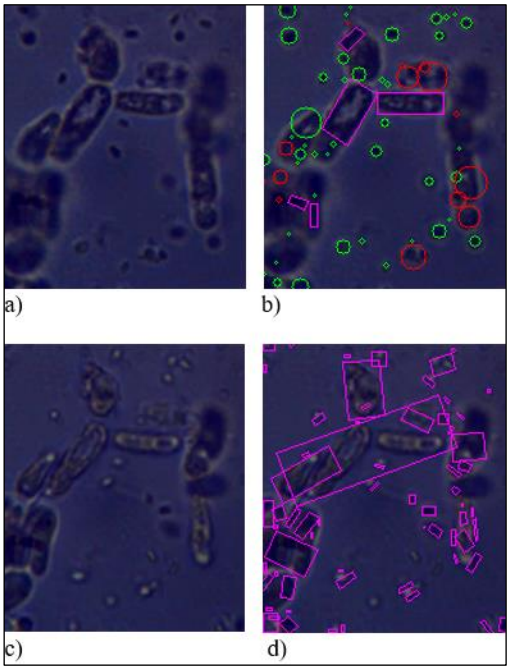

Figure 9: Example of variation of the degree of focus on the same sample: a) segment off an image of the sample and b) results obtained after processed the image in a), c) new segment image of the same microorganism by varying the focus of the camera-microscope d) results obtained after processed the image in c).
Source: Authors, (2021).

There are also problems associated with dust, fermentation residues or unusual objects that can be observed in the images and can belong to the imperfections in the camera, microscope lens or where the dissolution is prepared and are not the microorganism analyzed in the research.

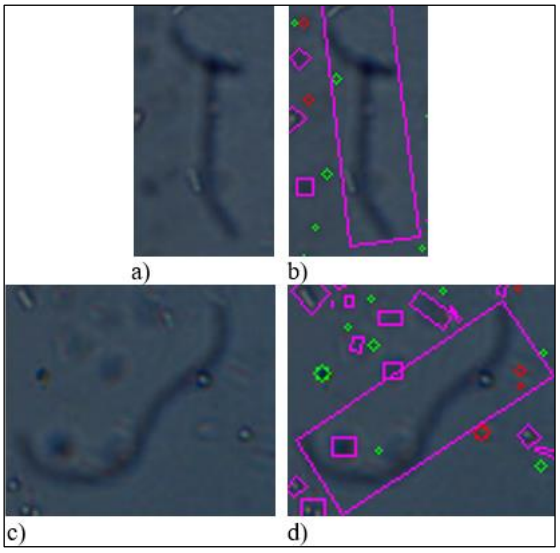

Figure 10: Example of count bias due to the appearance in the image of large objects that are not parts of the biological specimens: a) segment of an image of the sample and b) results obtained after processed the image in a); c) segment of an image of the sample and d) results obtained after processed the image in c).
Source: Authors, (2021).

Figure 10 shows how the visible silhouette of objects that are not part of the experiments, named artifacts, making the classification and counting process incorrect.

III.2 METHOD EVALUATION BY EXPERTS

After all parameters were adjusted for cover all experiments, the evaluation of the performance of the method was made by experts from the microbiologic laboratory of IBP.

The proceeding was made making a subjective evaluation [40], where the experts evaluate a set of images of microbial suspension with the count provided after processed by the method, and the original image whit out count.

Microorganisms detected as unknown were not taken in consideration because is decision of the user, when employ the method, make a visual inspection of the unknown shapes.

The experts analyzed the results taking the following assumptions:

- True Positive (TP): bacteria or yeasts that were correctly classified and counted.
- False Positive (FP): bacteria or yeasts that were counted but they are not.
- False Negative (FN): those microorganisms that were not classified or counted by the method (excluding unknowns) and which in the opinion of the experts should be counted because they were visible and well defined in the image.
- True Negatives (TN): were not counted because the intention of the method is not detect those elements that are not considered microorganisms, such as noise in the image, dirt on the microscope lens, etc.

If the research were approached from a point of view of image segmentation, where generally there is for each segmented image a ground truth label image, then it could be possible obtain values of TN; but in this investigation there is not intention follow that line.

The metrics used for the evaluation of the method were accuracy (Acc), precision (Pr), and sensitivity (Se) or recall [41], [42], as expressed in Equation of Accuracy, Equation of Precision and Equation of Recall, respectively.

Equation of Accuracy

$$Acc = \frac{\mathrm{TP} + \mathrm{TN}}{\mathrm{TP} + \mathrm{TN} + \mathrm{FP} + \mathrm{FN}} \quad (3)$$

Equation of Precision

$$Pr = \frac{\mathrm{TP}}{\mathrm{TP} + \mathrm{FP}} \quad (4)$$

Equation of Sensitivity or Recall

$$Se = \frac{\mathrm{TP}}{\mathrm{TP} + \mathrm{FN}} \quad (5)$$

For the validation process, nine images randomly chos n was given to the experts. This images were representative of the widely range of experiments, whit images taken under different magnifications. The annotations obtained by experts can be seen in Table 1 for bacteria, and in Table 2 for yeast.

In that tables can be appreciate the metrics results obtained after process the validation data.

Table 1: Experts evaluation and metrics in bacteria count.

Image	Method	TP	FP	FN	Acc	Pr	Se
A	280	265	15	2	0.93	0.94	0.99
B	728	726	2	32	0.95	0.99	0.95
C	1199	1190	9	54	0.94	0.99	0.95
D	1173	1153	20	46	0.94	0.98	0.96
E	77	74	3	0	0.96	0.96	1.00
F	1282	1243	39	5	0.96	0.96	0.99
G	1039	1018	21	10	0.97	0.97	0.99
H	877	866	11	7	0.97	0.98	0.99
I	269	263	6	2	0.97	0.97	0.99
Average	-	-	-	-	0.95	0.97	0.98

Source: Authors, (2021).

Table 2: Experts evaluation and metrics in yeast count.

Image	Method	TP	FP	FN	Acc	Pr	Se
A	9	6	3	1	0.6	0.66	0.85
B	166	152	14	34	0.76	0.91	0.81
C	101	85	16	18	0.71	0.84	0.82
D	99	83	16	20	0.69	0.83	0.80
E	0	0	0	0	0	0	0
F	152	149	3	4	0.95	0.98	0.97
G	123	117	6	0	0.95	0.95	1
H	124	123	1	4	0.96	0.99	0.96
I	11	8	3	2	0.61	0.72	0.8
Average	-	-	-	-	0.78	0.86	0.88

Source: Authors, (2021).

Analyzing the results obtained after processing the set of images, concluded that the method is able to detect with accepted accuracy the presence of bacteria whit a mean of 0.96, and the lowest value a 0.93. The precision and recall for those microorganism was high to, whit a 0.97 of precision and a recall of 0.98.

Lower level of count was achieve for yeasts. In this case, the accuracy obtained was around 0.69, whit the precision mean equal to 0.77 and a recall of 0.78.

Those results is mainly related to the situations explained above, which are accentuated in the case of yeasts.

In this case, the user can more easily corroborate and correct the yeast count since the number of yeasts in these solutions is much lower than the number of bacteria, enough to obtain a ratio that serves as an indicator for future research to establish the relationship between the number of microorganisms and other measurable parameters of the substances.

IV. CONCLUSIONS

General methods for the classification of microorganisms is an arduous task that has not yet been completely solved by the research reported so far. Most of the research are focused on determining and/or counting the presence of specific microorganisms, mainly bacteria due to the importance they report in different current contexts such as disease transmission, in the chemical, food and pharmaceutical industries, among others.

The method proposed in this work effectively classifies and count the presence of bacteria and yeasts in microbial bioproduct obtaining a average accuracy of 0.95 in the count of bacteria and 0.78 in the case of yeast. It is composed of three fundamental modules called: Primary Operations, Statistic Operations and Classification; and it mainly uses morphological operations contour detection operations, and statistical analysis.

As a prerequisite for the correct classification of microorganisms by means of this method, it is necessary that the presence of bacteria in the suspension be greater than that of yeast, and that the bacteria must have a regular circular shape.

The accuracy achieved is closely linked to the conditions under which the images are acquired, the degree of focus of the camera, the cleaning of the lens, and greatly influenced by the diversity of sizes and shapes of the microorganisms of interest in the research, the contrast between the microorganisms and the background in which they are found, and the degree of clustering of the microorganisms.

In the verification of the results obtained by the method by means of expert criteria, it was achieved an acceptable performance for the conditions of the experiments.

V. AUTHOR'S CONTRIBUTION

Conceptualization: Jorge Peña Martín and Yelenys Alvarado-Capó.
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Investigation: Jorge Peña Martín.
Discussion of results: Jorge Peña Martín, Yelenys Alvarado-Capó, Rubén Orozco Morales, Tatiana Pichardo and Ailet Abreu López.
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RESEARCH ARTICLE OPEN ACCESS

EXTENSION OF TIME (EoT) CLAIMS SUBSTANTIATION AND ASSOCIATED ISSUES IN COMPLEX-MULTI STAKEHOLDERS' BUILDING CONSTRUCTION CONTRACTS

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Multi-stakeholders.

ABSTRACT

In complex and multi-stakeholder construction projects, delays and disruption are commonplace. Delays trigger the request for Extension of time (EoT) to enable adequate time for the project to be completed. Substantiating the need for EoT is a difficult task and requires a lot of effort. The administration of EoT claims come with a lot of issues to the clients and the contractors. The purpose of this study is to assess the factors for substantiating Extension of time (EoT) claims and the common issues associated with (EoT) in complex-Multi Stakeholders' Building Construction contracts. This study adopted a well-structured questionnaire administered on construction professionals in consulting and contracting organisations, via electronic means and using snowball sampling techniques in Abuja and Lagos state, Nigeria. With a response rate of 39.60% and an instrument reliability index of above 0.70, the gathered data were analysed using appropriate descriptive analytical tools. It was found that the major documents and records that have the level of importance for substantiating claims for extension of time are; time impact analysis showing the potential impact of the changes before carrying out the changes, change of work notices, claim register, programme updates, minutes of the daily, weekly, and meetings, and daily progress reports. The major disputed issues associated with claims for extension of time in construction contracts are concurrent delay, The absence of notice of delay by the contractor as required by the contract, eligibility of time extension claim, inadequate effort in mitigating the delay and poor demonstration of the impact of the delay event to the project schedule. Regular training and continuous professional development is required to enhance the skills and expertise of project administrators/managers for effective claim administration and management.

I. INTRODUCTION

Globally, the construction industry is known for facing delays in the delivery of developmental projects. Delays in construction project delivery have remained a single most frequent phenomenon in the construction sector [1-3]. [4] posits that the construction sector has the lowest rate of meeting contract deadlines amongst the industrial sector, especially in emerging nations. This situation has been responsible for the high level of risks and uncertainty in the construction sector compared to other industries. Furthermore, the unique nature of construction projects, their complexity, intense time of designs, multiple stakeholders, construction methods and process [5-6], contributes to the worsening poor time performance of construction projects in the sector. In complex projects with multiple stakeholders (client, consultants, contractors, subcontractors, suppliers, among others), the success of the project lies in how well-emerging issues are taken seriously and managed by the project management team. Stakeholders' satisfaction and meeting of

project objectives depend on effective management of a project to meet key project performance parameters.

According to [1], cost, time, quality and health and safety are key project controlling features that impact project delays. The occurrence of delays in the delivery of large-multi stakeholder projects is a central cause of cost overrun, an extension of time, disputes, arbitration, litigation, loss of revenue and projects, among other issues. A critical determinant of construction project performance is timely completion. The time as well as the cost and quality performance of construction projects are the basis for declaring a project successful [7-9]. According to [10], time performance is used to benchmark project performance assessment as well as serve as a symbol of the project's organization efficiency. While considerable efforts have been made to avoid delays, it has remained a global epidemic on construction projects, and the Nigerian construction industry has received its fair share. In Nigeria, a large proportion of construction projects (public and private) experience delays with the consequence being time and cost overruns, disputes, abandonment, ideal resources, negative social impact [11]. One of the reasons for the invocation of the extension of time (EoT) clause is delays.

Delays in the execution of construction activities may trigger the need to apply Extension of time (EoT) to enable adequate time for the project to be completed. EoT claims emanate from delays that evolve from unforeseen events or situations for which provisions are made in most standard forms of contract, for claims for an extension in the initially agreed project completion deadline [12]. Contractors generally leverage the extension of time clause in building contracts to avoid the liability of paying for damages for liquidated damages due to failure to meet the contract completion date original contained in the signed contract. There is always a list of "relevant events" in most standard forms of contract that give the contractor the right to apply for an extension of time. It is also expressly provided in most contracts that claim for delaying events timely [5].

While there is a lot of extant literature on the causes of delays, effects of delays, time overrun and cost overruns [13-19,1,4], only a very few of them have focused on the extension of time in construction projects [5, 20-24]. Extension of time in construction contracts is an area that is understudied in Nigeria specifically and in other developing countries generally. The purpose of this study is to assess the factors for substantiating Extension of time (EoT) claims and the common issues associated with (EoT) in complex-Multi Stakeholders' Building Construction contracts. The specific objectives towards meeting the study aim are; (i) to assess the level of presentation of documents and records to back up claims for extension of time, and (ii) to assess the major issues in disputes with claims of EoT. The perspective of the Consultants and Contractors would be sought on this very important topic, as they are key to every construction contract.

This study will help contractors to know the required documents and records to provide success in their claims for extension of time. It will impact the knowledge of the contractor as regards the issues surrounding EoT claims and administration. Most assessment of EoT is carried out by the Quantity Surveyors. This study will assist the Quantity surveyors to ascertain whether the contractors have submitted the required documents to substantiate their claims for delays. The study also adds to the few existing studies on EoT in Nigerians and by extension of Developing countries of Africa.

II. LITERATURE REVIEW

II.1 PROJECT COMPLETION TIME AND EXTENSION OF TIME CLAIM

In a construction contract, it is the obligation of the contractor to proceed regularly and diligently with the works to the best of his endeavours. This is critical to prevent or avoid delay in the progress of the works and to any negative impact on the project completion date. Unless expressed, time is always of the essence in most construction contracts. This means that "the obligation to perform by the date stated or agreed is essential to the contract" [21].

It is recognized by most construction contracts that the completion date might be delayed by unexpected or unforeseen events or circumstances. When these delays occur, the impact of the risks is borne by either the employer or the contractor. To cushion the effects of the risks, an 'extension of time clauses' is usually provided to enable completion on a new date to be set [21]. Extension of time is described as the situation where the construction period is extended due to delays caused by the contractor, employer or his agents. When an extension of time is granted, the employer would not be entitled to liquidated and ascertained damages (LAD) until such a new date is elapsed.

II.2 TYPES OF DELAYS FOR EXTENSION OF TIME CLAIM AND COMPENSATION

The four major categories of delays identified in the literature are; Critical or non-critical, Excusable or non-excusable, compensable or non-compensable, and concurrent or non-concurrent [25].

Critical or non-critical: This type of delay may or may not impact the project completion date. Critical delays are those that impact the project completion date. Critical delays modify and affect the progress of work to the extent the completion date is exceeded. According to [20], delays that occur on the critical path of a project that consequently impacts the completion date is known as 'critical delay'.

Non-critical delays are those whose occurrence does not impact or modify the project milestone dates or completion date [25, 5]. Delays that does not occur on the critical path of the project with no consequent effect on the overall project completion date is known as non-critical delays [26].

Excusable or non-excusable: According to [27], non-excusable delays results from the contractors' action or inaction. This type of delay is attributed to the contractor because the events are within the sphere of his control, and no extension of time nor compensation will normally be granted to the contractor [20, 2]. The category of these delays is mismanagement, poor scheduling, errors or mistakes in construction, breakdowns of equipment and machines, and problems related to staffing [28]. Excusable delays are classified into; non-compensable or compensable excusable delays. The non-compensable excusable delays are caused by events that are beyond the control of the contractor and the employer; usually unforeseen circumstances [27, 20]. [29] listed things like 'Force Majeure, 'Acts of God', materials and labour shortages which are beyond the expectation of the employers and the contractor; as examples of non-compensable excusable delays. On the other hand, the compensable excusable delays are caused by the employer (owner) and not the contractor. [27] identified defective designs changes request from the client, difficult site

conditions, and failure of the client to give access to the site to the contractor; are some of the events that give rise to compensable excusable delays. A compensable excusable delay entitles the contractors to both extensions of time and compensation. While, non-compensable excusable delays entitles the contractors to an extension of time but with no compensation for delays costs [28, 5].

Concurrent delas: This results from delay events (say two or more) that occur at the same time. It is difficult to determine the party that is responsible for concurrent delays. This type of delay could be attributed to the client, contractor and/or third-party; examples include inclement weather, force majeure among others [5]. [21] posit that the responsibility for concurrent delays is shared by the client and contractor. Where a concurrent delay is established, the extension of time due to the contractor's delay should not be reduced. Any additional cost incurred by the contractor as a result of the delays by both the client and the contractor, the amount recoverable as compensation by the contractor should be to the extend he is able to identify separately the additional costs caused by the client delay and those by the contractor delay [21].

Concurrent delays are used as a defensive tool by both the client and contractors against each other. The interest of the client is to collect liquidated and ascertained damages (LAD), while that of the contractors is to avoid the payment of LAD [29]. Litigation is the ends point of unsettled several issues emanating from concurrent delays [30, 27].

Figure 1 shows the summary of the various types of delays in a construction contract. It is a modification of the work by [20].

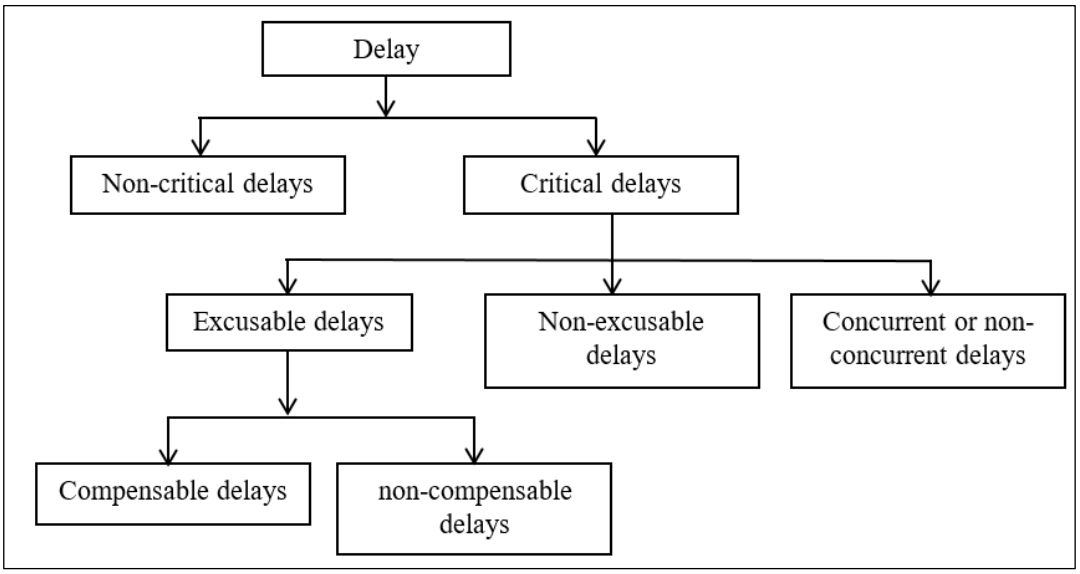

Figure1: Types of delas.
Sources: Modified from Maritz and Prinsloo [20].

II.3 BACKING OF CLAIMS FOR EXTENSION OF TIME

Extension of time for a project may be requested and considered under several different valid circumstances. However, not in all cases that delays claims are approved as an extension. In a construction contract, it is critical to keep records of claim events; emails, change requests, documents, scheduling [31].

Claims for extension of time are backed-up by certain specific supports documents that are paramount. Substantiation of reasons for delays that will guarantee the contractor/subcontractors to seek for time extension requires certain conditions, and they include the followings according to [31]:

i. A notice of the precise issues that triggered the delays
ii. List of activities that are affected by the delays- usually obtained from the project schedule
iii. The precise number of days/calendar days representing the time being claimed
iv. Photographs, images, sketches or other forms of illustration form supporting the delayed events
v. Suggestions/recommendations given to the project manager/contract administrator
vi. A clear description of actors taken by the contractors to avert or reduce other delas.
vii. Alternative ideas/solutions that were presented to the project manager
viii. Communications between the design team and construction team or among the project teams on issues relating to the delays evens and associated problems.

A summary of the guidelines for ensuring that claims in construction contracts are kept to a minimum is shown below. This guideline is as developed by [32].

i. Admissible and factual evidence such as photographs, videos, memos, drawings, minutes of meetings, memos, among others are under record keeping. This record should be kept, maintained and organised in such a way that ensures the smooth facilitation of construction contract administration.
ii. Preservation of contract parties' rights. Written notice of potential claim events should be served, especially within the time stated in the contract conditions.
iii. Pro-activeness of the parties: being proactive is a conscious attitude by either the contractor or clients to quickly respond to complaints or potential threats to the project completion date. Proactive actions facilitate the administration and management of projects.
iv. Having a sound knowledge of the contract; is an aspect that is mostly ignored by contractors. Effective delivery of

the project to specifications requires a clear understanding of the obligation and responsibilities contained therein. The onus is on the contractor to comply completely with the contract requirements, more especially claim and variation clauses, among others. The contractor must adhere to contract provisions, as failure to do so will mean loss of chances to successfully claim for EoT.

v. Adequate planning and scheduling are key for projects to be delivered successfully. Sufficient Planning ensures that resources are effectively utilised and managed. Events that will impact the critical path should be properly monitored. A regular update of the programme of work is required by parties.

vi. Proper attention to change requests/orders that will cause extra cost is required. Sound negotiation skill is required to effectively execute a change order [5].

Substantiating EoT claims requires detailed record keeping. [33] recommended for the establishment and maintenance of a good documentary control by the contractors; this will enable a huge amount of both hard-copy and electronic records to be available to the planning team and project managers/ contract administrators. The type of records to be kept according to [33] includes the following. the contractor estimate, contractors costing system and reports, internal management reports, ad-hoc studies and reports on profit and loss, records of bonuses, timesheets, updates of programmes, applications for payment, labour allocation returns and all labour reports and returns, and other relevant records to how the breakdown of labour hours used and the progress achieved [33].

[24] highlighted documents and records that are required to prepare well-substantiated claims for extension of time, and they are contained in Table 1.

Table 1: List of required records to establish properly substantiated claim.

S/Nr	Record description
1	Baseline schedule
2	Method of construction identifies the works that are intended to be executed by subcontractors.
3	Planned manpower and machinery resources
4	Programme updates
5	Notices for delay
6	Programme revisions indicate changes and their required resources and the impact on the contract completion date.
7	Delay analysis
8	Time impact analysis shows the potential impact of the changes before carrying out the changes.
9	Cause and effect analysis for each delay disruption event.
10	Productivity analysis reports
11	Minutes of the daily, weekly, and meetings.
12	Minutes of any special meeting
13	Change of work notices
14	Daily progress reports
15	Weekly progress reports
16	Monthly progress reports
17	Claim register
18	Delay events log

Source: [24].

II.4 DISPUTED ISSUES ASSOCIATED WITH EXTENSION OF TIME CLAIMS

A lot of studies exist on construction management literature regarding primary causes of disputes [34-35]. Extension of time claims is among the major causes of disputed issues in the construction industry [36]. One of the common causes of disputes in construction is EOT claims [37]. Similarly, the study of [38] indicates that claims evolving from delays and disruption top the major sources of disputes in construction contracts.

[5] identified the top five major disputed issues in construction projects as; concurrent Delay, Eligibility of time extension claim, Failure by the contractor to comply with the contractual requirement for EOT application, Inadequate effort in mitigating the delay, and Poor demonstration of the impact of the delay event to the project schedule. It is obvious that the commonly disputed issues in the construction contract, especially between clients and contractors are an extension of time. What these further means is that no construction contract can begin and end with claims or other issues to be disputed. Eleven most disputed issues associated with an extension of time claims as identified from the study of [5] is shown in table 2.

Table 2: Disputed Issues Associated with EoT Claims.

S/N	variables
1	Concurrent Delay
2	Eligibility of time extension claim i.e. the permissibility of any specific delay event for justifying a project time extension
3	Failure by the contractor to comply with the contractual requirement for EOT application
4	Inadequate effort in mitigating the delay
5	Poor demonstration of the impact of the delay event on the project schedule
6	Permissible period of time extension
7	Conflicting interpretation of contractual provisions
8	The absence of notice of delay by the contractor as required by the contract
9	The choice of method for evaluating the delay
10	Global Claim
11	Conflicts on the ownership of float

Source: [5].

III. MATERIALS AND METHODS

This study adopted a well–structured online questionnaire developed from the review of relevant literature. The objectives were to assess the level of presentation of documents and records to back up claims for extension of time and to assess the major issues in disputes with claims of EoT. The study covered Lagos and Abuja which are the two major areas that house the highest numbers of construction-based organisations in Nigeria. Experienced construction professionals that have attained managerial level, and working with consultants and contractors were sampled using snowball sampling techniques, as they are a key to project delivery in the construction industry. The Questionnaire was used for this study because covers wider audiences at an economical cost within a shorter time. Online means of questionnaire survey helps to avoid hard-copy paper questionnaires; it is eco-friendly [39].

The questionnaire used was designed into three sections. The first section garnered information on the demographic

characteristic of the respondents. Information gathered in this section served as a quality check to those obtained from other sections. The second section collected information on the role of documents and records in substantiating claims for extension of time, and the third section collected data on the major issues in disputes with claims of EoT. The questionnaire was based on a 5-point Likert scale in which 1 = lowest score/rating and 5=highest score/rating. The respondents were required to rate the variables on documents and records to substantiate claims for extension of time based on level of importance in obtaining approval of the request for EoT, and the variables on the major issues in disputes with claims of EoT were based on level of frequency of occurrence.

The population of 3888 construction organisations in Lagos and Abuja were obtained from the study of [40]. From the sample size determination Table in [41], 3888 is closer to 4000, and the corresponding sample size is 351. Three hundred and fifty-one questionnaires were administered to the target participants using the snowball sampling technique via Google form electronically. The snowball sampling technique is based on referrals and it can increase sample response rate [42-43]. The sampling method adopted in this study was informed by the inability to reach all the experienced target participants by self or physical means. Leveraging the benefits of the chain of referrals of snowball sampling method, a total of 139 responses (88 from Lagos, 51 from Abuja) were received after 12 weeks survey period, and this was deemed fit for analysis. This represents a response rate of 39.60% which is above the range suggested by [44].

The gathered data were analysed using descriptive statistics such as frequency, percentage, and mean score. The Cronbach's alpha test was used to determine the reliability of the research instrument and the internal consistency of responses. As can be seen in Table 3, the Cronbach's alpha coefficients obtained are above 0.70 suggested by [45-46]. This implies high instrument reliability and quality of data. The methodological flow chart is shown in Figure 2 below.

The cut-off points for determining the level of importance or significance as obtained from [47] is detailed below;

i. 90 to 100% = very high importance
ii. 70-89% = High importance
iii. 50 -69% moderate importance
iv. 30 to 49% = little importance
v. 1 to 29% very little importance.

Table 3: Reliability Evaluation.

Case Processing Summary				**Reliability Statistics**	
		N	**%**	**Cronbach's Alpha**	**No. of items**
Cases 1: the role of documents and records in substantiating claims for extension of time	Valid	139	100.0	0.727	18
	Excluded[a]	0	0		
	Total	139	100.0		
Cases 2: the major issues in disputes with claims of EoT.	Valid	139	100.0	0.821	11
	Excluded[a]	0	0		
	Total	139	100.0		

Source: Authors, (2021).

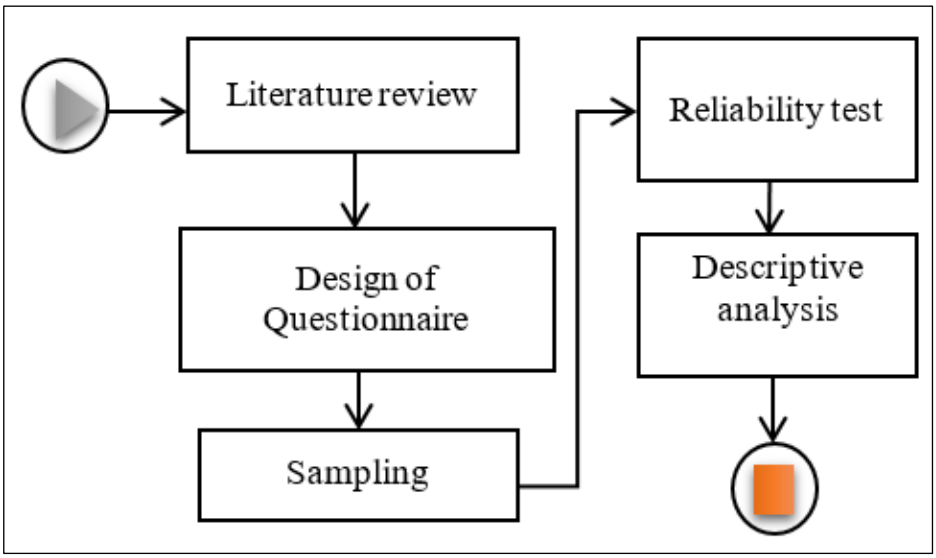

Figure 2: Methodological flow chart.
Source: Authors, (2021).

IV. RESULTS AND DISCUSSIONS

IV.1 RESPONDENTS BACKGROUND DETAILS

The results of the analysis of the data gathered on respondents background information are shown in Table 4. It can be seen that 38.85% of the respondents work with consultants, while 61.15% work with contractors' organisations. This shows a fair representation of the two major players in contract administration and management. The professional composition shows that 23.02% are Architects, 10.07% are builders, 38.85% are Engineers, and 28.06% are Quantity surveyors. This shows a fair representation of the major professions engaged by construction organisations. In terms of the rank/positions

occupied by the respondents, 32.37% are project managers, 26.62% are contract managers, 10.79% are works managers, 12.95% are production managers, and 17.27% are site managers. This reflects considerable experience and knowledge possessed by the respondents. The average working experience of the respondents is about 11. 34 years. This shows a considerable length of time to gain adequate experience and knowledge and attainment of managerial positions in the industry.

The educational qualification shows that 10.79% have HND, 8.63% have PGD, 43.88% have B.Sc/B.Tech., 35.25% have MSc./M.Tech., and PhD is 1.44%. The professional status of the respondents shows that 86.33% of them are chartered members of the respective professional bodies, and only 13.67% are yet to obtain their professional qualifications. The participants have the requisite education and are professionally qualified to participate in the subject of this study.

Table 4: Respondents background characteristics.

Variables	Classification	F	Per cent
Organisational category	Consultants	54	38.85
	Contractors	85	61.15
	TOTAL	**139**	**100.00**
Participants professions	Architect	32	23.02
	Builders	14	10.07
	Engineers (Civil/structural & Services)	54	38.85
	Quantity Surveyors	39	28.06
	TOTAL	**139**	**100.00**
Position/rank	Project managers	45	32.37
	Contract managers	37	26.62
	Works managers	15	10.79
	Production managers	18	12.95
	Site managers	24	17.27
	TOTAL	**139**	**100.00**
Years of experience	0-5years	11	7.91
	5-10years	35	25.18
	11-15 years	55	39.57
	16-20 years	23	16.55
	21-above	15	10.79
	TOTAL	**139**	**100.00**
Highest Educational Qualification	Higher National Diploma (HND)	15	10.79
	Postgraduate Diploma (PGD)	12	8.63
	Bachelor of Science/technology (B.Sc./B.Tech)	61	43.88
	Master's Degree (MSc./M.Tech.)	49	35.25
	Doctorate (PhD)	2	1.44
	TOTAL	**139**	**100.00**
Professional status	Chartered member	120	86.33
	Probationer	19	13.67
	TOTAL	**139**	**100.00**

Source: Authors, (2021).

IV.2 THE ROLE OF DOCUMENTS AND RECORDS IN SUBSTANTIATING CLAIMS FOR EXTENSION OF TIME

The result of the analysis of the data gathered on the documents and records for substantiating claims for extension of time is shown in Table 5. It can be seen that the top six (6) of these documents and records for substantiate claims for extension of time-based on level of importance in obtaining approval of the request for EoT are; Time impact analysis showing the potential impact of the changes before carrying out the changes (mean=4.53), Change of work notices (mean=4.53), Claim register (mean=4.52), Programme updates (mean=4.51), Minutes of the daily, weekly, and meetings (mean=4.47), and Daily progress reports (mean=4.46). While the least required are; productivity analysis reports (mean=4.25), Weekly progress reports (mean=4.25), Cause and effect analysis for each delay disruption event (mean=4.24), Delay events log (mean=4.24), Notices for delay (mean=4.22), and Method of construction identifies the works that are intended to be executed by subcontractors (mean=4.14).

However, disregarding the relative ranking of these variables, they all have a high influence on the success of EOT claims requests. This is premised on the range of mean score of the factors, the highest mean score = 4.53(90.50%) and the lowest mean score = 4.14 (82.73%), with an average mean score of 4.37 (87.44%). Furthermore, 66.67% (12) of the assessed variables have a high level of importance in substantiating EoT claims, while 33.33%(6) have a very high level of importance in substantiating EoT claims in construction contracts.

The result of this section supports the findings of [24, 31-32]. Record keeping and propoer documentations of events, meeting, instructions, change reques, among others are critical to the success of EoT request.

Table 5: List of required records to establish properly substantiated EoT claims.

S/No	Variables	Mean score	S.D.	Rank	Per cent	Remark
1	Baseline schedule	4.45	0.8180	7th	88.92	High
2	Method of construction identifies the works that are intended to be executed by subcontractors.	4.14	1.0915	18th	82.73	High
3	Planned manpower and machinery resources	4.43	1.1860	8th	88.63	High
4	Programme updates	4.51	1.0241	4th	90.22	Very High
5	Notices for delay	4.22	1.1167	17th	84.46	High
6	Programme revisions indicate changes and their required resources and the impact on the contract completion date.	4.40	1.0124	9th	88.06	High
7	Delay analysis	4.29	1.1258	12th	85.90	High
8	Time impact analysis shows the potential impact of the changes before carrying out the changes.	4.53	1.0857	1st	90.50	Very High
9	Cause and effect analysis for each delay disruption event.	4.24	0.9214	15th	84.75	High
10	Productivity analysis reports	4.25	1.3027	13th	85.04	High
11	Minutes of the daily, weekly, and meetings.	4.47	1.1628	5th	89.35	Very High
12	Minutes of any special meeting	4.40	1.0188	10th	87.91	High
13	Change of work notices	4.53	1.0857	1st	90.50	Very High
14	Daily progress reports	4.46	1.0513	6th	89.21	Very High
15	Weekly progress reports	4.25	0.9934	13th	85.04	High
16	Monthly progress reports	4.38	0.9356	11th	87.63	High
17	Claim register	4.52	0.9037	3rd	90.36	Very High
18	Delay events log	4.24	1.1770	15th	84.75	High

Sources: Authors, (2021).

IV.3 THE MAJOR ISSUES IN DISPUTES WITH CLAIMS OF EOT

The result of the analysis of the data gathered on the issues in disputes with claims of EoT is shown in Table 6. The top five (5) issues in disputes with claims of EoT based on their level of frequency of occurrence are; concurrent Delay (mean=4.53; SD=1.2057), The absence of notice of delay by the contractor as required by the contract (mean=4.50; SD =1.1818), Eligibility of time extension claim i.e. the permissibility of any specific delay event for justifying a project time extension (mean=4.47; SD=1.0857), Inadequate effort in mitigating the delay (mean=4.47; SD=1.1313), and Poor demonstration of the impact of the delay event to the project schedule (mean=4.44;

SD=0.9411). While the least 3 disputed issues associated with EoT claims are; the choice of method for evaluating the delay (mean=4.26; SD=0.9656), Conflicting interpretation of contractual provisions (mean=4.21; SD=1.2364), and Global Claim (mean=4.13; SD=1.3233).

Similarly, regardless of the relative ranking of the assessed variables, disputed issues associated with EoT claims have high level of occurrences in construction contracts. The mean score ranges from a maximum of 4.53 to a minimum of 4.13, and an average mean score of 4.38. Therefore, the level of occurrence of disputed issues in construction is high in the construction industry.

The finding in this section is in line with the report of (Yusuwan and Adnan, 2013). It was reported that concurrent delays, extension of time claim eligibility, contractors' failure to comply with contractual requirements for requesting EOT, among others. Extension of time claims comes with a lot of issues, and the need to request EoT is premised on events that impact project completion, and disputes in construction are linked to EoT claims [34-35, 37-38].

Table 6: Disputed Issues Associated with EoT Claims.

S/No	Variables	Mean score	S.D.	Rank
1	Concurrent Delay	4.53	1.2057	1st
2	Eligibility of time extension claim i.e. the permissibility of any specific delay event for justifying a project time extension	4.47	1.0857	3rd
3	Failure by the contractor to comply with the contractual requirement for EOT application	4.40	1.3062	6th
4	Inadequate effort in mitigating the delay	4.47	1.1313	4th
5	Poor demonstration of the impact of the delay event on the project schedule	4.44	0.9411	5th
6	Permissible period of time extension	4.35	1.0826	8th
7	Conflicting interpretation of contractual provisions	4.21	1.2364	10th
8	The absence of notice of delay by the contractor as required by the contract	4.50	1.1818	2nd
9	The choice of method for evaluating the delay	4.26	0.9656	9th
10	Global Claim	4.13	1.3233	11th
11	Conflicts on the ownership of float	4.37	1.0163	7th

Sources: Authors, (2021).

V. CONCLUSIONS

The purpose of this study is to assess the factors for substantiating Extension of time (EoT) claims and the common issues associated with (EoT) in complex-Multi Stakeholders' Building Construction contracts. This study adopted a well-structured questionnaire administered on construction professionals in consulting and contracting organisations, via electronic means and using snowball sampling techniques in Abuja and Lagos state, Nigeria. Interesting findings were made and discussed.

The study found that the major documents and records that have a high level of importance for substantiating claims for extension of time are; time impact analysis showing the potential impact of the changes before carrying out the changes, change of work notices, claim register, programme updates, minutes of the daily, weekly, and meetings, and daily progress reports. The major disputed issues associated with claims for extension of time in construction contracts are concurrent delay, The absence of notice of delay by the contractor as required by the contract, eligibility of time extension claim i.e. the permissibility of any specific delay event for justifying a project time extension, inadequate effort in mitigating the delay and poor demonstration of the impact of the delay event to the project schedule.

Effective contract management is at the centre of the successful delivery of construction projects. Contractors should have a formidable team to ensure that there is a proper understanding of all facets of the projects, including contract conditions and provisions. Proving delays responsibility and substantiating extension of time claims requires a lot of effort and knowledge of contract management. Efforts should be made to ensure that records for claim events are recorded and regularly updated. Contractors should ensure that they work as efficiently and effectively as possible to avoid delays on the critical paths that will impact the project completion date. This is because any critical delays will delay the entire project delivery time and the client will be entitled to a deduction of LAD on a weekly or monthly basis depending on the provision of the contract.

Regular training and continuous professional development are required to enhance the skills and expertise of project administrators/managers for effective claim administration and management. Recording keeping and proper documentation is a critical skill needed for effective contract administrations. Every built environment professionals should learn it. Communication, analytical and problem-solving skills are also needed by the contractors and other construction teams; for the efficient and effective delivery of construction projects.

The outcome of this study is critical to the success of the project managers/administrators who are vested with the responsibility of ensuring that projects are delivered within the planned schedule and critical delays are avoided by all means. Clients and their agents will also benefit from this study, as they have a role to play in ensuring that projects are delivered on time without delays that are attributed to design changes, payment issues, among other issues related to their activities. This study will also add to the few existing bodies of knowledge on an extension of time claims administration and delays management in developing countries.

This study is limited by a geographical boundary (Lagos state and Abuja), and the sample size may not be representative enough to enable the generalisation of the results. Caution should be taken in generalisation of the outcome of this study. Based on these, A similar study is therefore advised in other regions or states or developing countries, this will enable provide more reports for comparison. A critical question that requires an answer 'is what percentage of time extension is contributed by the contractors and clients and their agents'? The relationship between client and contractors-specific delay factors on the completion date of construction projects requires investigation.

VI. AUTHOR'S CONTRIBUTION

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CHALLENGES ASSOCIATED WITH THE IMPLEMENTATION OF INSURANCE IN BUILDING PROJECTS IN NIGERIA

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ABSTRACT

The nature, complexity of activities and multiple stakeholders involved in the delivery of construction projects have made the construction industry to be filled with risks and uncertainties. These uncertain events impact mostly on time, cost and quality performance of construction projects. The uptake of insurance is one of the key risk management tools for mitigating the impact of construction project risks. While, the implementation of insurance is important and widely used in developed countries, the same cannot be said about developing countries because of some challenges. The purpose of this study is to assess the challenges associated with the implementation of insurance in building projects in Nigeria. The well-structured questionnaire and convenient sampling technique were adopted in the collection of data from experienced clients, contractors, construction professionals and insurance experts on educational projects executed from 2012 to 2016 at the Federal University of Technology, Akure, Ondo State. With a response rate of 75.71% and a reliability index of 0.897, the gathered data were analysed using appropriate descriptive statistical tools and the Kruskal-Wallis test. The study that the major challenges with the implementation of insurance in a building project are; Lack of trust and confidence in insurance agents, No strict instruction from the government, Complex policy language, Failure to administer contractor's claim in time and Rising cost of the premium. Sensitization of the customer is also important as it is necessary to continue building trust and confidence in current and potential customers of insurance companies. Government should strengthen existing policies and institutions to ensure that implementation and compliances are strictly followed and monitored.

I. INTRODUCTION

The construction industry is the economic prime mover and bedrock for the socio-economic development of nations. This is premised on the critical role it plays in employment creation, infrastructure provisions and wealth creation [1, 2]. However, constructions projects are complex and involve multiple stakeholders, laden with risks and uncertainties and suffer from a lot of poor performance issues that have financial implications in both developed and developing economies [3]. According to [4], the Construction sector is prone to more risks than many other sectors of the world. A persistent challenge in the delivery of projects in the construction industry is cost and time overrun, poor safety record, quality issues, wastage and loss of value for client monies [5]. A vital risk management tool for managing construction project risks especially that of poor time, cost and quality performance is insurance [6-7,4].

Effective implementation of building construction insurance helps to satisfy the interest of the client, the contractor will have peace of mind in the event of any loss, as he/she is required to achieve the required quality and standard and to provide for the safety of workers [8]. Insurance provides an effective risks mitigation measure whether at a country, market or project level [9]. In the industrial and construction sector, if investments in buildings are to be feasible, investors must take up insurance overs [10]. According to[11], construction insurance

transfers risks from clients, contractors, subcontractors and other construction project parties to an insurer to offer contingent funding in times of difficulty. This is important as building projects does not experience 'smooth sail' as it progresses from one stage to another, but are fraught with numerous problems [12, 13]. The cost of risks is a concept that a lot of companies neglect even when it constitutes a major cost item [14]. [15] states that owing to the high number of uncertainties inherent in major construction projects, contractors have to cope with the uncertainties and the clients have to pay for them. This has made the effective and efficient analysis and management risks inherent in construction projects have remained a serious challenge to practitioners in the industry.

A construction project entails the production of a long-lived capital product whose production process involves a complex interaction of design, construction, finance, law and insurance [16]. The wide range of interaction in building production also means that the risks involved are high and taking up construction insurance is a fundamental way of dealing with the risks in construction project delivery. [17] suggested the introduction of provisions in contracts clauses that will require contractors to maintain certain types and levels of insurance. This is important to ensure that the effect of the financial losses that accompany risks on construction projects are minimised. In the most standard form of contracts, adequate provisions for insurance were made [18]. Similarly, in advanced construction industries, [19] posit that the concept of insurance is statutorily established, thus, making it a crime for citizens that failed to take insurance policies. In a developing country like Nigeria, insurance implementation is made compulsory between clients and contractors under the insurance act 2003. This is to ensure that buildings are projected against unexpected developments [19].

In Nigeria, it was observed that despite the importance of insurance, insurance practices implementation has remained unclear among construction firms [20]. Construction practitioners lack a clear understanding of what risks are transferred/covered by insurance. This has made it impracticable to successfully claim for difficulties that impact the project delivery cost, time and quality [21]. Preventable expenses that result from unsafe behaviours lead to a high level of site accidents which most often leads to site closure, loss of productivity, loss of profits, labour turnover, reputation losses, among others [22, 23]; have been reported to be worsened by lack of insurance coverage and/or ineffective implementations. [24] state that the lack of interaction among various parties, absence of risks management continuity at different stages of projects, and lack of formalised risk management procedures, were responsible for the ineffective implementation of insurance.

Evidence exists that despite enormous benefits and the provisions in insurance acts and contract conditions, the level of patronage for insurance is inadequate in Nigeria [25]. Construction insurance is one of the research areas that have been overlooked by researchers, thus, making available studies in this area scarce. It is based on the foregoing, that this study assessed the challenges associated with the implementation of insurance in building projects in Nigeria. This study leverage the experiences of clients, contractors, and construction professionals, insurance companies in the execution of education building projects that span between 2012 and 2016 at the Federal University of Technology Akure, Ondo State (FUTA) to gather useful data. This study will be of great benefit to the contractors and their relationship with the clients and even the field operative who are mostly the causer and victims of safety failures and other unsafe behaviours on construction sites. This study will also add to the few existing studies in insurance implementation in construction in developing nations and beyond.

II. REVIEW OF LITERATURE

II.1 INSURANCE IN THE CONSTRUCTION INDUSTRY

Insurance involves the complex social and economic scheme of life and property risks handling that have high destructive impacts when these entities experience it [26, 27]. Insurance is a conscious and deliberate transfer of risks from a company, party or an individual to another company in which the losses are equitably shared by all members [28]. In the case of unexpected losses, insurance is meant to protect the economic welfare of individuals, an entity or company [29]. Insurance helps in the distribution of pool of burdens by acting as a financial mechanism for reducing losses due to uncertainty [30]. Basically, insurance is a risk transfer mechanism which involves financial compensation or cover for losses that are beyond the control of the parties involves.

The discharge of insurance contract is guided by certain principles. These principles are fundamental to the success of any insurance agreements. [31] identified six basic principle of insurance law and practices and they are; “insurable interest”, “utmost good faith”, “indemnity”, ”Disclosure”, “subrogation”, and “proximate causes”. [32] identified insurable interest, non-disclosure, fraud, misrepresentation, premium and subrogation; as the basic insurance principles identified. Similarly, the study of [33] identified insurable interest, utmost Good faith, subrogation and indemnity as the basic principles of insurance.

[4] defined risks as a likely threat, damage, liability, injury or other negative events triggered by internal or external factors, which however, can be avoided to proactive approach. Construction industry is commonly challenged by risks such as environmental risk, technical risk, financial risk, and construction risk. [4] highlighted 10 types of insurance available for construction projects, and they are; contractor's All Risk Policy (CAR); Workers Compensation Insurance; Employer's Liability Insurance; Contractor Plant and Machinery Policy; Public Liability; Product Liability; Professional Indemnity Policy; Standard Fire and Special Perils Insurance; Burglary Insurance; and Marine Insurance. [34] reported that the most important insurances in construction are four, and they are construction All Risk insurance, Business liability insurance, Professional liability insurance and Design and construct insurance. It was further stated that others are based on the nature and complexity of the project involved and they are; Insurance for hidden defects, Excess liability (for design) insurance, Soil remediation insurance, Machinery and equipment insurance, Assembly insurance, and Warranty insurance.

When effectively implemented, insurance help to improve project performance and relations of stakeholders. However, there certain challenges or barriers that construction insurance is faced with in the construction industry. While some are caused by the insurance companies, other comes from the contractors and general perceptions of stakeholder in the sector.

II.2 CHALLENGES ASSOCIATED WITH THE IMPLEMENTATION OF INSURANCE IN BUILDING PROJECTS

[29] reported that a key reason raised by contractors for the low interest in taking up insurance cover is the inefficiency of

insurance companies in giving immediate attention and assistance in the invent of uncertainties. The insurance sector has performed believe expectation. [35] found that the absence of trust and confidence in the insurance companies due to lack of knowledge about the life insurance products. The long period taken to settle insurance-related problems between contractors and insurance companies were also reported as being part of the problems facing the implementation of insurance in the construction sector. Poorly developed distribution channels resulting from brokers interference, unwillingness to pay claims as at when due, poor perception by the public, lack of the capability to secure skied workforce, poor regulations of the sector, rigidity to follow trends and development in information and communication technology, low level of investment and capabilities to manage assets; were submitted in support of the argument for the persistent poor performance of the insurance sector [36]. Other factors are corporate governance issues, ignorance on the part of customers on the benefits of insurance products, lack of innovation in product development, poor assets quality, unethical practices, dearth of professionals, and non-enforcement of compulsory insurance, among others.

In China, [37] investigated the major issues and challenges in risk management and insurance and found that priority is not given to risk management and loss prevention and that the contractor is not motivated to transfer risks to insurers as losses are reimbursed by the government. This is because the government remains the largest client of the sector. Large and medium-sized construction projects are procured by the government. [38] pointed out that the poverty line and low per capita income; affect the level of penetration of insurance in any society. Attitude and perception of the insurance companies is another factor that is responsible for the low patronage of insurance cover. The large numbers of defaulting claims by insurers have given consumers the impression that all is not well and the public image and significance of insurance is being eroded in the construction industry. [39] pointed out that the clauses in insurance policy documents still carry distrust items and have been given diverse interpretations by customers.

Poor premium collection, ethical issues, low liquidity, solvency problems, poor management, lack of standards, lack of integrity, low information adoption level, lack of government support, attitudes and perception towards insurance, and motivation issues; are the problems affecting the implementation of insurance by construction firms [40]. [41] reported that the reasons for the very low uptake of insurance in Ghana and other developing countries are; lack of awareness of the existence of insurance products, poor understanding of the concept of insurance. According to [42], credit constraints, trust issues, basic risks, household wealth, risk aversion, hyperbolic preferences and marketing methods, are the factors determining the uptake of insurance by household.

The demand for insurance in low-income countries is another factor influencing insurance uptake. Majorly, the lack of demand for insurance and low availability of information about insurance schemes were highlighted by [43] as the factors affecting insurance uptake. The lack of confidence and trust in insurance companies is a major factor inhibiting the implementation of insurances [8, 44]. The high cost of the premium, complex language policy, inadequate companies willing to insure were reported by [45, 6] as being the consequence of the inefficiency of insurance companies in managing risks in construction. Care must be exercised by insurance companies to void any element of distrust, as this will further reduce their market size. This is because trust is a key in insurance and the insurance sector is a volatile sector [8].

III. MATERIALS AND METHODS

This study assessed the perception of construction experts, clients and insurance agents on the challenges with the implementation of insurance in educational building construction projects. Twenty (20) ongoing and completed building projects in the federal university of technology, Akure, Ondo State, Nigeria. A total of Seventy (70) construction practitioners (15 contractors, 20 consultants, 20 client's representatives and 15 insurance brokers) who were directly involved in the construction projects, took part in the study. A well-structured questionnaire administered to these professionals served as the tool for data collection. The questionnaire provides a fast and economical means of a survey, it provides quantifiable data from which inferences can be drawn.

The questionnaire was designed using variables obtained from a detailed literature review. The questionnaire has two sections; the first section collected data on the respondents' profiles, and this information served as a quality check to data obtained in the second section. The second section garnered data on the challenges with the implementation of insurance on building construction projects. A 5-point Likert scale was adopted in the questionnaire; where 5 is the highest scale and 1 is the lowest scale. The respondents were required to rate the identified variables regarding the challenges with the implementation of insurance in building projects based on the level of significance. The convenient sampling technique was adopted in the survey to administer the data collection instrument. The use of convenient sampling was informed on the need to meet the research aim and ensure that only participants with the response of the requisite experience to the questionnaire [46]. Furthermore, the practical experience of the researcher on construction-related activities was also considered in selecting respondents in convenient sampling techniques [47].

A total of 53 completed questionnaires were retrieved after a survey period of 12months, and this represents a response rate of 75.71% which is above the suggested response rate in construction management studies as submitted by [1]. A response rate of 20-30% was suggested to be adequate for questionnaire-based studies [48]. The high response rate was attributed to the follow-up visits and calls to non-responding participants as suggested by [1].

The gathered data were analysed using frequency, percentage, mean score and Kruskal-Wallis H-Test. Frequencies and percentages were used to analyse the data on the respondents' profiles. Mean score was adopted in determining the relative weight of the variables on challenges of implementation of insurance and in ranking the variables. The Kruskal-Wallis H-Test was adopted to ascertain if differences exist in the perception and rating pattern of the participants regarding the challenges of insurance implementation. Furthermore, it was used to determine the proportion of variables in which the views differs [5]. Since, these participants came from different organisation backgrounds, have different levels of experience and education; there is a tendency to have differing opinions. This further reinforced the use of the Kruskal-Wallis H-test. [5] state that the Kruskal-Wallis H-Test is appropriate when the target is to determine the existence of different opinions of more than three groups of respondents. However, these tests stated above were proceeded by a reliability evaluation using Cronbach's alpha. Cronbach's alpha (α) value is

the widely used tool for determining the internal consistency and reliability of a study [49]. The aim was to ascertain the suitability and dependability of the research instrument and the internal consistency of participants' responses. A Cronbach's alpha coefficient of 0.897 was obtained (see Table 1), and this is above the 0.70 recommended for good reliability by [50, 51]. Based on this, the instrument has good reliability and the gathered data are of good quality. Figure 1 below shows the methodological flow of the study.

Table 1: Reliability Evaluation.

Case Processing Summary				**Reliability Statistics**	
		N	%	Cronbach's Alpha	N of Items
Cases	Valid	53	100.0	0.897	12
	Excluded[a]	0	0.00		
	Total	53	100.0		
a. Listwise deletion based on all variables in the procedure.					

Source: Author, (2021).

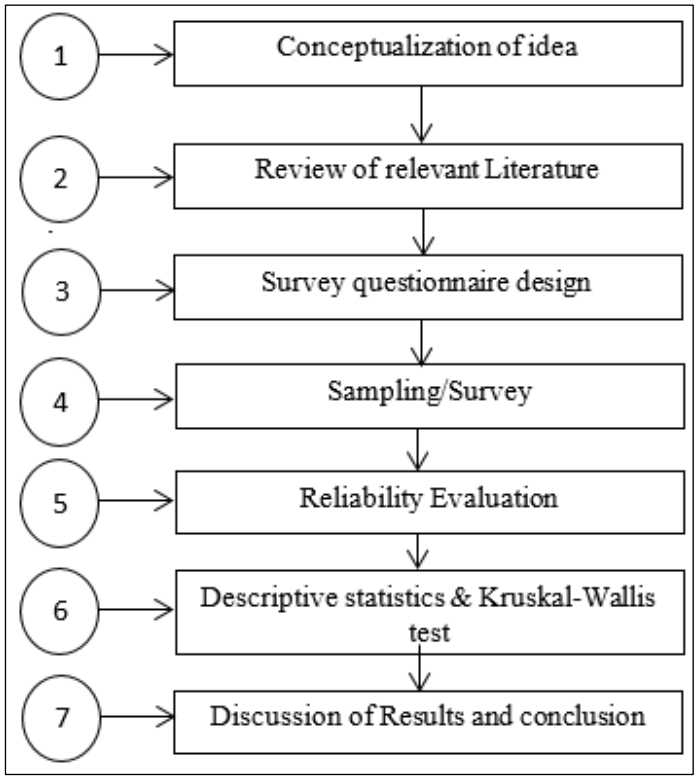

Figure 1: Methodological procedure flow chart.
Source: Author, (2021).

IV. RESULTS AND DISCUSSIONS

IV.1 BACKGROUND INFORMATION OF THE RESPONDENTS

From Table 2, it can be seen that 20.75% of the respondents are clients' representatives, 37.74% are consultants, 18.87% are contractors, and 22.64% are insurance agents. This shows a fair representation of the parties involved in insurance in construction. In terms of years of experience, 5.66% have 1-5 years of experience, 30.19% of them have 6-10 years, 4.17% have 11-20 years of experience, and 16.98% have 20 years and above experience. This shows that they are experienced enough in construction-related businesses. The academic qualification of the respondents shows that 18.87% have HND, 13.21% have PGD, 47.17% have B.SC/B.Tech, 20.75% have M.Sc/M.Tech and none of them have PhD. This implies that they have the requisite educational qualification to contribute to this study.

In terms of the positions of the respondents, 43.40% are top management staff, 22.64% are middle management staff, and 33.96% are experts in their field. This implies that the respondents' occupies decision making responsibility in their organisations. In terms of professional qualification, 83.02% are chartered members of their different professional bodies and 16.98% are probationer members. This show that the respondents are professionally qualified to aid in meeting the subject of this study.

Table 2: Profile of the Respondents Involved in the Study.

Category	**Classification**	**Freqy**	**%**
Type of respondents	Client's Rep.	11	20.75
	Consultant	20	37.74
	Contractor	10	18.87
	Insurance agents	12	22.64
	TOTAL	**53**	**100.00**
Years of experience	1-5 years	3	5.66
	6-10 years	16	30.19
	11-20 years	25	47.17
	above 20 years	9	16.98
	TOTAL	**53**	**100.00**
Academic qualification	HND	17	31.48
	PGD	5	9.26
	B.Sc/B.Tech	26	48.15
	M.Sc/M.Tech	6	11.11
	TOTAL	**54**	**100.00**
Position of respondents	Top management	23	43.40
	Middle management	12	22.64
	Expert	18	33.96
	TOTAL	**53**	**100.00**
Professional Status	Corporate/Registered	44	83.02
	Probationer	9	16.98
	TOTAL	**53**	**100.00**

Source: Author, (2021).

IV.2 CHALLENGES ASSOCIATED WITH THE IMPLEMENTATION OF INSURANCE IN BUILDING PROJECT

Table 3 shows the results of the analysis of the data collected on the challenges associated with the implementation of insurance in building projects. It can be seen that according to the contractors' group, the top 5 challenges to insurance implementation in building construction projects are; complex policy language (mean=4.91), Lack of trust and confidence in insurance agents (mean=4.82), No strict instruction from the government (mean=4.45), Rising cost of the premium (mean=4.45), and Inefficiency of insurance companies in handling construction risks (mean=4.09). For the clients' representative, the top challenges to insurance implementation are; Lack of trust and confidence in insurance agents (mean=4.90), No strict instruction from the government

(mean=4.90), Complex policy language (mean=4.80), Failure to administer contractor's claim in time (mean=4.66), Rising cost of the premium (mean=4.20), and Lack of proper knowledge and understanding of insurance (mean=4.20).

The Consultants rated No strict instruction from the government (mean=4.95), complex policy language (mean=4.65), lack of trust and confidence in insurance agents (mean=4.60), failure to administer contractor's claim in time (mean=4.40), and Rising cost of the premium (mean=4.30); as the top challenges to the implementation of insurance in building projects. While, for the Insurance Company, the top major challenges to the implementation of insurance in construction projects are; No strict instruction from the government (mean=4.92), lack of trust and confidence in insurance agents (mean=4.90), failure to administer contractor's claim in time (mean=4.75), complex policy language (mean=4.58), and the rising cost of the premium (mean=4.58).

Overall, the top 5 challenges with the implementation of insurance in building projects are; Lack of trust and confidence in insurance agents (mean=4.81), No strict instruction from government (mean=4.80), Complex policy language (mean=4.74), failure to administer contractor's claim in time (mean=4.43), and the rising cost of the premium (mean=4.38). The finding in this section is in support of the studies of [8, 35, 44-45]. Trust is a key driver for improved confidence and performance, especially in the construction sector. The lack of trust and confidence in the operation mode of insurance companies has negatively impacted the number of construction companies taking-up insurance. This was stressed by [8, 44, 35]. It was emphasized that lack of trust and inefficiencies in insurance companies in handling issues when uncertainties occur is a serious drawback to the implementation of insurance by construction organisations. There is usually an avoidable delay in settling claims by constructors, and this is identified by [8] as a barrier to the implementation of insurance.

[36] identified regulations of insurance companies and compliance monitoring. [45] identified the high cost of the premium, complex language policy, and inadequate companies willing to insure their properties as being the consequence of the inefficiency of insurance companies in managing risks in construction. The high cost of insurance premiums charged by the insurance companies is a major issue with the implementation of insurance by construction organisations.

To ascertain if a significant statistical difference exist in the ways the different professional groups rated the assessed variables, the Kruskal-Wallis test was performed. It was observed the perception of the respondents converged in 9 (75.0%) of the assessed variables. These variables have their p-value to be greater than 0.05 significant levels. This implies that there is no significant statistical difference in the perception of these variables by the survey participants. However, A significant statistical difference was observed in the rating of the 3 (25.0%) of the assessed variables by the survey participants. These variables are; failure to administer contractor's claim in time (mean=4.43; Sig. =0.000), Lack of proper knowledge and understanding of insurance (mean=3.94; Sig. =0.036), and Contractor opting for increased profit margin (mean=3.86; Sig. =0.016). it implies divergent views in the rating of these variables. These differences in views could be attributed to the varying level of implementation of insurance by the organisations sampled. The management of insurance cover by the different organisations is another factor that might have caused the divergence of opinion (see columns 12 and 13 of Table 3).

The overall Kruskal-Wallis Test showed a significant value of 0.751 (see Table 4). This implies that there is no statistically significant difference in the views of the target participants concerning the ways the assessed variables were rated. It is based on this that the hypothesis (H1) is not rejected.

Table 3: Challenges Associated with the Implementation of Insurance in Building Project.

Challenges with Implementation	Contractors		Clients'Rep		Consultants		Ins. Comp		Overall		K-W	
	Mean	Rk	Mean	Rk	Mean	Rk	Mean	Rk	Mean	Rk	Sig.	Decision
Lack of trust and confidence in insurance agents	4.82	2	4.90	1	4.60	3	4.90	2	4.81	1	0.053	Accept
No strict instruction from the government	4.45	3	4.90	1	4.95	1	4.92	1	4.80	2	0.648	Accept
Complex policy language	4.91	1	4.80	3	4.65	2	4.58	4	4.74	3	0.159	Accept
Failure to administer contractor's claim in time	3.91	6	4.66	4	4.40	4	4.75	3	4.43	4	0.000*	Reject
The rising cost of premium	4.45	3	4.20	5	4.30	5	4.58	4	4.38	5	0.300	Accept
Lack of proper knowledge and understanding of insurance.	3.64	12	4.20	5	4.25	6	3.67	12	3.94	6	0.036*	Reject
Too procedural	3.91	6	3.90	9	3.90	7	4.00	6	3.93	7	0.835	Accept
Contractor opting for increased profit margin	3.82	9	3.80	11	3.90	7	3.92	7	3.86	9	0.016*	Reject
The inefficiency of insurance companies in handling construction risks	4.09	5	4.00	7	3.60	11	3.92	7	3.90	8	0.116	Accept
No motivation for contractors to transfer risk	3.91	6	3.90	9	3.85	9	3.75	11	3.85	10	0.848	Accept
Not taking risk management and loss prevention as a priority	3.73	11	4.00	7	3.75	10	3.92	7	3.85	11	0.410	Accept
A tendency to underestimate risks	3.82	9	3.80	11	3.60	11	3.83	10	3.76	12	0.392	Accept

Ins. Comp. = Insurance Company; Clients'Rep= Client representative; *Sig. = p-value <0.05; df=3; Rk=Rank; K-W = Kruskal-Wallis Test

Source: Author, (2021).

Table 4: Overall Comparison of participants perception of Challenges with Insurance Implementation in construction.

	Respondents	Mean Rank	Chi Sq.	P-value	Decision
Challenges with Implementation	Contractors	22.79	1.206	0.751	Accept
	Clients Representative	27.42			
	Consultants	21.96			
	Insurance company	25.83			
df=3					

Source: Author (2021).

V. CONCLUSIONS

The aim of this study assessed the challenges associated with the implementation of insurance in building projects in Nigeria. The well-structured questionnaire and convenient sampling techniques were used to collect data from experienced clients, contractors, construction professionals and insurance experts on educational projects executed between 2012-2016 at the Federal University of Technology, Akure, Ondo State. The gathered data were analysed using descriptive statistical tools and the Kruskal-Wallis test, and interesting findings were made.

It was found that the major challenges with the implementation of insurance in building projects are; Lack of trust and confidence in insurance agents, No strict instruction from the government, Complex policy language, Failure to administer contractor's claim in time and Rising cost of the premium. Insurance cover is very important in the delivery of building construction projects as it offers a level of protection on the clients, contractors and even the site operatives in the event of any eventualities. It is recommended that continuous training of insurance agents on the latest techniques of handling uncertainties speedily and effectively should be embarked upon. Sensitization of the customer is also important as it is necessary to continue building trust and confidence in current and potential customers of insurance companies. Government should strengthen existing policies and institutions to ensure that implementation and compliances are strictly followed and monitored. Professionals should look at the strategy to address the issue of rates and take

Stringent steps to ensure that adequate rates are charged. Contractors should have a good negotiation skills, this is important enable them have improved conditions when negotiating terms and conditions with insurance companies. Also, there should negotiate to have best premium cost reduction. However, this can be achieved through proper control of losses and measures for managing risks by engaging knowledgeable and experienced experts especially for managing risks and insurance.

The study will benefit clients, contractors and even the workers on-site and other stakeholders that are impacted by the outcome of construction projects. This is because of the protections and assurance insurance cover provided. This study is very important because it adds to the scarce existing studies on insurance implementation in Nigerian and by extension other developing nations of the world. This study is a stepping stone and background for researchers who may want to carry out further research on the subject area. This study is limited by geographical boundaries and a small sample size. Thus, caution should be taken in an attempt to generalise its findings. A similar study is therefore recommended in other states or regions of Nigeria or other developing countries. An empirical study on the performance differential between contractors with insurance cover and those with insurance cover should be investigated.

VI. AUTHOR'S CONTRIBUTION

Conceptualization: Uchenna Afonne.
Methodology: Uchenna Afonne.
Investigation: Uchenna Afonne.
Discussion of results: Uchenna Afonne.
Writing – Original Draft: Uchenna Afonne.
Writing – Review and Editing: Uchenna Afonne.
Resources: Uchenna Afonne.
Supervision: Uchenna Afonne.
Approval of the final text: Uchenna Afonne.

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RESEARCH ARTICLE OPEN ACCESS

DEVELOPMENT AND TESTING OF A HYBRID DISTRIBUTION BOARD

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ABSTRACT

The intermittent power supply in the country has given rise to the use of direct current (DC) source as a substitute, however, most devices such as LED lamps, refrigerators, television, and radios are available in DC nowadays and cannot be connected to the conventional mains supply without the help of other devices like AC to DC converters. This prompts the need for a hybrid distribution board capable of supplying AC and DC concurrently to a final sub-circuit of an electrical installation of a building where DC and AC devices are required. Major components used are an isolator, miniature circuit breakers, and a rectifying module that convert a section of the AC source to the correct voltage level to power the DC load. The design was implemented and tested on a demonstration board having two separate circuitry loads installed on it. The circuitry loads are DC and AC, the DC load is comprised of a 5W DC bulb controlled with a gang switch, while the second circuitry is comprised of a 13A single socket outlet and a 10W LED lamp controlled with a gang switch. The result shows that both the DC and AC output works perfectly which when encourage will minimise power consumption and make provision for the connection of DC appliances without the use of external converter and step-down transformers.

I. INTRODUCTION

The intermittent power supply in the country and the need for low rating equipment with higher efficiency have given rise to the use of DC Equipment and fittings such as LED fittings, fans, television sets, refrigerators, and sound systems that require less energy [1, 2]. In most electrical installations where many circuits are to be wired, the distribution fuse board becomes a necessity. Consequently, to develop equipment that can supply both AC and DC load concurrently to the final sub-circuit, a hybrid distribution board is proposed, which will take in and supply AC/DC load concurrently and also gives room for future expansion [3].

A distribution board is a piece of equipment or an assemblage of parts that includes the main switchboard, fuses, or circuit breakers suitably arranged for the distribution of electrical power to the final sub-circuit in an electrical installation [4, 5]. However, there are several types of distribution boards which include: main breaker panel, main lug panel, sub-panel, and transfer switch and are available in 4-way, 6-way, 8-way, and 12-way configurations [6, 7]. The distribution board protects devices by allowing individual circuits to draw power from correctly rated breakers [8].

It is worthy of note that the rise of photovoltaic panels production increases the usage of DC electricity. DC distribution has more advantages such as stability, controlled emergency support, and no contribution to the short circuit level, and also used today in long-distance high-voltage cables, such as transmission cables on the floors of oceans [9]. However, there is a need for a step-down transformer or the usage of a converter before the DC load can be used in an AC supply board, but with the introduction of the hybrid distribution board, it is possible to use all these gadgets with ease with the use of an AC/DC module of adequate current rating that is capable of supplying AC and DC concurrently to a final sub-circuit in an electrical installation where DC and AC devices are required.

Hybrid is the combination of two or more things, while a hybrid distribution board refers to an electrical board that supplies alternating and direct current to the final sub-circuit. For effective energy efficiency management culture, the process of observing, controlling, and conserving electricity usage must be employed in residential and commercial installations [10], this will help more people to have access to electricity and also reduces the burden on the available power stations [11].

Several works on literature related to the study have been reviewed and [12] proposed a Smart Distribution Board that is optimized for the implementation of EMS for measuring the electricity usage on each circuit with the installation of a sensor that will enhance energy efficiency management. [13] opined that the applied AC and DC hybrid power distribution system has greater efficiency when deployed in renewable energy and also helps to boost energy regeneration in the building. Similarly, [14] proposed a system that can work in centralized as well as in autonomous modes which makes the grid smarter.

II. MATERIALS AND METHODS

The design is based on both DC and AC output supply, The AC load is connected to the AC output supply and the DC load is connected to the DC output supply. The board is expected to handle a total current of about 100Amps for the AC and DC module demand while the total current on the DC module shall not exceed 20A (DC).

The block diagram of the Hybrid Distribution Board is shown in Figure 1.

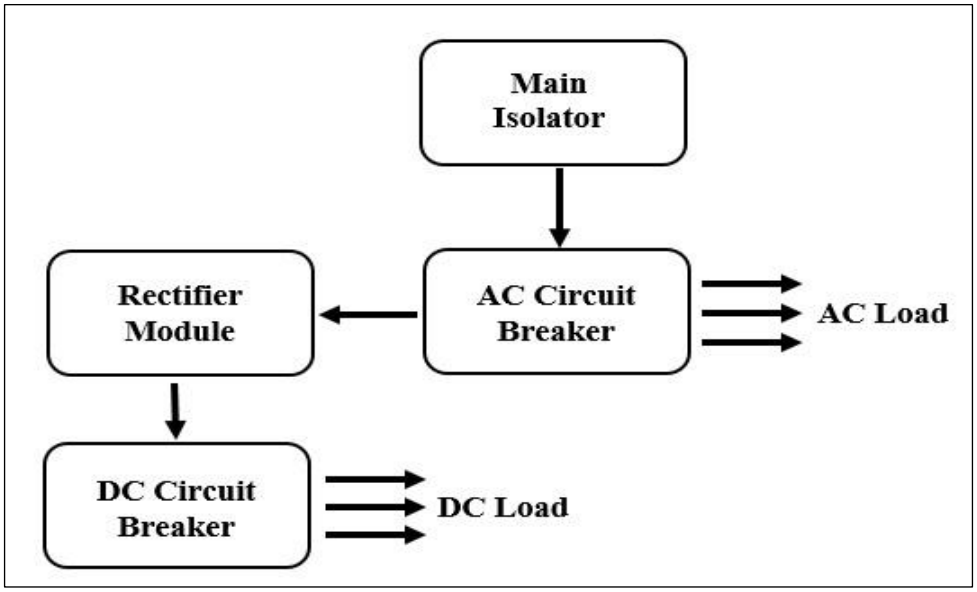

Figure 1: Block Diagram of Hybrid Distribution Board.
Source: Authors, (2021).

The construction is based on both DC and AC output supply. A 100A double pole AC isolator was fixed on a rack with the aid of the isolator clip. The rack was mounted in an enclosure with screws. This 100A isolator helps in controlling the incoming source voltage. The output from the isolator was connected to one side of the AC circuit breakers with a 10mm single core cable and the neutral from the isolator was connected to the neutral bar.

The S-240-12Vdc Switch Power Supply Module was screwed onto the enclosure with a rubber insulator under it; the rubber insulator prevents the module from having direct contact with the metallic enclosure thus preventing electric shock. The supply voltage to the DC module was connected from one of the outputs of the 20A circuit breakers. This circuit breaker serves as a protection device for the incoming supply of the module and the neutral was terminated on the neutral connector. The module does the work of conversion i.e. the converting 220V AC to 12V DC thus supplying DC voltage. The entire board has two output supplies which are AC output and DC output. AC load is connected to the AC output supply and DC load is connected to the DC output supply.

II.1 DEVELOPMENT PROCEDURE

The following materials are selected for the implementation of the design.

- 100A 240V Main Isolator Switch
- 20A 240 V AC – 12 V DC Switched Power Supply Module
- AC Miniature Circuit Breakers 10A, 25A, 25A and 30A
- DC Circuit Breakers

1) *100A 240V Main Isolator Switch:* It is a manually operated mechanical switch that separates a part of the electrical power, it is used to open a circuit under no-load conditions. Its main purpose is to isolate one portion of the circuit from the other and is not intended to be opened while current is flowing in the line. Main isolators are generally used on both ends of the breaker so that repair or replacement of the circuit breaker can be done without any danger.

2) *ModuleS-240V-12Vdc Switch Power Supply:* It is a switching device that converts 240V AC to 12V DC, AC input range selectable by auto-sensing, protecting short circuit/overload and overvoltage. The ModuleS-240V-12VDC Switch Power Supply circuit diagram is shown in figure1; it supplies electrical power to DC load, the primary function is to convert electric current from a source to the correct voltage, current, and frequency to power the load. As a result, power supplies are sometimes referred to as electric power converters.

3) *AC Circuit Breaker:* It is a circuit breaker that is also known as an overcurrent protection device (OCPD) designed to protect equipment or device from damage by shutting the power

when there is overload or malfunctioning in the circuit [15]. It is available in different ratings like 10A, 15A, 20A, 25A, 30A respectively. It can be reset after an overload has been cleared in a circuit.

4) *DC Circuit Breaker:* It is a circuit breaker that automatically shut off the power whenever the circuit is overloaded or experience short circuit conditions. The breaker detects a fault and immediately interrupts the continuity in the electrical flow. The main difference between direct current and alternating current is that in DC the voltage output is constant, while in AC it cycles several times per second [16].

III. RESULTS AND DISCUSSIONS

The construction was tested with a wooden board having two separate circuitry loads installed on it. The circuitry loads are DC and AC. The DC load is comprised of a 5W DC bulb controlled with a gang switch. The second circuitry comprised of a 13A single socket and a 10W LED lamp controlled with a gang switch. The input of the hybrid distribution board was connected to a 220V AC supply and the main isolator and all other circuit breakers were turned ON. Voltages were supplied to the two circuits and the entire devices connected to the circuit were all working.

Figure 2: Internal Connection when all cables are connected.
Source: Authors, (2021).

Figure 3: Constructed Hybrid Distribution Board Unpowered.
Source: Authors, (2021).

Figure 4: Constructed Hybrid Distribution Board Powered.
Source: Authors, (2021).

Figure 5: Hybrid Load on Wooden Board when Not Powered.
Source: Authors, (2021).

Figure 6: Hybrid Load on Wooden Board when Powered.
Source: Authors, (2021).

Figure 3. Shows the complete hybrid distribution construction when the board is not powered, and Figure 4. Shows the complete hybrid distribution construction when the board is powered, it was observed that the DC voltage displayed 12.6V while the AC voltage displayed 200V as shown in Figure 4. Similarly, Figure 5 and 6 displayed the extended load which comprises of both the AC and DC load when not powered and powered respectively. it was observed that energy efficiency can be achieved by hybrid distribution systems in a building. In addition to this when connecting DC load on the distribution board the polarity of the device to be connected needs to be done correctly i.e. positive connections to be made on the positive terminal and negative to the negative terminal. The testing of the project was done and the output result was achieved. The 5W LED DC bulb illuminated brightly at the output. Also, the 13A socket outlet and the 10W LED AC bulb worked perfectly fine.

IV. CONCLUSIONS

It is imperative to note that Hybrid Distribution Board implementation will minimize power consumption and make provision for the connection of DC appliances without the use of external converter and step-down transformers. The result shows that both the DC and AC output works perfectly, which when encouraged will reduce the cost of installing an inverter. It is concluded that in general, DC systems can improve energy efficiencies by simplifying system structures and improving conversion efficiencies of various converters.

V. AUTHOR'S CONTRIBUTION

Conceptualization: Najeem O. Adelakun, Banji A. Olanipekun and Samuel A. Omolola.
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Investigation: Najeem O. Adelakun and Banji A. Olanipekun.
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RESEARCH ARTICLE OPEN ACCESS

BUILDING INFORMATION MODELING (BIM) AND QUANTITY SURVEYING CONSULTANCY SERVICES IN NIGERIA

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ABSTRACT

In the growing Sustainable construction business, Building Information Modelling (BIM) represents a new paradigm. This new paradigm shift needs to be embraced by quantity surveyors to remail globally competitive. The construction industry has seen a many advances, including ecosystems, construction software, building information modeling (BIM) and augmented reality among others. As a result of these developments and evolutions, new tools, procedures, and software have been developed to help construction professionals be more productive. For potential integration into the life cycle of construction projects, BIM has advantage, which will enable it to become a reference point for construction projects and, as a result, it will be a vital instrument in project procurement in the future. As a result, major functions of Quantity Surveyors (QS) in BIM-based construction procurement would be significantly different from what they are now. There are concerns that BIM adoption could jeopardize the profession of Quantity Surveying. Understanding the possible expansions of QS positions in BIM-based project delivery is essential. Therefore, this study submits the review of role and responsibility of Quantity Surveyors in the adoption of BIM in Nigeria with a few to outlining the derivate benefits of its adoption.

I. INTRODUCTION

Surprisingly, the construction sector is ladened with traditional –based mode of operation that mainly relies on using of documents made by paper with huge fragmentation among stakeholders. [1, 2]. According to [3]. this type of conduct has forced the construction industry into inefficiency and a lack of willpower to use information communication technology. In the way projects are completed, construction industry is on the zenith of a major transformation. This move has the potential to dramatically improve construction process and the design. Sustainable design building and BIM are two major industry trends that are propelling these improvements [4]. Inefficiencies of Construction industry has the following drivers: issuing specifications and drawings at many stages from consultants to the contractor, stratified approach and inadequate design coordination. [5]. At planning and design stages, the most important decisions about a building's sustainable design can be made. More activity in the construction industry has centered on BIM and sustainable design ideas as the value of BIM has grown. [6] BIM is a vital component in minimizing industry waste, such as wasted energy, providing value to industry products, and reducing environmental damage [7]. High design performance facility and the practice of traditional design can be changed by combining BIM technology and sustainable design strategies as submitted by [8]. According to [9]. Building information technology has the technological capability of enhancing the efficiency and productivity of construction project problem in terms of project delivery. [10]. added that Building information modelling can optimize stakeholders' performance and platform for integrating

construction Industry, engineering and architectural that is fragmented.

Quantity surveyors, on the other hand, must be kept informed about the significant benefits that this BIM paradigm change will offer. As a result, QS must become familiar with BIM-based project delivery. This will pave the path for present Quantity Surveyors to get the skills and competencies they need to ride the next global wave of sustainable development and stay at the forefront of the business. If quantity surveyors want to remain competitive globally, they must be willing to embrace and adopt any construction industry innovation. According to [11]. the construction industry has witnessed a lot of improvement, including ecosystems, augmented reality, building information modeling (BIM) and construction software among others. As a result of these developments and evolutions, new tools, procedures, and software have been developed to help construction professionals be more productive. BIM has become one of the most popular construction technologies in the last decade [12]. According to [13]. BIM is a process for developing, managing, storing, exchanging, and sharing interoperable building information. This automation, which has been studied through the usage of BIM, has aided in cost estimation efficiency, among other things [14].

To achieve an effective performance of quantity surveying services, firms of Quantity Surveying are established which provides structure of an organization. These services include final account preparation, cost control, variation assessment, cost planning and estimating, negotiating contacts among others. [15]. The way QS firms are structured in Nigeria is synonymous to fragmentation in that about twenty-five percent of the firms have between 8 to 15 staff, Sixty-percent have 1 to 7 staff, while small firms account for fifteen percent have staff strength more than 15 number [15]. The study conducted by [16], blamed the fragmentation witnessed in the firm of QS on construction sector weakness which has the tendency to deter performance improvements. Non -existent is the study that examined adoption of Building Information Modelling among quantity surveyors when discharging their duties in the Nigerian construction industry. Therefore, this study asked the following questions. (1) What benefit can QS firms derived from adopting BIM ?(2) What are the associated challenges towards it application? (3) How applicable is BIM to QS firms and finally What are the practices in use among the Nigerian QS firms?

I.1 BUILDING INFORMATION MODELING CONCEPT

The desire to generate correct construction details of a building planned in a complex form sparked the development of 3D modeling [17]. BIM was first introduced in the 1990s, and it has provided the construction sector with numerous benefits. BIM has progressed from a software to an integrated system. Information technology (IT) solution provider is BIM which is used for combining software applications and IT tools to design a building in a common platform without depending on the utilization of software [18]. The emergence of BIM has resulted in a significant shift in how operations are carried out in the sector. According to [19]. BIM saves qualitative data and quantitative data. As a result, BIM allows estimators to export to specialist costing platforms without having to perform significant additional computations on design quantification of elements. BIM primary concept is based on the necessity to create a platform that addresses 2D computer-aided design (CAD) technologies' shortcomings by assuring a collaborative platform that puts all building information into a single file that can be exchanged and used by all project stakeholders [20]. According to several studies, the notion of BIM lacks a clear definition. According to [21], because to its developing nature, the idea of BIM has no approved definition.

The collaborative effort of all the BIM characteristics discussed thus far, according to [22], is an evolution that can solve problem which allows designers to optimize designs easily with visualizations, analyses, and simulations resulting in higher-quality construction documentation. The building's major IT-based information system promotes and unifies all of the building's designs and functions. The introduction of BIM marks a watershed moment in the built environment, removing the hurdles that all professionals face. BIM provides a comprehensive perspective of a project, from beginning to completion, even before completion, allowing for the mitigation of any recognized risk.

I.2 OVERVIEW OF QUANTITY SURVEYING FIRM

Quantity surveyors are employed in all aspects of the built environment around the world [23]. Because of the industry-wide influence and effect on project baseline, customer happiness, operational dynamics, and management efficiency, among other things, a favorable atmosphere is critical for quantity-surveying firms in the adoption of Building Information modeling.Quantity surveying is a broad term that refers to a wide range of projects utilizing highly specialized technologies and novel approaches for operating and implementing them. This, combined with a misunderstanding of function of quantity surveyors in projects of engineering [23] has resulted in quantity surveyors being excluded from some of these engineering projects due to a misunderstanding of their capabilities. To manage and procure some of these projects successfully, the circumstance necessitates collaboration and the deployment of specific resources among different QS firms.

Meanwhile, the scope of work of quantity surveying organizations includes residential, commercial, industrial, recreational, agricultural, and retail projects, as well as infrastructure provision [23]. Quantity-surveying organizations provide a variety of vital services to clients based on the previously established scope of work (engagement wise). Some of these services include but not limited to risk management, preliminary cost advice, post contract management, contractor selection advice, feasibility studies, obtaining or negotiating tenders/bids offer, taxation and insurance, technical auditing, valuing construction works, document preparation, cost control and project control, Expert guidance, security management, and investment assessments are also important services supplied by QS firms, as are condition surveys, value management, due diligence studies, project management analysis and coordination engineering [24]. Contract audits asset management, lifecycle costing, property condition appraisals, scheduling and planning, property management, financial analysis, procurement management, facilities management, and engineering analysis, to mention a few of other services available.

II. LITERATURE REVIEW

II.1 QUANTITY SURVEYORS KEY ROLE IN THE CONSTRUCTION INDUSTRY

In the construction business, quantity surveyors are everywhere [25]. The quantity surveyor's role, according to a report published by [26], is "to ensure that the construction industry's resources are used to the best advantage of society by providing financial management for projects and a cost consultancy service

to the client and designer throughout the construction process." The typical QS performs various responsibilities, as we stated before in the introduction section. A Quantity Surveyor's main responsibilities include financial control, cost management, and contractual administration of a project from start to finish. Table 1 QS's Roles in Cost Management in Construction Projects.

Table 1: QS's Roles in Cost Management in Construction Projects.

No.	Pre-Contract Stage	Pre-Contract Stage
1	ProbableCost Estimate	Valuation and Payment
2	Procurement Advice	Preparation of Final Account
3	Cost Planning	ContractualDisputes Settlement
4	Preparationof Quantities	Construction Cost Control
5	Bill of Quantities Preparation	Risk Analysis
6	Bidding Process	Insurance Valuations

Source: Adapted from [27].

From the start of a project until the completion of a structure, quantity surveying is an important aspect of the construction process. It's a job that requires a high level of expertise as well as carefully developed deployment abilities. It necessitates precise design interpretation and numerical representation of component quantities. It's traditionally been a manual procedure, which is prone to errors and takes a long time. However, automating the process BIM, time issues can be eradicated and errors addressed.

Preliminary Cost Estimating: Early in the design process, a BIM model may provide a relatively accurate cost estimate and measurement, as well as cost implications of additions and revisions, thus saving money and time and avoiding project overruns. This method allows designers to view the cost implications of their changes in real time, which can help reduce unnecessary overruns of the budget caused by project changes. If the BIM model is shared with the contractor, the time for detail estimates can be drastically reduced, and precision can be much improved [28].

Procurement Advice: [17] posits that considerable work early in the design process is required to build up the model and develop and analyze various design ideas in order to maximize the potential of BIM. To make this possible, fees and payment schedules may need to be adjusted. Similarly, for virtual prototyping exercises to be useful, the contractor must be involved. To fulfill this potential, a procurement method that allows involving contractor early is required. Furthermore, the usage of BIM models, which combine the work of architects, engineers in various forms, contractors, subcontractors, and suppliers, raises additional legal concerns.

5D Cost Planning: Cost planning services that provide cost certainty by providing realistic and precise cost estimates from concept to completion and at any point during the development process [29]. Cost planning has the objectives of ensuring that the client receives value for money spent based on the predetermined amount, reducing the time required to produce a successful design, to make the design process more efficient, and to ensure that all work emanating from the client's brief to the design team is contained in the cost planning process. Particularly, allocating cost targets to each element of the building to arrive at a contract sum is what cost planning seeks to achieve. It is also helps in providing basis for cost control as according to [30] in that abandoned work is prevented from the design work. As a result, BIM gives quantity surveyors the ability to undertake cost planning automatically across all building elements.

Cost Estimating: Automated quantity generation gives you a faster, more precise way to analyze data and give better advise. This allows for real-time option modeling and scenario testing in order to examine ways to enhance cost, efficiency, performance, and building design [31]. Early in the design process and throughout the project lifespan, quantity take-offs generated in a BIM model can quickly be used to derive cost estimates by project teams to assist in making an informed decision and communicate cost information about alternatives to the clients. Estimating cost databases are combined with BIM model which is has better efficiency and risk of omissions and errors are greatly decreased. Quantity take-off time is reduced so that estimators can have more time to concentrate on other valuable responsibilities such as factoring risk, selecting construction assembly and pricing. [32].

Preparing Bills of Quantities: With its 4D modeling capabilities, BIM is now capable of automating many classic QS functions. Quantity measurements from construction plans can be computerized using a BIM system. This will make it easier for quantity surveyors to have design documentation in electronic format that include exact numbers and specified materials. A BOQ can be generated automatically with the help of a properly equipped Building Information Model. After that, the BOQ is used to create reports in the required format. This can be done at any point in the QS dispatch process, including tendering, construction control, and estimating [33].

Bidding Process: Due to the transparency and accessibility of project information and documentation, competitive tendering and bidding with BIM models can eliminate the hazardous gap that occurs between project members [34] Traditional tender processes can be used for procurement at the bidding stage. The BIM produced far higher quality construction information and a more accurate bill-of-quantities than traditional working drawings. In addition, the BIM can provide instruction in quantity extraction and measurement to aspiring constructors. Bidders can identify and remedy model problems throughout the tender process, resulting in more accurate bids. The bidders were able to completely comprehend the structure and the risks connected with it, lowering the tender return costs [35].

Cost Control: In real-time, cost and quantity progress can be monitored, controlled with precision and transparency, thanks to the development of 3D building information modeling (BIM) integrated with quantity information management. Discrepancies, cost overruns, and other issues are identified early, allowing efforts to be taken to correct them or at the very least mitigate the repercussions. The main difficulty is that quantity and cost information is tracked as-it-occurs, and as-built quantity surveying is performed in tandem with site progress. As the foundation for cost management, schedule management, procurement, logistics, and resourcing, project can derive many benefits from accurate quantity control. The better the precision and priority given to it, the better the results: a more well-managed project [36].

II.2 NEED OF A QUANTITY SURVEYOR TO GET ACCUSTOM TO BIM BASED PROJECT DELIEVRY

Overbudgeting, conflict, rework, poor communication, standing time, material waste, and delays are all common problems in the construction sector today. With the current global economic troubles adding to the pressures, the need to address and resolve these issues has never been higher. Optimizing the efficiency and correctness of building design information interchange with the

goal of providing significant assurance in construction project delivery could be key to addressing such widespread and internationally recognized issues. As a result, intelligent BIM may provide a remedy to the aforementioned flaws [37].

Furthermore, owners are frequently confronted with cost overruns or unforeseen charges, forcing them to either "value engineer or Quantity Surveyor" the project above budget or terminate it. Contingencies are added to estimates by service providers and clients or put aside a budget to deal with construction uncertainties to avert the risk of overruns and incorrect estimates [38]. Unreliable estimates put owners at risk and unduly inflate the total cost of the project. A lot of factors influence the accuracy of cost estimates, including changing market conditions, the period between estimate and execution, design revisions, and quality difficulties [39]. The fact that BIM is accurate and computable makes it a more dependable source for owners to execute estimating and measurement of quantity, as well as providing quick design revisions feedback on cost. Because the capacity to impact cost is greatest early in the process, at the conceptual and preliminary stages, this is critical [40]. Quantity surveyors also blame poor estimates on communication failures among project parties, lack of time, poor documentation, between quantity surveyor and the client [41].

According to several researchers, the following are the grounds for BIM adoption in the Quantity Surveying profession [42].

• 30% of projects do not meet original programme or budget
• 92% of clients said that designer's drawings are typically not sufficient for construction
• 37% of materials used in construction become waste
• 10% of the cost of a project is typically due to change orders
• 38% of carbon emissions are from buildings not cars

This leads to the notion that because BIM decreases the number of resources required for a construction project and so saves money, professional fees should be reduced [43].BIM is currently only used in the late stages of design and engineering or the early stages of building. BIM will have a greater impact on cost if it is used earlier in the design process. The goal of using BIM-based cost estimate methodologies is to improve overall cost reliability [40].BIM is being deemed highly significant to the future development of construction information technology and to the construction industry, based on current academic research, professional development, and industrial market [44].Furthermore, BIM has developed as a cutting-edge method of project management. BIM improves project team cooperation, resulting in increased profitability, lower costs, better time management, and better customer/client relationships [45]. As a result, there should be a requirement for QS to become familiar with BIM-based project delivery.

II.3 CHALLENGES OF BIM

Many design firms are not ready to practice the on real time projects, which is a huge obstacle. As a result, they frequently form a BIM group and assign BIM specialists to work alongside with project teams. As a consequence, the project will have a BIM model, but the project team will have minimal or no experience with it. Worse yet, this method will almost always increase project costs, as the BIM teams' efforts will incur additional fees and may not result in significant cost savings [46, 47] point out the following issues with BIM**:**

• Because BIM systems generate large, complicated files, scaling and managing a fully loaded central BIM project database becomes a substantial difficulty.
• Data Sharing in BIM takes the form of drawing files. Instead of sharing intelligent objects from the model, users are reverting to documents exchange (views of a building model is created as drawing files).
• The requirement for more complex data management at the level of building objects. To help tackling the challenges like real-time, object versioning, object-level locking and multiuser access that arise when multi-disciplinary design teams try to adopt a unified BIM, server technology for Model was therefore created.
• When employing a single detailed BIM to depict a number of the various design schemes under consideration, there is a conflict in the work process. While parametrically defined architectural items can be readily reproduced using selected dimensions and features, maintaining numerous BIM models for different design options is prohibitive.
• Only one BIM system can be used by the entire project team. For design and analysis, each organization often has its own set of preferred and trusted software packages. Rather than relying on a single building model, project team members typically rely on a variety of purpose-built models on any given building project amongst different businesses and through lifecycle phases of the project.

II.4 COMPUTER SYSTEMES AND SOFTWARE

Despite the various limitations of software supporting traditional methods for generating building products in terms of collaborative capabilities, most experts choose such systems because the traditional approach to software implementation' makes the systems user-friendly. They also provide a gradual transition to automated systems, with most systems presenting data in traditional paper formats such as paper for taking-off [48].However, while current methods appear to be working well, they have a significant impact on the quantity surveyor's ability to accomplish his duties during the design stage of a building project [48].Cost estimates are prone to mistakes since they are typically based on limited information and created in a short period of time [49]. Creating a three-dimensional (3D) model of client's proposal is the first step in an environment of BIM that is perfect, followed by resource requests that is automatically generated, calculation of cost or cost estimations, bills of quantities and a list of specifications for product, [50]. This necessitates extracting all measurements and information about components of building from

The 3D model, then merging it with databases including Information and other costs unit [51].

II.5 RESPONSIBILITIES AND SERVICE ARE BEING ADJUSTED

Traditionally, after the proposed project's design has gotten to a stage where it can virtually be frozen, the Quantity Surveyor begins to produce documentation relating to procurement and bills of quantities. Estimating during the design phase is typically notional and based on limited project knowledge, hence Quantity Surveyors are increasingly active in the design review process later on [48].Bills of quantities automation eliminates errors and misunderstandings while also evolving in tandem with design modifications [52].It alleviates some of the monotony and expedites the process [53].This frees up time for data interpretation, analysis, and arrangement into a consistent, understandable, and logical format, as well as shifting the traditional responsibility of

designing to a cost, to costing a design [48].'Value for money,' requirement is satisfied by designing to a cost and hence fulfills one of the quantity surveyor's most important roles [54]. However, in order to avoid data re-entry inaccuracies and assure model consistency, an individual must control the data exchanged between consultants.

II.6 EXPENSES AND TRAINING

The creation of new technology and the application of new tools and processes are frequently accompanied by a slew of expenses and a lack of technological skill and knowledge. The shift from existing methodologies to next-generation BIM technologies will not be without its difficulties. Training seminars, workshops, programs, and tutorials software may typically overcome a lack of knowledge and expertise relating to complicated processes and software [55].

II.7 QUANTITY SURVEYOR PREREQUISITE

In order to implement BIM with substantial consequences, project teams will need new abilities, and fee scales will need to be changed to reflect professional duties [56]. The distinguishing abilities or skills of a Quantity Surveyor, according to [26]. Are related with value and measurement, which provide the basis for proper cost controlling, analyzing, management of a construction project in the context of predicting, planning, and accounting.

V. CONCLUSIONS

To a traditionally oriented Quantity Surveyors and allied professional, Building Information Modeling will pose a great challenge in the aspect of services they rendered. [48] as cited by [57].BIM came to bear as a development that aimed at integrating economics value addition and working systems to delivery of project. Delivering good-quality results, by eliminating drudgery and monotony from a variety of tasks, BIM offers this benefit [53].Continue reliance on the preparation of bills of quantities by Quantity surveyors as their major source of revenue, will soon be put to an end and dramatically be reduced as a result process automation [48].Quantity Surveyors' capability and ability in terms of contractual and financial decision as regards construction development has made them to redefine their role [53]. Quantity surveyors who can overcome these obstacles will have a bright career in this rapidly changing business. As a result, they must concentrate on improving the learning experience with BIM techniques and collaboration technology updating industry techniques and methods and developing QS specific skills such as quantification, data scheduling, visualization (3d viewing), and pricing, as well as multi-disciplinary work-based projects. To fully comprehend the QS's future function, a thorough examination of what precise information will be made accessible to him via BIM at various stages of the project, as well as what information the QS must give at each level, is essential. This has been determined to be the best course of action for the current research.

VI. AUTHOR'S CONTRIBUTION

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