NIGERIAN INSTITUTION OF AGRICULTURAL ENGINEERS SOUTH WEST ZONE

(A DIVISION OF NIGERIAN SOCIETY OF ENGINEERS)

IBADAN
2023



MAIDEN **Zonal Conference** & **FIRST** **Annual General Meeting**

INNOVATIONS IN AGRICULTURAL ENGINEERING: SOLUTIONS TO FOOD, ENERGY AND ECONOMIC CHALLENGES IN NIGERIA

CONFERENCE PROCEEDINGS

EDITED BY:
ENGR. PROF. J.A.V. OLUMUREWA,
ENGR. PROF. YAHAYA MIJINYAWA,
ENGR. DR. O. O. OLABINJO

IBADAN 2023

NIGERIAN INSTITUTION OF AGRICULTURAL ENGINEERS

SOUTH WEST ZONE

(A DIVISION OF THE NIGERIA SOCIETY OF ENGINEERS)

PROCEEDINGS OF THE MAIDEN CONFERENCE ANDTHE FIRST ANNUAL GENERAL MEETING OF THE NIGERIAN INSTITUTION OF AGRICULTURAL ENGINEERS SOUTH WEST ZONE (NIAE SW)

INNOVATIONS IN AGRICULTURAL ENGINEERING: SOLUTIONS TO FOOD, ENERGY AND ECONOMIC CHALLENGES IN NIGERIA

HELD AT THE

FACULTY OF TECHNOLOGY, THE UNIVERSITY OF IBADAN, IBADAN

EDITED BY
ENGR. PROF. J.A.V. OLUMUREWA,
ENGR. PROF. YAHAYA MIJINYAWA,
ENGR. DR. O. O. OLABINJO

PREFACE

IBADAN 2023 collection of articles contained herein represents the papers presented at the maiden conference of the Nigerian Institution of Agricultural Engineers south West Zone (NIAE SW) held at the Faculty of Technology, University of Ibadan, Ibadan Nigeria between 30th and 31st August 2023. The theme of the conference is 'Innovations in Agricultural Engineering: Solutions to Food, Energy and Economic Challenges in Nigeria'.

The authors are appreciated for meticulously incorporating the comments and corrections pointed out by the reviewers. The group of anonymous reviewers are also appreciated for their efforts. We hope that the various recommendations made in the papers will go a long way in stimulating further intellectual debate as well as influencing policies formulation at various levels of governance. The papers are recommended for the reading of our students especially the post graduate students, researchers, policy makers, analyst and the general public.

However, the institution is not responsible for the views expressed in these papers, thus the contributors are responsible for the contents of their articles.

Engr. Prof. Yahaya Mijinyawa
Chairman, Technical Committee

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S/N.	NAME	POSITION/OFFICE	EMAIL ADDRESS	PHONE NO
1.	Engr. Prof. John A. Victor Olumurewa MNIAE	Chairman	jav_murewa@yahoo.com	08062966602
2.	Engr. Dr. Agunbiade Lamidi, MNIAE	Vice Chairman	Wasiu.agunbiade @uniosun.edu.ng	08135860977
3.	Engr. Prof. Bamidele Dahunsi MNIAE	Immediate Past Chairman	deledahunsi@gmail.com	08033261699
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7.	Engr. Dr. Bola Asiru FNIAE	Lagos State Chairman	bolaasiru@gmail.com	08035775861
8.	Engr. Prof. Kehinde Jaiyeoba MNIAE	Osun State Chairman	jaiyeobakehinde@gmail.com	08033841417
9.	Engr. Prof. Johnson Fasinmirin MNIAE	Ondo State Chairman	jtfasinmimirin@futa.edu.ng	08069192434
10.	Engr. Lukman Olatoye MNIAE	Ogun State Chairman	toyelookman@gmail.com	08034492310
11.	Engr. Dr. Akinfoye Oyime D. Adejumo MNIAE	Oyo State Chairman	akindanoyime@yahoo.com	08076559099

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FARM STRUCTURES AND ENVIRONMENT

POST HARVEST AND FOOD ENGINEERING

SOIL AND WATER ENGINEERING

ADDENDUM

PART ONE

THE LEAD PAPER

Engr. (Prof.) Mike Faborode, FAEng, FNSE, FNIAE

Former Secretary General, Association of Vice Chancellors of Nigerian Universities (AVCNU), 9th Vice Chancellor, Obafemi Awolowo University, Ile-Ife and President of PASAE

Transforming the Nigerian Economy and Exploiting its Potentials through Sustainable Innovation and Startup Ecosystem

Mike FABORODE, FAEng, FNSE

Former Secretary General, Association of Vice Chancellors of Nigerian Universities (AVCNU), and 9th Vice Chancellor, Obafemi Awolowo University, Ile-Ife.

NIAE SW Maiden Conference Themed: "Innovation in Agricultural and Biosystems Engineering: Solution to Nigeria's Food, Energy and Economic Challenges"

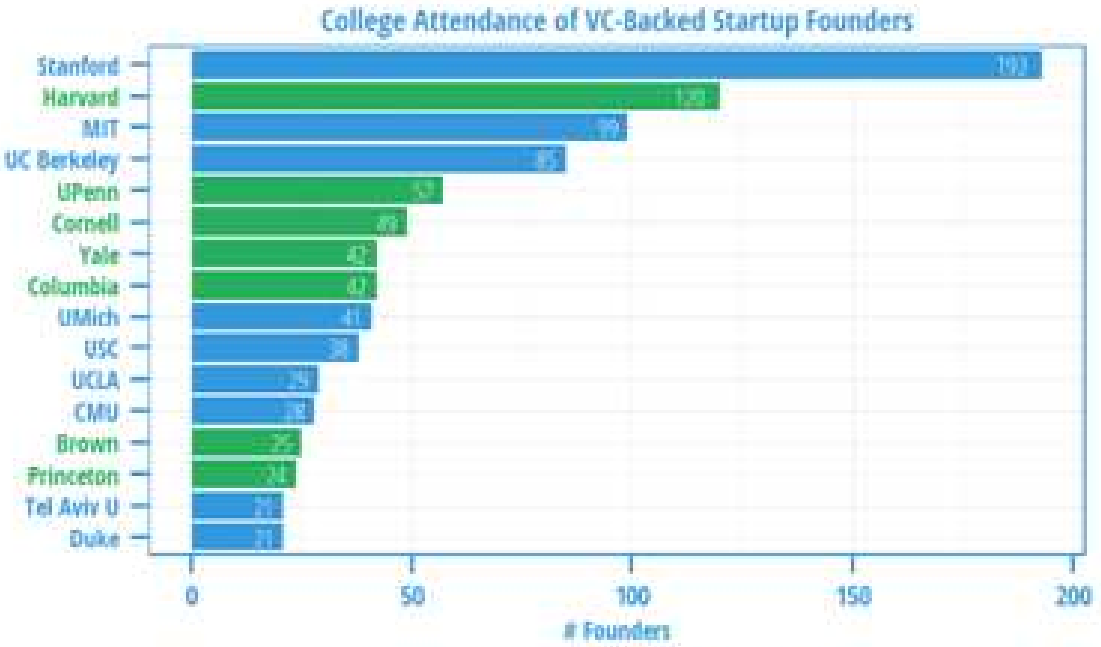
Faculty of Technology, University of Ibadan

AUG 30, 2023

OUTLINE OF PRESENTATION

- Understanding the Innovation and startup Ecosystems
- The Nigerian Startup Ecosystem
- Revitalizing Research and Innovation: Universities and the Value of Knowledge
- Managing Poverty Vs Wealth
- Nigeria Needs a Big Bang Like Nollywood to Harness the creativity of the Youth and the Diaspora
- Conclusion/Summary

TECHNOVATION ECOSYSTEM



THE SILICON VALLEY ECOSYSTEM AND CULTURE CONT'D

OUTCOME: A SUSTAINED SYMBIOTIC MUTUALLY BENEFICIAL PARTNERSHIP

UCT has Enabling Environment for Building Tech

Universities Behind African Visionaries - A Look at the Alma Maters of CEOs Driving African Startup Success

University	Continent	Country	Number of Startup CEOs	Notable Startup CEOs
University of Cape Town	Africa		74	Kanlego Mashai - Sam Clarke - Michael Heyink
The American University in Cairo	Africa		40	Mostafa Kandil - Amir Barsoum - Ahmad Hammouda
University of Oxford	Europe		39	Jesse Moore - Kaelen Hilgroen - Ladi Delano
Obafemi Awolowo University	Africa		36	Tosin Eniolorunda - Femi Asiri - Adeyinka Adewale
Stanford University	North America		35	Noureddine Tayebi - Neil Tozun - Fi Yotuk
Harvard University	North America		25	Chopin Mutira - Sangu Delle - Sim Shagaya
Cairo University	Africa		24	Omar Gabr - Ahmed Khairy - Amr Shweiy
MIT	North America		21	Adetunji Bamidburo - Ani Vallabhaneni - James Paterson
Columbia University	North America		19	Sara Menker - Kavan K. Suttar - Elizabeth Rossello
University of Lagos	Africa		19	Adeyemi Simoobywa - Michael Adeyeri - Damilola Olokenou
Imperial College London	Europe		18	Mansoor Hamayun - Alasi Eze-Obong - Uzoma Dozie
INSEAD	Europe		18	Dare Okoudjou - Joseph Rahmann - Mumtaz Moussa

Source: Africa The Big Deal

By Yassin El Hamdaoui

OAU iLabs, Humane and Robotics Olympiad

iLabs OAU was established in 2005 as an extension of iLabs at the Massachusetts Institute of Technology (MIT) to provide remote laboratories which were easily accessible to people who, through remote online time booking, could be granted access to equipment for experiments.

Over the years, iLabs OAU has produced prominent figures in the Nigerian tech ecosystem; Example: Pelumi Aboluwarin and Segun Famisa.

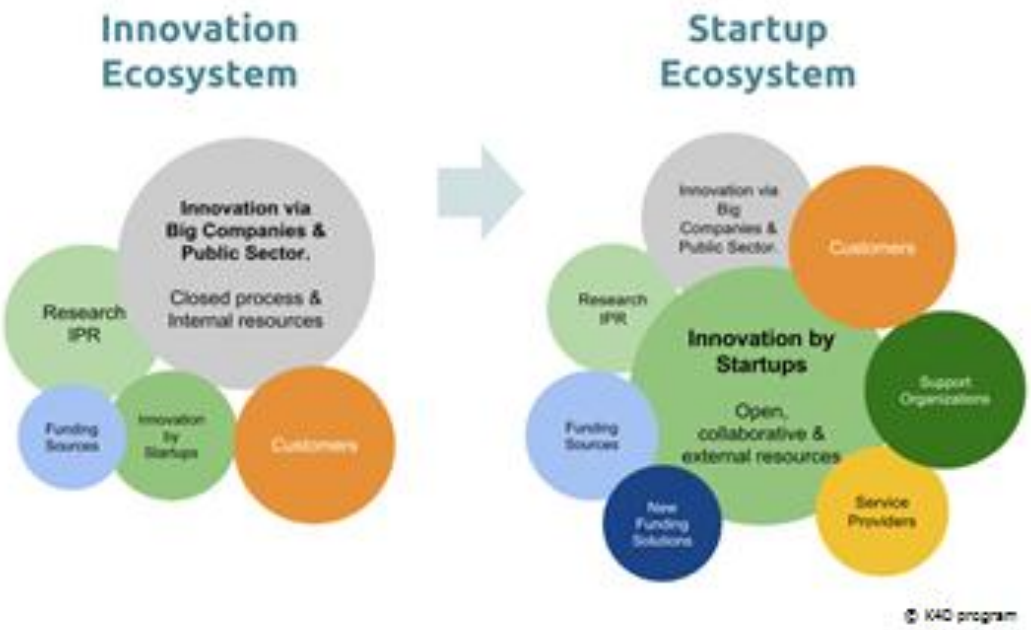
iLabsRobotics, or iLabRoc, is the resident robotics research team of the OAU, with a major aim of furthering robotics research in Nigeria.

iLabs and iLabRoc, not being startups, have just one major challenge – lack of indigenous investors. For initiatives that are as inventive and economy-boosting as iLabs and iLabRoc, it is sad that indigenous investors are nowhere to be found.

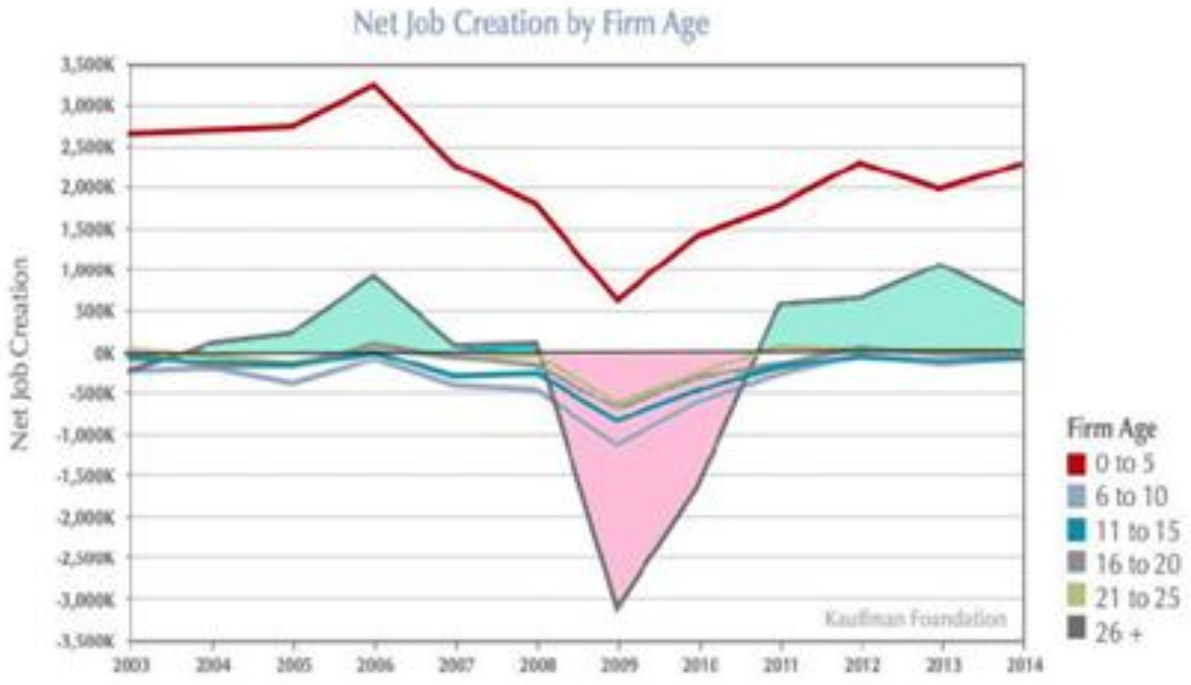
OAU Engineering students built the robot "HUMANE" to make smartphones accessible to the blind. The innovation got to the World finals of the Robotic Olympiad in Indonesia

OAU iLabs Robotics

Importance of Industrial Innovation by Firms/Startups



Firm's Job Creation Dynamics with Age

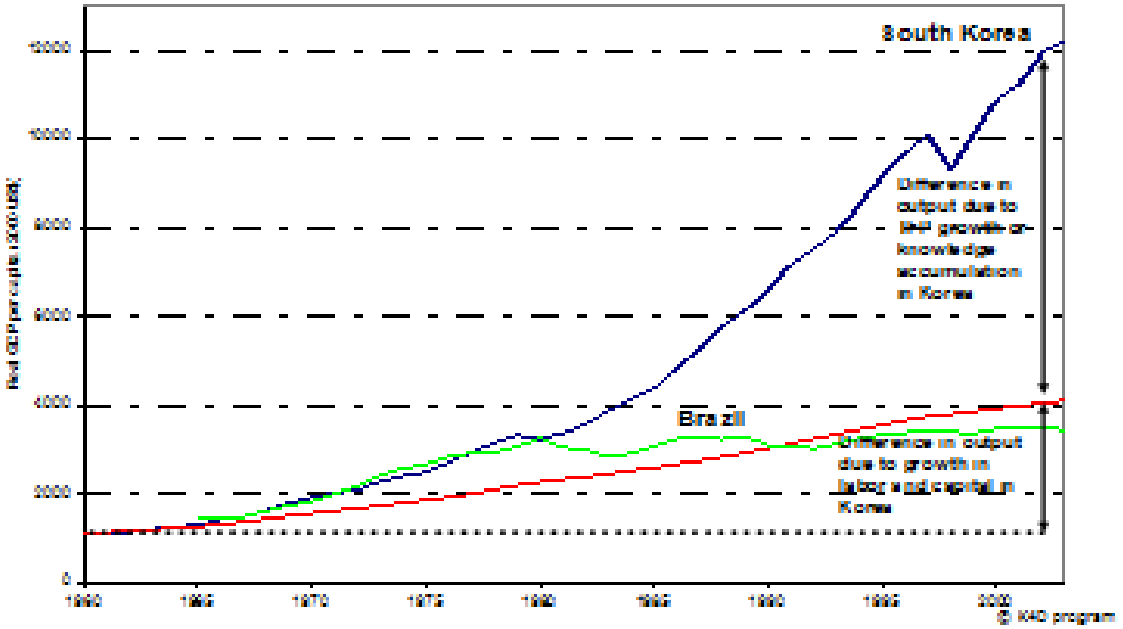


Source: Arnobio Morelix, Kauffman Foundation calculations from the U.S. Census Business Dynamics Statistics

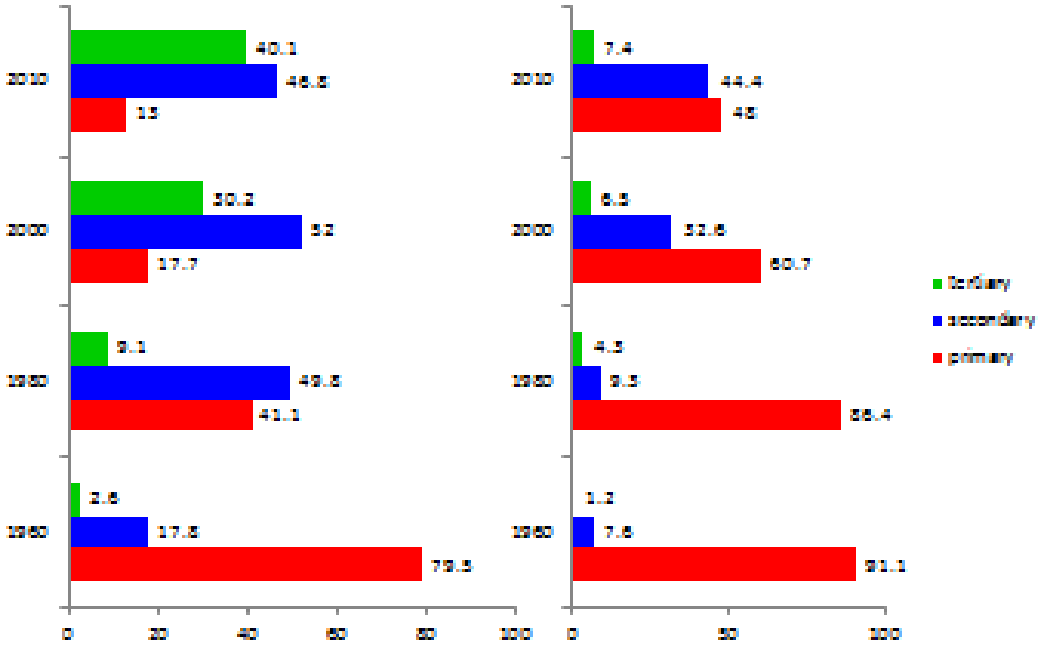
Economic Value of Oxford University

Economic impact
of the University of Oxford

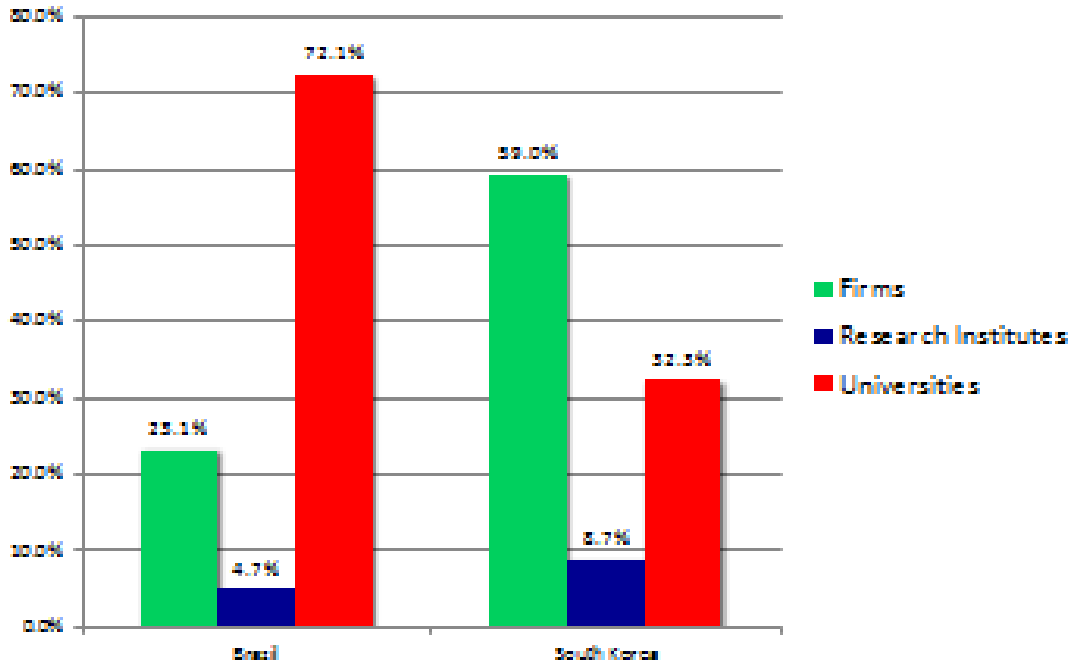
Explaining the difference between poverty and wealth



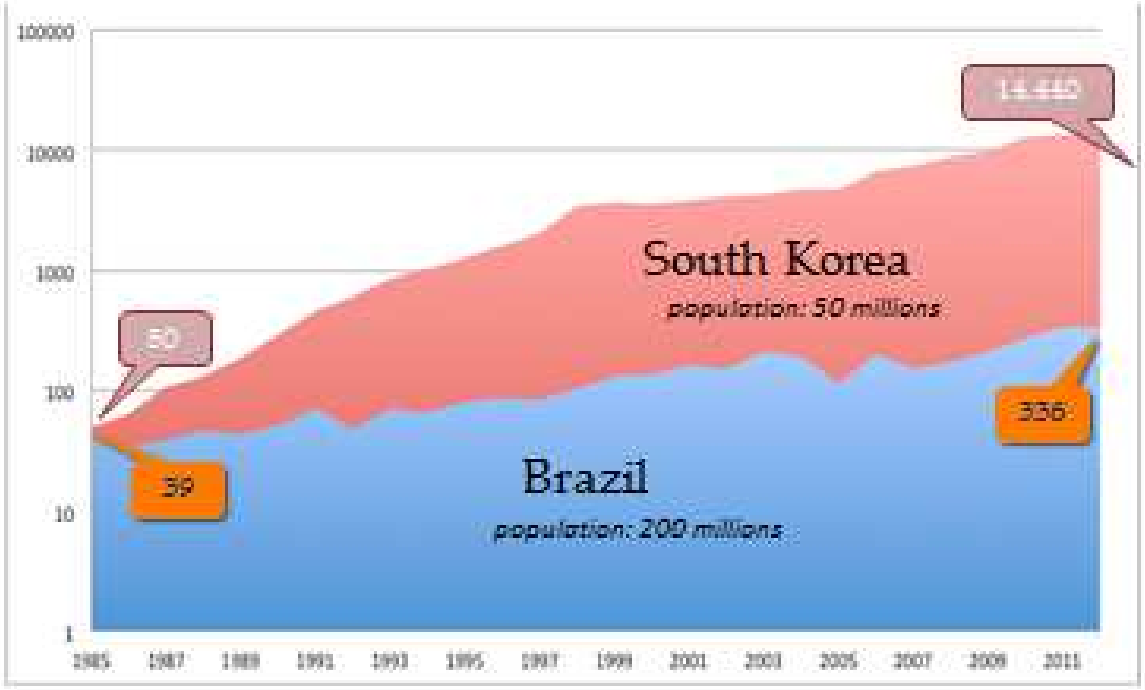
South Korea and Brazil
(Evolution of Educational Attainment of Population of 15 years and Older)



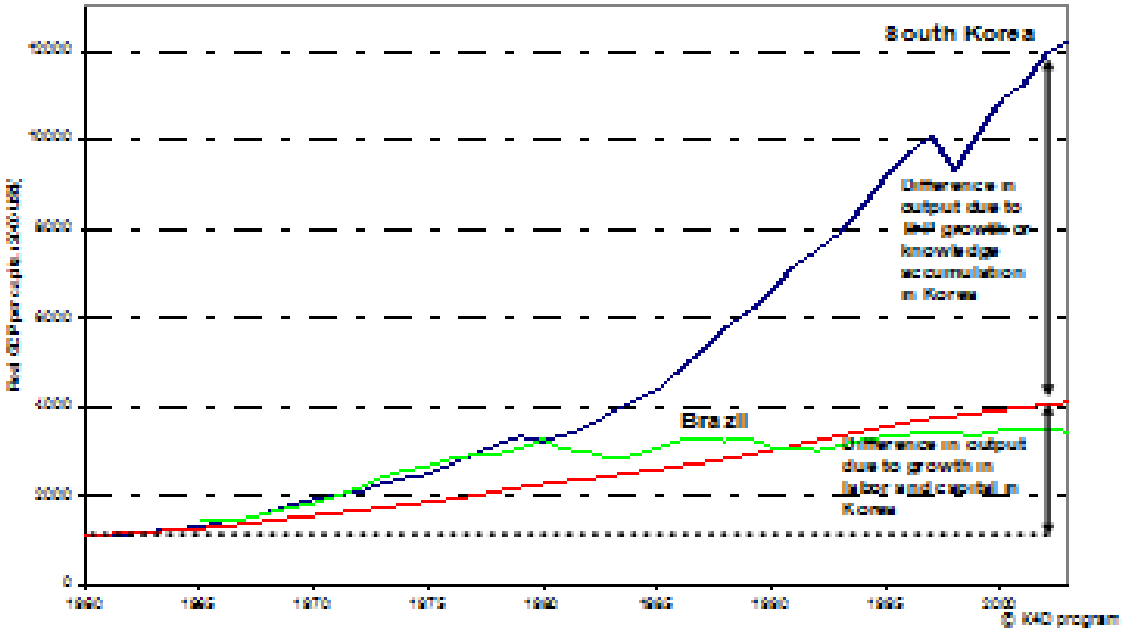
Scientists Active in R&D



Patents/USPTO, 1985-2012



Explaining the difference between poverty and wealth



In the preceding graph we compare the per capita income growth of Brazil and Korea. In 1965, they had the same per capita income. By 2003, Korea's per capita income had risen to 4.7 times that of Brazil. Why is there such a difference? One reason is that Korea has had a higher rate of investment to GDP. However, Korea has also been better at harnessing knowledge—both technical and policy knowledge—for its development. In the graph we decompose the per capita income growth for Korea into that which can be explained by increases in the labor force and in capital. The per capita income that would result from simple factor accumulation is shown by the red line. The difference between the red line and the actual per capita income growth in Korea can be attributed broadly to better use of knowledge---both technical and policy knowledge. The key point here is that the effective use of knowledge, which depends on knowledge, skills and innovation, can make a very big impact on growth performance. Brazil needs to do more to improve the effectiveness with which it uses knowledge for its growth and development.

So, you can appreciate where Nigeria is compared to the two countries!

Singapore in 1950s

Singapore in 2016

Emerging Technovation Ecosystem in Nigeria

- Over the last few (eight/ten) years, several tech communities have sprung up across different locations in Nigeria, fostered by 30+ accelerators and hubs

- Nigeria's leading technology cluster: Yaba Innovation Headquarters (YiHQ); founded by Co-Creation Hub creator Bosun Tijani is perhaps Africa's most valuable startup ecosystem. It is however devoid of some key features of an ideal tech-ecosystem: The much needed academia engagement, expected to source talent is sorely lacking in spite of its proximity to the talent hubs of UNILAG, Yaba Tech and Federal College of Education, Akoka.

- YiHQ is a partnership between Lagos State, Technovision, the Co-Creation Hub and MainOne. Fortunately, what YiHQ lacks in government support and academia engagement, it makes up for in its vibrant, youthful culture, abundant capital and industry collaboration.

Emerging Technovation Ecosystem

- **Supporting the emergence and nurturing the growth of innovation ecosystems**

A conducive culture,

Enabling policies and leadership,

Availability of appropriate finance,

Quality human capital,

Venture-friendly markets for products, and

A range of institutional and infrastructural supports

- **Re-focusing on middle-level human capital dev and sustaining some current YOUTH EMPOWERMENT (N-Power) and EASE-OF-DOING-BUSINESS initiatives.**

Emerging Technovation Ecosystem in Nigeria

- A roll-call of industry partners at the Co-Creation Hub reads like a Fortune 500 list: Google, Amazon, Facebook, Oracle, Nokia, Microsoft, Ford Foundation, Tony Elumelu Foundation and MainOne, to mention a few.

- YiHQ itself is home to companies like BudgIT, Paradigm Initiative, Paga, Hotels.ng, Paystack, and birthplace of d Andela, Flutterwave among several others.

- Cumulatively, it has attracted millions dollars of investment and created thousands of direct/indirect jobs.

- *Nigerian startups raised a total funding of $9.2 million in Q1 2018 (See TechPoint Report 2018).*

List of Nigeria Tech Hubs

NORTH:

1. Enspire Hub, Abuja
2. Blue Hub, Kano
3. StoneBricks, Abuja
4. StartPreneurs, Abuja
5. CoLab Hub, Kaduna
6. nHub, Jos
7. Ventures Park, Abuja
8. TD4PAI – Technology Dev for Poverty Alleviation Initiative, Kuje, FCT
9. Civic Innovation Lab, Abuja
10. BD Hub, Abuja
11. The Tangent Eco-Innovation Hub
12. Founders Hub, Ilorin
13. Arewa Hub, Kaduna

SOUTH SOUTH

1. Start Innovation Hub, Uyo
2. RootHub, Uyo
3. Olotu Sqquare, Port Harcourt
4. Delta State Innovation Hub, Asaba
5. Edo Innovates
6. GIG Innovation Hub
7. Focus Hub, Port Harcourt
8. Strategic Hub, Port Harcourt

SOUTH EAST

1. Roar Nigeria Hub, UNN
2. Innovation Growth (IG) Hub, Aba

List of Nigeria Tech Hubs

SOUTH WEST:

1. Wennovation Hub, Ibadan & Lagos
2. iDEAHub, Yaba, Lagos & Tinapa
3. Co-Creation Hub (CcHub), Yaba, Lagos
4. Leadpath Hub, Lagos
5. AkureTechUp, Akure
6. DevsDistrict Hub, Akure
7. Passion Incubator, Yaba
8. Impact Hub, Lagos
9. VerveTree, Abeokuta
10. Artificial Intelligence Hub, UNILAG
11. Hebron Startup Labs, COVENANT, Ota
12. Project Enable Africa Hub, Lagos (Disability compliant; US supported)
13. Facebook NG_HUB, Yaba
14. OAUTech Hub, Ife (ACE-based)

For more info: visit, TechPoint.Ng website

Nigeria University Tech Start-ups

Jobberman: Olalekan Elude, Ayodeji Adewunmi and Opeyemi Awoyemi would probably be remembered for their ambitious effort in taking on Nigeria's disorganised labour market while still studying at the Obafemi Awolowo University (OAU). By providing an easy way to match unemployed people with their dream jobs, the 3 individuals brought in a fresh perspective to dealing with unemployment in Nigeria.

Printivo: As a student of Ladoke Akintola University of Technology, Ogbomosho, Oluyemi Ojo, one of the co-founders, executed different printing and design jobs for clients. Shortly after graduation, he teamed up with his co-founders, Ayodeji Adeogun and Ibukun Oloyede, to pursue his passion. Together they saw the need to provide printing solutions for the under-served SME market.

Nigerian University Tech Start-ups

Sharphire (PushCV): PushCV was founded by seven young Nigerians consisting of Somtochukwu Ifezue, Odunayo Eweniyi, Joshua Chibueze, Terry Kanu, Nonso Chinagorom, Ibukun Akinola and Ayo Akinola. They were largely products of Covenant University, which places a strong emphasis on ICT entrepreneurship, with an ICT entrepreneurship hub located within its premises. The startup launched in 2014 as an online platform that connects pre-screened candidates with organizations or employers that need their services. PushCV has since been consolidated into one of the subsidiaries of a parent company — Sharphire Global — under which many other interesting startups have emerged.

CashEnvoy: As an undergraduate of OAU, Olaoluwa Awojoodu, began his journey into entrepreneurship with a recharge card business during the peak period of a 2002 ASUU strike that inevitably kept him out of school for eleven months. Going back to school, he ran all sort of business including a weekly newspaper, a fast food outlet and an online platform for selling IT hardware. Upon graduation in 2007 Olaoluwa had gained a lot of insight to spur the execution of Electronic Settlements Limited, the parent company of CashEnvoy, PayPad and a host of other company under its portfolio.

Nigeria University Tech Start-ups

ToLet and MoveMe.Com: Another product of OAU is the quartet of Seyi Ayeni, Sulaimon Balogun, Fikayo Ogundipe and Dapo Eludire. They couldn't have found a better cause to unite them than what ToLet offered. All friends since the formative stage of the startup in 2011, they've since carried the vision of ToLet to become a product valued at more than a million dollars. Between the founders, they have a mix and match educational affiliation that isn't only ideal for what ToLet as a business represents but has also been crucial to the eventual success of the startup, and its diversification into MoveMe.Com, a packaging and relocation outfit.

MyMusic: The journey of MyMusic all started with 3 Babcock University students — Damola Taiwo, Dolapo Taiwo and Tolu Ogunsola. Despite their strong tech background — they all studied Computer Science — the three co-founders in the waiting were bound by a common interest for music. Apparently, Damola is good with the bass guitar while Dolapo has a penchant for the keyboard.

Nigeria University Tech Start-ups

Abiola Olaniran
Founder,
Gamesole

Gamsole, is arguably one of the best gaming companies to emerge from Nigeria. Likewise, the man behind the company, Abiola Olaniran, is without doubt one of Nigeria's most decorated online entrepreneurs. Kick starting his rise to prominence, Abiola was originally one of the members of team Indwell (all 400 level students) from Obafemi Awolowo University that emerged national winners of the 2010 Microsoft Imagine competition — with a solution that granted access to quality education across the world. The team went on to represent Nigeria at the World Finals of the Microsoft Imagine Cup held in Poland later that year.

Right after the Imagine Cup, Abiola pitched for the Samsung Developer Challenge where he won both the game and edutainment categories. He was also fortunate to be admitted into 88mph Accelerator program, the only Nigerian. Since then it's been an interesting journey for Abiola, as each footstep brought him a step closer to founding Gamsole.

Nigeria University Tech Start-ups

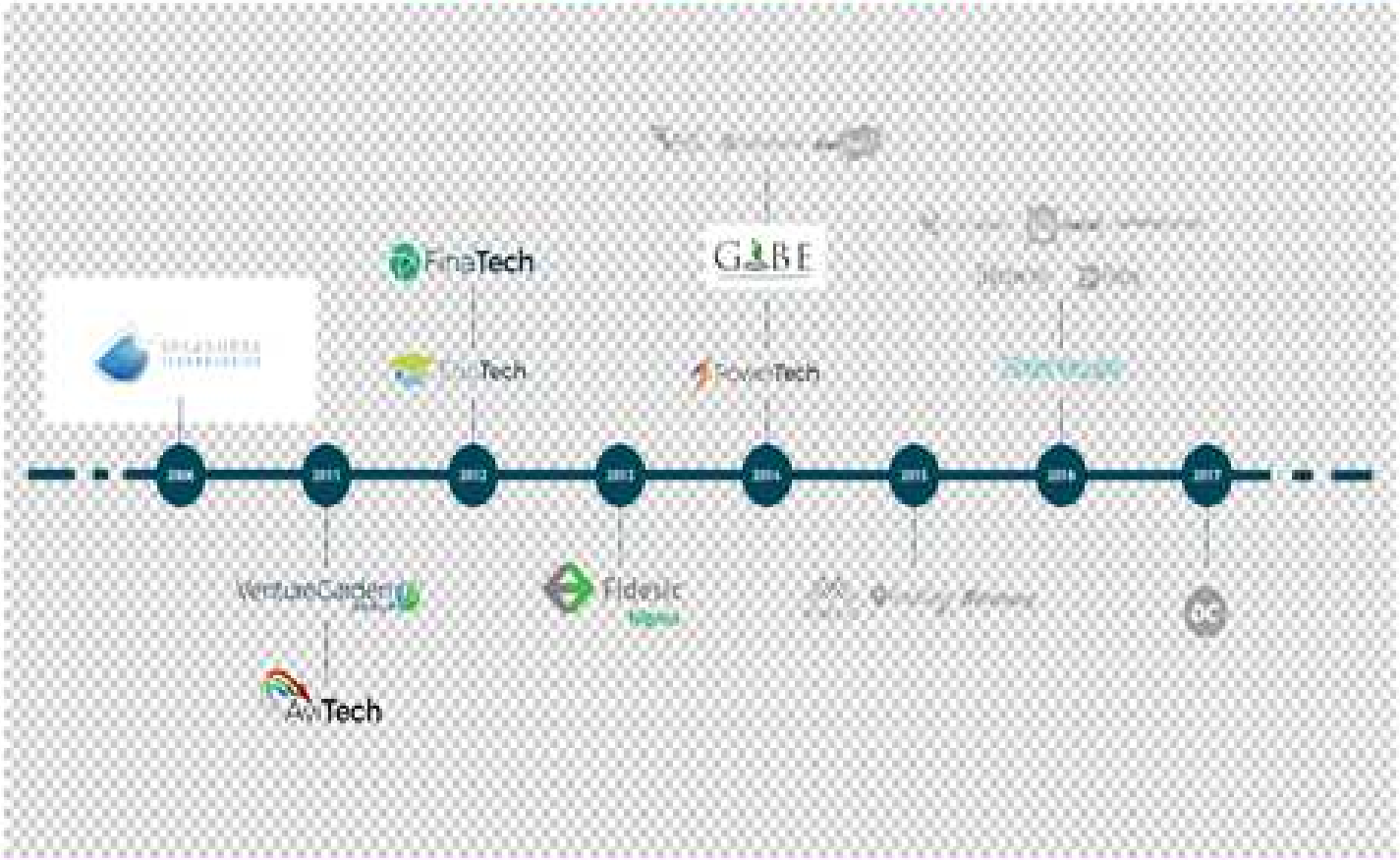
Eyo Bassey
MD/CEO, PayPorte

Bunmi Akinyemiju
MD/CEO, VGG

PayPorte: Eyo Bassey is the Founder, MD.CEO of Payporte Global Systems, an online retail coy. A graduate of Pure and Applied Physics from LAUTECH. He also attended MIT and the London Business School, as well as Harvard. After finishing from LAUTECH, he worked with a Socket Works Global, as the Global Systems Administrator, then Head Software Engineering. He later disengaged and set up Rom-Flex Networks Ltd, an IT company that does both IT infrastructure and Software Development, that gave birth to PayPorte and other companies.

Venture Garden Group (VGG) is a leading provider of innovative, data-driven, end-to-end technology platforms addressing reconciliation and payment processing inefficiencies across multiple sectors of the African economy. Our mission is to transform Africa by using innovative technologies to solve real socio-economic challenges in impact sectors critical to sustainable economic development. Focus areas are Knowledge, Investment and Technology, and have successfully raised considerable funds for joint ventures and other emerging tech start-ups.

Growth, Exploits and successes of the Venture Garden Group



LEARNING FROM NOLLYWOOD

- Our greater concern here as Africans, is that Africa must also be part of this evolution as creators of content and not just consumers. It is the African knowledge system, her universities, that can come to the rescue of the continent.

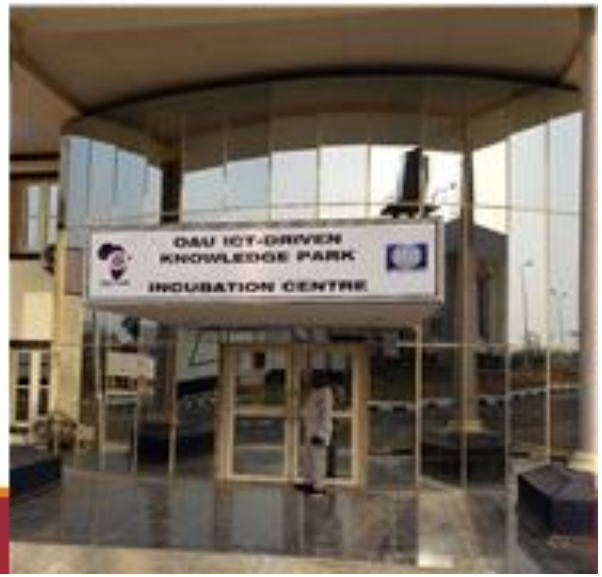
- The Nigerian Nollywood analogy gives us hope that we can do it. By putting African content into the global movie/motion picture industry domain, the narratives have since changed, as more and more people now watch African Magic movies and this is cascading to the African music and fashion industries. Yet people have not recognised the place of the quiet artistic knowledge revolutions in the Drama Schools of Obafemi Awolowo University, Universities of Ibadan and Port Harcourt, where the late Olarotimi, Nobel Laureate, Wole Soyinka, Femi Osofisan and late Dapo Adelugba etc, inspired a new generation of actors and actresses.

LEARNING FROM NOLLYWOOD

African science and innovation must emulate these developments in the Nollywood, African music and fashion industries and situate African scientific and technological innovation in the locus of local and global transformation.

A KEY MESSAGE IN THIS LECTURE.

Obafemi Awolowo University



Examples of Companies that started from OAU ICT-Driven Knowledge Park

01 Intellifarms Ltd (2019) - IoT devices

02 Bleep Tech Ltd (2019) – Financial systems

03 Zillion Studios Ltd (2019) - Games

04 Datalight Resources (2019) – Data Analytics

05 Visionfesh Ltd (2019) – Cybersecurity products

Fayele, M
(CEO)

Salihu, J.
(CTO)

Fayele, J.
(PM/CAD Design)

Fesomade, A
PM

Ibrahim
Web Developer

David
Game Developer

Adewole F.
Mobile Developer

James
Hardware Design

Victor
Hardware Design

- HARDWARE DESIGN AND MANUFACTURING
- LASER CUTTING SERVICES
- PCB DESIGN AND MANUFACTURING SERVICES
- 3D PRINTING SERVICES
- WEB DESIGN AND DEVELOPMENT SERVICES
- GAME DESIGN SERVICES
- MOBILE APPLICATION DEVELOPMENT SERVICES
- PCB ASSEMBLY SERVICES
- Founded: 2018 University: OAU Ile-Ife
- Employees: 15 (2019) Revenue: N15,000,000

GESTURE CONTROLLED LAMP BOARD: Outsourced to IF by a company(LIFE OF KLASS)

MICROCONTROLLER MODULES.

MICROPROCESSOR TRAINING KIT (6502 PROCESSOR):

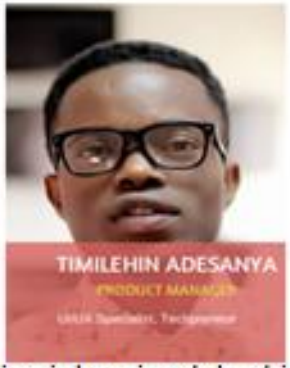
BASIC, Assembly language, and Computer Architecture.

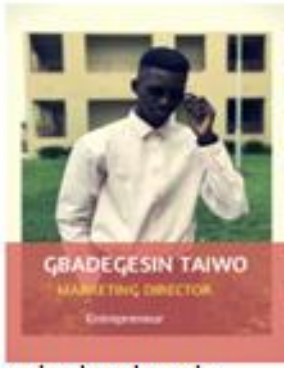
BEDSIDE ALARM CLOCK

FINGERPRINT SCANNER:

BLEEP ME Founded: 2019 University: OAU Ile-Ife.

Employees: 7 (2019)



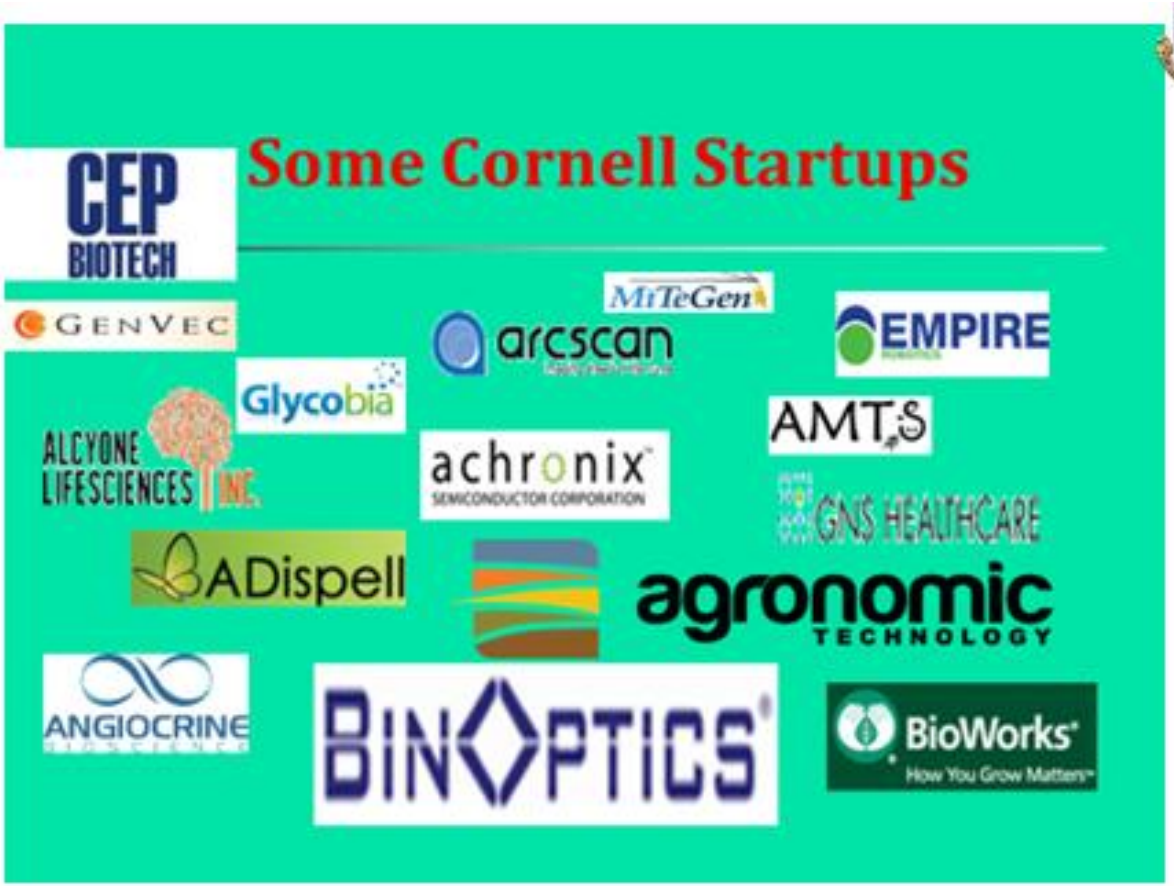


Mission: To build a world-class tech outfit using intensive data-driven technology to solve societal challenges in finances, health, social-living and governance.

Recallo HomeCare THE WORLD BANK OAK-PARK

BLEEP ME	KONTRIBUTE	Help Plus	X-insights
N24M/Year	**N20M/ Year**	**N18M/ Year**	**N150M/ Year**
Pay On Demand	Subscription Based/ Shared Earning	Ads Subscription Based	Licencing/ Subscription Based
✓ N100-N150 per ride ✓ 5000 Users in the first Year ✓ 1500 rides per month ✓ Profit After Tax N24Million Per Year	✓ N50 Service Charge ✓ 50,000 - 100,000 users in the first Year ✓ 10k - 20k transactions Profit after tax - N20 Million per year	✓ Ads Revenue Per Unit Cost ✓ 50000 - 10000 users	✓ 250 – 500 Users

Some Cornell Startups



CONCLUSION/SUMMARY

- Nigeria's economy, STI ecosystem, STEM ecosystem, vis-a-vis science research is in need of a major change/transformation, a big-bang disruption that will change our development paradigm from the management of poverty to a mindset of wealth management.
- Harnessing the creativity vortex of the youth, her knowledge ecosystem, global talents and the diaspora, including its lost sheep of "misguided eccentrics", who attract bad labels for the citizenry, for a new dawn.
- Female engineers & scientists must not be found wanting in this definitive forward march, and our universities must rise up to the occasion to imprint their value on national development.
- Emulate Nollywood to turn Nigeria into a global powerhouse of sustainable development: Nollywood's Success in the Nigerian movie industry, provides a model of how we can compete favorable and upstage the global market place with our human and material endowments

WATER QUALITY INDEX MODEL USING AHP-NSF METHODS; A CASE STUDY OF USUMA DAM RIVER, ABUJA, NIGERIA

Abatan, O. A [a, b*], Animashaun I. M. [b], Muhammad, A. S[b],

[a] National Biotechnology Agency, Abuja
[b] Department of Agricultural and Bioresources Engineering, Federal University of Technology Minna, Nigeria.
[*]Corresponding Author: oluwatoyinabatan@yahoo.com

ABSTRACT

Understanding physicochemical properties and identifying potential contaminants such as heavy pathogens in freshwater systems is crucial for monitoring environmental health and detection of any signs of pollution or change in water quality overtime. This research aimed at assessing the spatiotemporal variation in the water quality of Usuma Dam River, Abuja, Nigeria. Water samples were obtained at predetermined locations along the River and analysed for physicochemical parameters using APHA standard methods. The analysis was done for both the wet and dry seasons. National Sanitation Foundation Water Quality Index (NSFWQI) in combination with Analytic hierarchy process (AHP) models were employed to assess water quality variation for various uses. The results of the analyses shows that while some of the parameters are within the established limits, others are not. The results of the index also showed that the water fall into the medium class during the wet and dry seasons. This indicated that the Usuma Dam River has probably been polluted. Hence, the water is not suitable for domestic uses. Though the river could be used for irrigation, there is need for caution. The study showed that WQI is a useful for proper water treatment plan.

Keywords: Analytic hierarchy process, Physicochemical parameters, Water Quality Index.

1. INTRODUCTION

Water is a vital natural resource that is needed for the proper functioning of every sector of the economy- agriculture, power generation, processing industries, tourism- and for the survival and sustainability of life (Ahaneku and Animashaun, 2013). Conversely, the integrity of the freshwater system has been under continuous threat due to the activities of same sectors that have been the major beneficiaries of water of good health status. Though human - caused activities seems to be the major source of pollution, natural factors such hydrological, atmospheric, climatic, topographical, and lithological elements are all contributors (Uddin *et al.,* 2018).

The rate at which freshwater bodies are polluted in recent time is alarming and the trend is likely to continue due to increasing urbanisation, industrialisation and geometric increase in the world population. The complex and varied water quality is not a challenge faced by only the developing nations, even developed ones are in constant struggle to maintain or improve the quality of their water in the face of issues such as eutrophication of water resources (Uddin *et al.,* 2021).

Hence, for immediate attention and appropriate action, there is a need for monitoring and gathering of accurate and timely information about the water quality of freshwater system of every locality and the world at large.

Water quality refers to the overall status of water as relate to its physicochemical and biological characteristics, and its suitability for designated use such as domestic, industrial and agricultural purpose. The quality of surface water is a reflection of the surrounding environment just as the health status of the people around a particular area depends largely on the quality of their freshwater system (Roopshah, 2016). Assessment and management of water quality requires analysis of several water quality parameters which can be difficult to evaluate or cost and time-consuming. To this end, a number of approaches have been adopted recently among which is the use of indices. Water Quality Index (WQI) is a numerical scale used to classify a single metric arrived at based on computation and use of certain water parameters to express the overall quality of water of a particular source at a specific time (Ahaneku and Animashaun, 2013).

WQI is an effective tool for assessing water quality. It has acceptance worldwide due to its simplicity, consistency, and easiness to compute and use to convey important information about water quality to both non-technical personnel and policymakers. Though several indices have been developed, National Sanitation Foundation Water Quality Index (NSF-WQI), is among the widely used. It is a more rigorous version of Horton's WQI model and about 142 water quality experts informed decided on its parameter selection and weighting (Abbasi and Abbasi, 2012). However, due to its subjective nature during parameter weighting, analytic hierarchy process (AHP) method has been proposed. AHP is a decision-making technique and it is used in the context of WQI parameter weightings to allow for the determination of the most appropriate weightings for given parameters that are reflective of their influence on overall water quality (Uddin *et al.,* 2021).

A number of literatures as reported the use of water quality indices on surface water in Nigeria, only few reported the use of NSF. To our knowledge, no work has been reported on the use of AHP to reduce the bias introduce during the weighting process in NSF. To this end, this research work aimed at assessing the spatiotemporal variation in the water quality of Usuma Dam River to determine its suitability for drinking among other uses.

2. MATERIALS AND METHODS

2.1 Study Area

The area of study is Usuma Dam River, which is situated in Bwari, Federal Capital Territory (FCT), Abuja, Nigeria (Figure 1). Usuma Dam River is a perennial river and stands as the largest among the six drainage basins in Abuja. However, its flow rate significantly decreases during the long dry season, while in the wet seasons, it experiences high run-off and low infiltration capacity due to flash floods. These floods lead to swift transportation of large volumes of sediments downstream (Balogun, 2020). The dam receives inflow of water from Usuma and Gyedna Rivers

Figure 1: Usama dam

2.2 Sample collection and Analysis

In this study, water samples were collected at various sampling points (i.e., on Usuma river, Gyedna River and at the mid-station) in the study area during dry and wet season. The collected water samples were immediately taken to the laboratory for analyses. The analyses were done using the methods specified by the American Public Health Association (APHA) standard method as documented in the APHA's guidelines (APHA, 2012). The measured parameters measured are pH, Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS), Temperature, Turbidity (Tur) and Nitrates (NO_3).

2.3 National Sanitation Foundation (NSF) Water Quality Index

The Water Quality Index(WQI) for the Usuma Dam River was calculated from the above-mentioned parameters to assess its suitability for drinking purposes among other uses. The WQI employed in this study, is a modified version of the National Sanitation Foundation (NSF) method. The modification involved the use of AHP as against the traditional way of assigning weight. The process for computing the NSF water quality index consists of four key stages.

2.3.1 Selection of water quality index parameters

Though about twenty parameters were measured, the eight mentioned in this article are those considered for calculating the water quality index. The choice of parameters is based on their significance for drinking water, as indicated by experts in water resources and engineering. (Uddin *et al* 2021)

2.3.2 Calculation of parameter sub-Index weights using rating curves (q):

Rating curves are employed to establish sub-index ratings for each parameter. Each parameter possesses its own rating curve. These rating curves transform measurements of the chosen water quality parameters into dimensionless sub-index curves, represented as a percentage.

2.3.3 Allocation of weights (w):

In this step, certain parameters are deemed more critical than others based on the extent of harm they can cause when present in water. Parameters with higher potential hazards are assigned greater values, whereas those with lesser potential harm are assigned lower. The assignment of weights is accomplished using the analytical hierarchy approach (AHP). AD Sutadian *et al* 2017. This method helps to reduce uncertainty resulting from inappropriate weighting of parameters. The respective weight assigned to each parameter is presented in Table 1 below.

Table 1: Weight Assigned to water quality parameter based on AHP Approach

Parameter	DO	BOD	COD	pH	NO_3^-	TDS	Turbidity	Temperature
AHP Weight	0.16	0.13	0.15	0.13	0.10	0.12	0.10	0.11

2.3.4 Generation of the ultimate index value

This step involves a mathematical formula that adds together the results of multiplying the weights of various parameters with their respective sub-index values. The equation is below is used to generate water quality index;

Water Quality Index (WQI) $=\sum_{i=1}^{n} Qi\ wi$ (1)

where Qi represents the sub-index corresponding to the i^{th} water quality parameter,
wi stands for the weight linked to the i^{th} water quality parameter, and
n denotes the count of water quality parameters.

The Water Quality Index (WQI) was computed using the accepted Q-value for each parameter along with the assigned weight, and then compared against the NSF's recognized water quality rating. Water quality rating for NSF is selected from the Table 2

Table 2: **Water Quality Index Scoring System**

S/No	WQI range	Class
1	90-100	Excellent
2	70-89	Good
3	50-69	Medium
4	25-59	Bad
5	0-24	Unsuitable for drinking

Uddin *et al* 2021

3. RESULTS AND DISCUSSION

3.1 NSF-WQI Classification of Usuma Dam River during the Dry Season

The National Sanitation Foundation (NSF) Water Quality Index outcomes of dry season water quality assessment for Gyedna River, Mid-section and Usuma river are 55.22, 55.17, and 53.92 respectively (Table 3-5). Using the NSF-WQI approach for classification, the findings for these three stations reveal that the water quality is medium during the dry season.

Table 3 NSF- AHP WQI for Gyedna River during Dry season

S/N	Parameter	Measured value	Rating Qi	Weight factor wi	QixWi
1	DO	6.98	6.4	0.16	1.02
2	BOD	3.60	60	0.13	7.80
3	COD	10.60	30	0.15	4.50
4	pH	7.20	89	0.13	11.57
5	NO_3^-	1.80	97	0.1	9.70
6	TDS	38.63	82	0.12	9.84
7	Turbidity	1.91	98	0.1	9.80
8	Temperature	29.97	9	0.11	0.99
				WQI	**55.22**

Table 4 NSF-AHP WQI for Mid-section during Dry season

S/N	Parameter	Measured value	Rating Qi	Weight factor wi	QixWi
1	DO	8.30	8.5	0.16	1.36
2	BOD	4.00	57	0.13	7.41
3	COD	12.10	24	0.15	3.60
4	pH	7.10	88	0.13	11.44
5	NO_3^-	1.90	97	0.1	9.70
6	TDS	44.40	86	0.12	10.32
7	TURB	3.60	91	0.1	9.10
8	TEMP	29.73	9	0.11	0.99
				WQI	**53.92**

Table 5: NSF-AHP WQI for Usuma Dam River during the Dry season

S/N	Parameter	Measured value	Rating Qi	Weight factor wi	QixWi
	DO	6.90	6.3	0.16	1.01
1	BOD	9.20	33	0.15	4.95
2	COD	7.20	89	0.13	11.57
3	pH	2.13	90	0.1	9.00
4	NO_3^-	37.73	81	0.12	9.72
5	TDS	37.73	81	0.12	9.72
6	TURB	2.39	92	0.1	9.20
7	TEMP	30.03	9	0.11	0.99
				WQI	**55.17**

3.2 NSF-WQI Classification of Usuma Dam River during the Wet Season

In the wet season, the Water Quality Index for the Gyedna River, Mid-section and Usuma river are 53.69, 50.91, and 50.95 respectively (Tables 6-8). The obtained index values for the three stations also indicate a medium level of water quality during the wet season.

Table 6: NSF- WQI for Gyedna River during Wet Season

S/N	Parameter	Measured value	Rating Qi	Weight factor wi	QixWi
1	DO	8.47	8.5	0.16	1.36
2	BOD	3.97	64	0.13	8.32
3	COD	11.60	31	0.15	4.65
4	pH	7.20	89	0.13	11.57
5	NO_3^-	4.80	76	0.1	7.60
6	TDS	46.47	86	0.12	10.32
7	TURB	6.05	80	0.1	8.00
8	TEMP	26.13	17	0.11	1.87
				WQI	**53.69**

Table 7: NSF-WQI for the Mid-Section during the Wet Season

S/N	Parameter	Measured value	Rating Qi	Weight factor wi	QixWi
1	DO	8.08	8.1	0.16	1.30
2	BOD	4.23	55	0.13	7.15
3	COD	12.57	26	0.15	3.90
4	pH	7.20	89	0.13	11.57
5	NO_3^-	5.23	68	0.1	6.80
6	TDS	45.97	86	0.12	10.32
7	TURB	5.92	80	0.1	8.00
8	TEMP	26.27	17	0.11	1.87
				WQI	**50.91**

Table 8: NSF-AHP WQI for Usuma Dam River during Wet Season

S/N	Parameter	Measured value	Rating Qi	Weight factor wi	QixWi
1	DO	7.93	7.3	0.16	1.17

2	BOD	3.97	57	0.13	7.41
3	COD	12.13	27	0.15	4.05
4	pH	7.20	89	0.13	11.57
5	NO_3^-	4.60	75	0.1	7.50
6	TDS	26.23	84	0.12	10.08
7	TURB	9.71	73	0.1	7.30
8	TEMP	26.37	17	0.11	1.87
				WQI	**50.95**

The river's water quality was computed using the NFS-AHP WQI using eight parameters. The obtained index values fall within the range of 50-55 across the three stations during dry and wet season which suggested a medium water quality (Ewaid, 2016). The results of the physicochemical parameters used for WQI calculation reflected the medium water quality class of the three stations. For instance, while the pH values mostly fall within the established limit of WHO and NSDWQ (6.5-8.5), the high COD values suggest the presence of the biological active and inorganic matter in the soil (Mahi and Isah, 2016). The result is in agreement with the finding of Okunlola et al. (2014) which ranked Usuma dam rivers low and concluded that the river water quality has been compromised.

4. Conclusion

Physicochemical parameters of Usuma River were assessed during the wet and dry seasons. The obtained results of the analysis were used to establish the river water quality status using NSF-AHP WQI. The result of study indicated medium class of the river water and hence not suitable for domestic purposes in any of the three stations. The high values of some of the parameters suggest probable influence of man activities on the rivers. There is therefore a need in using the water without treatment. The study showed the effectiveness of the WQI in assessing the overall quality of river

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