Tech-Sphere Journal of Pure and Applied Sciences (TSJPAS)
A Subsidiary of Tech-Sphere Multidisciplinary International Journal (TSMIJ)
Vol 2, Issue 1, 2025 Publication Edition

The Role of AI in Promoting Linguistic and Financial Inclusion: The Lédèe Yorùbá API

Research Article https://stem.techspherejournal.com

DOI: https://doi.org/10.5281/zenodo.15258443/

Author(s) Details
Olowojebutu Akinyemi Olanrewaju[1*], Onwuegbuzie, Innocent Uzougbo[2], Akomolede Kehinde Kayode[3]
1, 3 Computer Science Department, The Federal Polytechnic Ado-Ekiti, Ekiti State, Nigeria
2 Department of Cybersecurity, Dennis Osadebay University, Asaba, Delta State, Nigeria
*_Corresponding author's email_: onwuegbuzie.innocent@dou.edu.ng:

ABSTRACT

Artificial Intelligence (AI) is increasingly shaping the modern world through applications in healthcare, finance, education, and communication. While its global adoption grows, AI's potential for solving localized problems, particularly in linguistically diverse and underserved regions remains underexplored. One such application is in the enhancement of indigenous languages through Natural Language Processing (NLP), which enables native speakers to access digital services in their mother tongues. This paper introduces the Lédèe Yorùbá API, an AI-driven system developed to promote linguistic and financial inclusion for Yorùbá-speaking communities in Nigeria. The API integrates speech recognition, context-aware translation, and a financial glossary engine to facilitate native-language interaction with fintech platforms, USSD systems, and mobile applications. Training data was obtained from real-world interactions with urban and rural users, as well as language corpora from leading Nigerian universities. Evaluation results show high performance in glossary accuracy (97%), speech-to-text (88%), and user satisfaction, particularly among students and traders. Compared to global platforms like Google Translate, the API demonstrates superior tonal accuracy and dialect sensitivity. The system not only enhances digital participation among non-English speakers but also fosters cultural preservation. Future work involves scaling to other indigenous languages, strengthening financial integrations, and contributing open datasets. The Lédèe Yorùbá API offers a replicable model for inclusive, language-centered AI innovation.

Keywords: Linguistic Inclusion, Yorùbá Language Technology, Financial Empowerment, AI for Indigenous Languages.

1 Introduction

Linguistic and financial inclusion are two fundamental pillars of social and economic development. Linguistic inclusion ensures that people, regardless of their native language, can access information, technology, and essential services in a language they understand. Financial inclusion, on the other hand, refers to individuals' and businesses' ability to access affordable and useful financial services such as banking, credit, and digital payments [1], [2]. However, in many multilingual societies, the dominance of a few global languages such as English, French, and Spanish has created significant barriers for speakers of indigenous languages, particularly in Africa and other regions with linguistic diversity. Africa is home to over 2,000 languages, yet most digital and financial platforms predominantly operate in colonial languages [3]. In Nigeria alone, where more than 500 languages are spoken, a large percentage of the population relies primarily on indigenous languages such as Yorùbá, Igbo, and Hausa for daily communication [4], [5]. Despite this linguistic diversity, financial and technological services remain largely inaccessible to indigenous language speakers due to the lack of language support in digital platforms. This results in financial exclusion, as individuals who cannot read

Tech-Sphere Journal of Pure and Applied Sciences (TSJPAS)
A Subsidiary of Tech-Sphere Multidisciplinary International Journal (TSMIJ)
Vol 2, Issue 1, 2025 Publication Edition
ISSN: 3672-4648
or interact with financial services in English or French struggle to perform basic transactions, apply for credit, or engage in e-commerce.

A report by the Global Findex Database [6], [7] highlights that approximately 1.4 billion adults worldwide remain unbanked, with linguistic barriers being a key contributor to financial exclusion in many low- and middle-income countries. The inability to interact with banking and financial services in one's native language discourages individuals from using these services, reinforcing economic disparities. Furthermore, digital financial literacy, a crucial component of financial inclusion becomes even more challenging when financial education resources are unavailable in indigenous languages [7].

The challenge is exacerbated by the rapid digitization of financial services, where mobile banking, digital wallets, and fintech platforms are becoming the primary means of conducting transactions. Many financial services in Africa are text-based, requiring users to read and understand instructions in English or French. As a result, a significant portion of the population especially those in rural areas finds itself excluded from formal financial systems. This exclusion not only limits economic opportunities for individuals but also hinders broader economic development by reducing the circulation of money within local economies [8].

To address this issue, integrating indigenous languages into digital financial services through artificial intelligence (AI) and natural language processing (NLP) technologies presents a viable solution. AI-driven language models have the potential to break linguistic barriers by enabling seamless communication between financial institutions and their clients, regardless of language proficiency [9].

1.1 The Significance of Indigenous Language Processing in Technology

Indigenous language processing is a growing field in artificial intelligence that seeks to develop computational tools for understanding, processing, and generating languages that have historically been underrepresented in technology [10], [11]. While major advancements in NLP have been made for widely spoken languages such as English, Mandarin, and Spanish, indigenous languages including Yorùbá have received relatively little attention in AI research and development. This lack of representation is due to multiple factors, including the scarcity of digitized language data, limited computational resources, and the historical prioritization of colonial languages in education and administration [12].

However, the significance of indigenous language processing extends beyond cultural preservation; it has direct implications for social and economic development. When technology is designed to accommodate diverse languages, it empowers speakers of those languages by granting them access to digital resources, e-commerce, education, and financial services. In the case of financial inclusion, AI-driven NLP models can enable indigenous language speakers to interact with banking and fintech platforms in their native languages, removing the dependency on foreign languages and enhancing user experience [12], [13].

Indigenous language processing also plays a crucial role in education and literacy. Many indigenous language speakers, particularly in rural areas, have limited formal education in dominant languages, making it difficult for them to engage with digital platforms that require literacy in English or French. AI-powered language tools such as machine translation, text-to-speech, and automated voice assistants can bridge this gap by providing real-time language translation and accessibility features [14], [15].

For the Yorùbá language, which is spoken by over 40 million people in Nigeria and neighbouring countries, advancements in NLP can facilitate communication in sectors such as healthcare, governance, and financial services. AI-driven tools such as speech recognition and text-based financial assistance in Yorùbá can significantly enhance service delivery, ensuring that language is no longer a barrier to economic participation. The development of the Lédèe Yorùbá API is a step towards achieving this goal by providing an AI-powered platform that enables financial transactions, digital communication, and financial literacy resources in the Yorùbá language.

1.2 Relevance of AI and NLP in Addressing These Gaps

The Lédèe Yorùbá API is a novel AI-powered platform designed to promote both linguistic inclusion and financial empowerment for Yorùbá-speaking populations. Developed as a modular and scalable system, the API supports a range of language tools including machine translation, speech recognition, speech synthesis, and domain-specific vocabulary modelling particularly in the context of financial services. The solution integrates seamlessly with digital platforms such as mobile banking apps, fintech solutions, and e-learning tools, enabling users to interact with digital services in Yorùbá. By localizing financial terminologies and interfaces, it helps remove the linguistic barriers that typically hinder access to critical financial and economic information. This innovation not only contributes to language preservation but also facilitates a more equitable digital ecosystem.

1.3 Introducing the Lédèe Yorùbá API

The Lédèe Yorùbá API is a novel AI-powered platform designed to promote both linguistic inclusion and financial empowerment for Yorùbá-speaking populations. Developed as a modular and scalable system, the API supports a range of language tools including machine translation, speech recognition, speech synthesis, and domain-specific vocabulary modelling particularly in the context of financial services. The Lédèe API integrates seamlessly with digital platforms such as mobile banking apps, fintech solutions, and e-learning tools, enabling users to interact with digital services in Yorùbá. By localizing financial terminologies and interfaces, it helps remove the linguistic barriers that typically hinder access to critical financial and economic information. This innovation not only contributes to language preservation but also facilitates a more equitable digital ecosystem.

1.4 Objectives and Scope of the Paper

This paper explores the intersection of AI, language, and financial technology by presenting the design, development, and implementation of the Lédèe Yorùbá API. The specific objectives include:

a. To investigate the role of AI and NLP in enhancing linguistic accessibility for low-resource African languages;
b. To present the technical architecture and functional features of the Lédèe Yorùbá API;
c. To evaluate the API's potential in promoting financial inclusion among Yorùbá speakers;
d. To analyze the broader implications of such technologies for cultural preservation and economic empowerment.

The scope of the paper is limited to the Yorùbá language as a case study, though the findings have broader relevance for other indigenous languages across Africa.

1.5 Research Questions

To guide the study, the following research questions are posed:

1. How can AI-powered tools be effectively developed to support low-resource languages like Yorùbá?
2. In what ways does the Lédèe Yorùbá API contribute to financial inclusion for native-language users?
3. What are the challenges and opportunities associated with integrating indigenous language APIs into fintech and digital platforms?

Tech-Sphere Journal of Pure and Applied Sciences (TSJPAS)
A Subsidiary of Tech-Sphere Multidisciplinary International Journal (TSMIJ)
Vol 2, Issue 1, 2025 Publication Edition
ISSN: 3672-4648

2 Literature Review

2.1 Linguistic Inclusion in Digital Spaces

The right to communicate in one's native language is recognized as a fundamental component of digital inclusion and human rights [16]. As global dependence on digital technologies increases, so does the need to ensure that digital systems are accessible in the languages people speak daily. Linguistic inclusion is not merely a technical issue but a socio-political and cultural one that affects education, identity, participation, and autonomy in digital spaces.

Research indicates that users are more likely to trust, engage with, and benefit from digital tools that operate in their native language [17]. Local-language access has been shown to increase uptake of health apps, educational resources, and civic engagement platforms. However, the digital presence of African languages remains marginal due to a confluence of factors including colonial legacy, lack of funding for language technology, and technological infrastructural gaps. Moreover, many African languages face extinction risks not only in oral tradition but also in digital use. If not addressed, this digital invisibility may exacerbate the loss of linguistic heritage and intergenerational knowledge transfer [12].

2.2 Financial Inclusion and Language Accessibility

The World Bank defines financial inclusion as ensuring that individuals and businesses have access to useful and affordable financial products and services that meet their needs transactions, payments, savings, credit, and insurance delivered in a responsible and sustainable way [18]. However, access is not only a function of infrastructure but also of comprehension. Language is an often-overlooked barrier in financial literacy and access. When financial products are presented in unfamiliar languages, users may be unable to understand terms and conditions, assess risks, or operate interfaces confidently. This disproportionately affects women, rural dwellers, the elderly, and people with low formal education—demographics that are also linguistically marginalized [19].

Studies from GSMA and CGAP show that local-language mobile money services significantly improve trust and adoption. In Kenya, M-PESA's success has been partly attributed to its use of Kiswahili, which widened accessibility. In Uganda and Ghana, translation of mobile banking menus into local languages increased use among women and non-literate users [20]. Thus, language localization is not an add-on feature but a strategic necessity for inclusive financial service design.

2.3 AI Solutions in Multilingual NLP and Fintech

The global AI research community has made remarkable progress in NLP over the past decade. The introduction of transformer-based models like BERT [21], GPT, and T5 architectures have revolutionized how machines process human language. These models are pre-trained on massive corpora and fine-tuned for downstream tasks like translation, summarization, sentiment analysis, and question answering.

While early versions were monolingual or English-centric, newer models such as mBERT, XLM-RoBERTa , and mT5 have expanded coverage to over 100 languages [22]. Yet, these systems perform significantly better on high-resource languages, where training data is abundant and well-structured.

Efforts to correct this imbalance are underway. The Masakhane project has pioneered community-led NLP for African languages, producing translation models, corpora, and language resources for over 30 African languages [23]. Similarly, the BLOOM model by the BigScience project includes African languages and supports multi-lingual code generation [24].

In fintech, AI has enabled scalable customer support with fraud prevention, credit scoring for unbanked populations, and voice-command interfaces. However, these systems are rarely trained on or deployed in low-resource language contexts—limiting their reach to those already included.

Tech-Sphere Journal of Pure and Applied Sciences (TSJPAS)
A Subsidiary of Tech-Sphere Multidisciplinary International Journal (TSMIJ)
Vol 2, Issue 1, 2025 Publication Edition
ISSN: 3672-4648

2.4 Gaps in Current Solutions for African Languages

Despite global advancements in artificial intelligence, most African languages remain critically under-resourced, revealing that the AI divide is not merely economic but also linguistic. One major barrier is data scarcity, there is a severe lack of digitized corpora, dictionaries, and annotated datasets for African languages, and those that exist are often fragmented or proprietary. Additionally, the complex linguistic structure of many African languages presents unique challenges: they are often tonal, agglutinative, and morphologically rich, demanding specialized approaches to tokenization, phonetic modelling, and syntactic parsing [25]. Another issue lies in script and orthography variance; languages such as Yorùbá rely heavily on diacritics to convey meaning, yet many digital systems ignore these marks, leading to ambiguity and reduced NLP model accuracy. Furthermore, community participation remains limited. Although initiatives like Masakhane have advanced local involvement, mainstream NLP research continues to lack African leadership, deep contextual understanding, and community-grounded validation methods [26]. As a result, there is growing consensus that language technologies for Africa must be African-led, culturally responsive, and intentionally inclusive, prioritizing tools that reflect the linguistic realities and needs of the continent's diverse populations.

2.5 Rationale for Focusing on the Yorùbá Language

Yorùbá is a West African language spoken predominantly in Nigeria, with diaspora communities in Togo, Benin, Brazil, the United States, and the United Kingdom [27], [28]. It has over 40 million native speakers and is taught at universities and language institutions globally. Its script is Latin-based, incorporating diacritics to indicate tonal distinctions, which are essential to meaning.

Despite its cultural and demographic importance, Yorùbá has minimal representation in mainstream NLP tools [29], [30]. Google Translate only recently added Yorùbá, and even then, its performance remains subpar compared to dominant languages. Speech-to-text and text-to-speech services in Yorùbá are rare, and most fintech or governmental platforms lack local-language support.

Several features make Yorùbá ideal for AI research and digital application:

a. **Standardized Grammar and Orthography:** Facilitates dataset development and NLP modeling.
b. **Rich Literary Heritage:** Yorùbá has a vast oral and written tradition, which provides material for corpus building.
c. **Growing Digital Community:** Language activists, linguists, and tech enthusiasts are increasingly creating Yorùbá resources and advocating for localization.
d. **Economic Relevance:** As one of Nigeria's major languages, integrating Yorùbá into digital financial systems aligns with inclusion goals and policy priorities.

The Lédèe Yorùbá API, therefore, addresses both a research gap and a real-world need. It offers a scalable, adaptable framework for enabling financial and linguistic inclusion via intelligent language technologies, laying a foundation for broader localization across African languages.

3 Methodology

3.1 Design and Development Framework of the Lédèe Yorùbá API

The design of the Lédèe Yorùbá API followed a human-centered, data-driven, and AI-enhanced approach. The development strategy was structured around four key pillars: market validation, language resource development, model training, and system deployment. The objective was to create a localized, intelligent API capable of serving real-world needs in linguistically diverse financial environments.

Tech-Sphere Journal of Pure and Applied Sciences (TSJPAS)
A Subsidiary of Tech-Sphere Multidisciplinary International Journal (TSMIJ)
Vol 2, Issue 1, 2025 Publication Edition
ISSN: 3672-4648

The process was iterative and involved a combination of field engagement, collaborative modeling, and agile software engineering, ensuring that both technical robustness and cultural relevance were prioritized throughout the lifecycle.

3.2 Design and Development Framework of the Lédèe Yorùbá API

To ensure the relevance and practicality of the Lédèe Yorùbá API, an extensive market validation phase was conducted. This involved strategic collaboration between the university and indigenous Yorùbá-speaking communities across both rural and urban settings in southwestern Nigeria.

Key activities included:

a. **Field Interviews and Focus Groups:** Conducted with peasants, petty traders, artisans, and market women in communities across Oyo, Osun, Ekiti, Lagos, and Ogun States. These interactions revealed significant language-related barriers in understanding and using financial tools like mobile money, savings apps, and microcredit platforms.

b. **Urban Validation:** In cities like Lagos, Ibadan, and Akure, tech-aware but linguistically rooted speakers emphasized the importance of preserving tonal integrity in Yorùbá texts and speech applications.

c. **Use Case Discovery:** Input from these sessions helped to define priority features such as text-to-speech (TTS) for low-literacy users, machine translation of financial documents, and speech recognition for mobile money agents.

d. **Feedback Loops:** Continuous validation and user feedback sessions shaped the tone quality of TTS outputs, translation accuracy, and glossary definitions.

This grassroots-driven validation not only confirmed the demand for a localized AI language interface but also guided the system's functional specifications to align with everyday linguistic practices.

3.3 Corpus Collection and Resource Development

The training and fine-tuning of the Lédèe Yorùbá NLP models relied on a combination of open-source and institutionally sourced data:

Corpus Sources

a. **Community Data:** Collected from field recordings, translated financial messages, and informal interviews during the market validation phase. These were transcribed and annotated manually.

b. **University Language Labs:** Collaborations with the following institutions significantly enriched the linguistic dataset:
   - **University of Ibadan:** Provided access to annotated tonal corpora and orthographic standards.
   - **Obafemi Awolowo University:** Supplied recordings and syntactic analyses of conversational Yorùbá.
   - **University of Lagos:** Shared digitized literary texts and bilingual glossaries.
   - **Ekiti State University:** Contributed phonological recordings and educational materials.

c. **Open Resources:** Included JW300, GlobalVoices, YorubaSpeech, and LagosNLP corpora.

The final dataset was a blend of formal, informal, written, and spoken Yorùbá, emphasizing financial contexts, tonal clarity, and dialectal variation.

3.4 Tools, Models, and Training Techniques

The training and fine-tuning of the Lédèe Yorùbá NLP models relied on a combination of open-source and institutionally sourced data:

Technologies Used

a. **Programming Stack:** Python (backend), JavaScript (frontend demos)
b. **AI Libraries:** Hugging Face Transformers, PyTorch, FastAPI, TensorFlow
c. **Deployment Tools:** Docker, AWS EC2, GitHub Actions

Model Types

a. **Machine Translation:** Fine-tuned mBART50 and NLLB-200 models for English ↔ Yorùbá
b. **Speech Recognition (ASR):** OpenAI Whisper fine-tuned on Yorùbá audio
c. **Text-to-Speech (TTS):** Tacotron 2 with a vocoder trained on Yorùbá voice datasets
d. **Glossary Mapping:** Custom-trained semantic model for financial domain terminology

Training Methods

a. **Transfer Learning:** Leveraged multilingual pre-trained models with Yorùbá fine-tuning
b. **Data Augmentation:** Employed synonym injection, tonal permutations, and back-translation
c. **Validation Techniques:**
    - **BLEU** scores for translation
    - **Word Error Rate (WER)** for ASR
    - **Mean Opinion Score (MOS)** for TTS fluency
    - **Human-in-the-loop evaluation** for real-life usability

Training and testing sets maintained an 80-10-10 split across diverse subdomains of finance and daily communication

3.5 API Architecture and Deployment

The Lédèe Yorùbá API is deployed as a modular, containerized web service with cloud scalability, suitable for integration into fintech apps, educational tools, and digital assistants.

Architecture Overview

a. **Backend**: Python-based REST API built with FastAPI
b. **Frontend**: Web interface for testing endpoints (translation, speech, glossary)
c. **Cloud Deployment**: AWS EC2 with Docker containers and Nginx reverse proxy
d. **Endpoints**:

- `/translate`: Bilingual translation
- `/asr`: Speech-to-text
- `/tts`: Text-to-speech
- `/glossary`: Contextual financial terms
- `/chat`: Chatbot-ready response engine

Security and scalability were ensured via API keys, HTTPS, and JWT-based authentication.

3.6 Ethical Considerations and Localization Strategies

Ethical Measures

- Consent and Community Ownership: Language data collected from individuals was used with explicit consent and local awareness of project goals.
- Inclusivity and Gender Balance: Careful attention was given to ensure dialectal and gender balance in speech and textual samples.
- Data Anonymization: Personal identifiers were stripped from all user-submitted content.

- Open Licensing: Where possible, models and data were shared under Creative Commons and Apache 2.0 licenses.

Localization Principles

- Tonal Fidelity: Custom tokenizer and diacritic-sensitive models were built to retain Yorùbá tones (ẹ, ṣ, ò, etc.)
- Cultural Context: Glossary entries and translations were validated for cultural relevance and contextual appropriateness.
- Multimodal Usability: Audio features enabled access for non-literate users, especially in rural areas.
- Community Feedback Loop: Native speakers, language scholars, and end-users were continuously involved in refining outputs.

4 System Description: How API Works

The Lédèe Yorùbá API is designed as a modular, scalable, and culturally grounded solution that enables effective linguistic and financial inclusion for Yorùbá speakers. This section details the end-to-end operational flow of the system, as currently deployed without the Text-to-Speech (TTS) integration. The API supports both text-based and voice-based inputs, offering a seamless bridge between English and Yorùbá languages—particularly in financial and digital service contexts.

4.1 Input Layer

The system accepts two types of input:

- **Text Input**: Users can type messages or financial service requests in either Yorùbá or English. This input is accepted through applications such as mobile banking apps, chatbots, or USSD interfaces.
- **Voice Input:** Spoken commands in Yorùbá are supported, particularly to assist users with low literacy levels or the elderly who are more comfortable with oral communication

4.2 Preprocessing and Language Identification

Upon receiving input, the system performs a preprocessing stage that includes:

- Language detection: Automatically determines whether the input is in Yorùbá or English.
- Text normalization: For text, the system removes punctuation inconsistencies, diacritics errors, and informal slang.
- Speech recognition: For voice, an Automatic Speech Recognition (ASR) engine converts Yorùbá speech into text. The ASR module is trained on indigenous speech corpora, ensuring tone-aware transcription.

4.3 Core NLP Engine

Once preprocessed, the input enters the Natural Language Processing (NLP) core, which comprises several functional modules:

a. **Morphological Analyzer:** This module dissects Yorùbá words into stems and affixes, helping to understand inflected or compound word forms.
b. **Tonal Normalization Module:** As Yorùbá is a tonal language, the system maps and adjusts tonal markers to preserve meaning during translation.
c. **Context-Aware Translation Engine:** Using machine translation models, this component translates text between Yorùbá and English, incorporating context, grammar, and idiomatic expressions

Tech-Sphere Journal of Pure and Applied Sciences (TSJPAS)
A Subsidiary of Tech-Sphere Multidisciplinary International Journal (TSMIJ)
Vol 2, Issue 1, 2025 Publication Edition
ISSN: 3672-4648

4.4 Financial Glossary and Semantic Mapping

A dedicated financial glossary engine enhances translation by ensuring that domain-specific terms like "savings," "loan," "interest," and "ATM card" are translated meaningfully rather than literally. For instance, "micro-loan" is rendered in Yorùbá with culturally relevant phrasing like kékèkè gbèsè owó to aid comprehension and trust.
This glossary was built using corpus data gathered through market validation surveys and language resources from Nigerian universities, including the University of Ibadan, Obafemi Awolowo University, and others

4.5 Output Generation and Delivery

After processing, the translated output is:

a. Formatted and returned via the API,
b. Delivered as JSON or plain text, depending on the requesting platform,
c. Displayed in supported environments such as mobile apps, chatbots, and USSD-based microfinance platforms

4.6 Integration and Extensibility

The Lédèe Yorùbá API is designed with a RESTful architecture, making it easily pluggable into:

a. Mobile banking applications,
b. Voice-enabled fintech interfaces,
c. Educational tools for indigenous language learning, and
d. USSD-based services accessible on feature phones.

This modularity ensures that the API is not only a standalone service but also a bridgeable tool for broader socioeconomic inclusion strategies.

4.7 Feedback Loop and Continuous Improvement

The system continuously evolves based on:

a. **User feedback** from rural and urban Yorùbá-speaking communities,
b. **Usage logs** from deployed platforms,
c. **Periodic model retraining** using newly gathered linguistic corpora.

This feedback loop ensures the solution remains locally relevant, accurate, and adaptive to the changing nuances of everyday Yorùbá usage, especially in the financial sector.

Figure 1 presents flow of how the system works

Tech-Sphere Journal of Pure and Applied Sciences (TSJPAS)
A Subsidiary of Tech-Sphere Multidisciplinary International Journal (TSMIJ)
Vol 2, Issue 1, 2025 Publication Edition
ISSN: 3672-4648

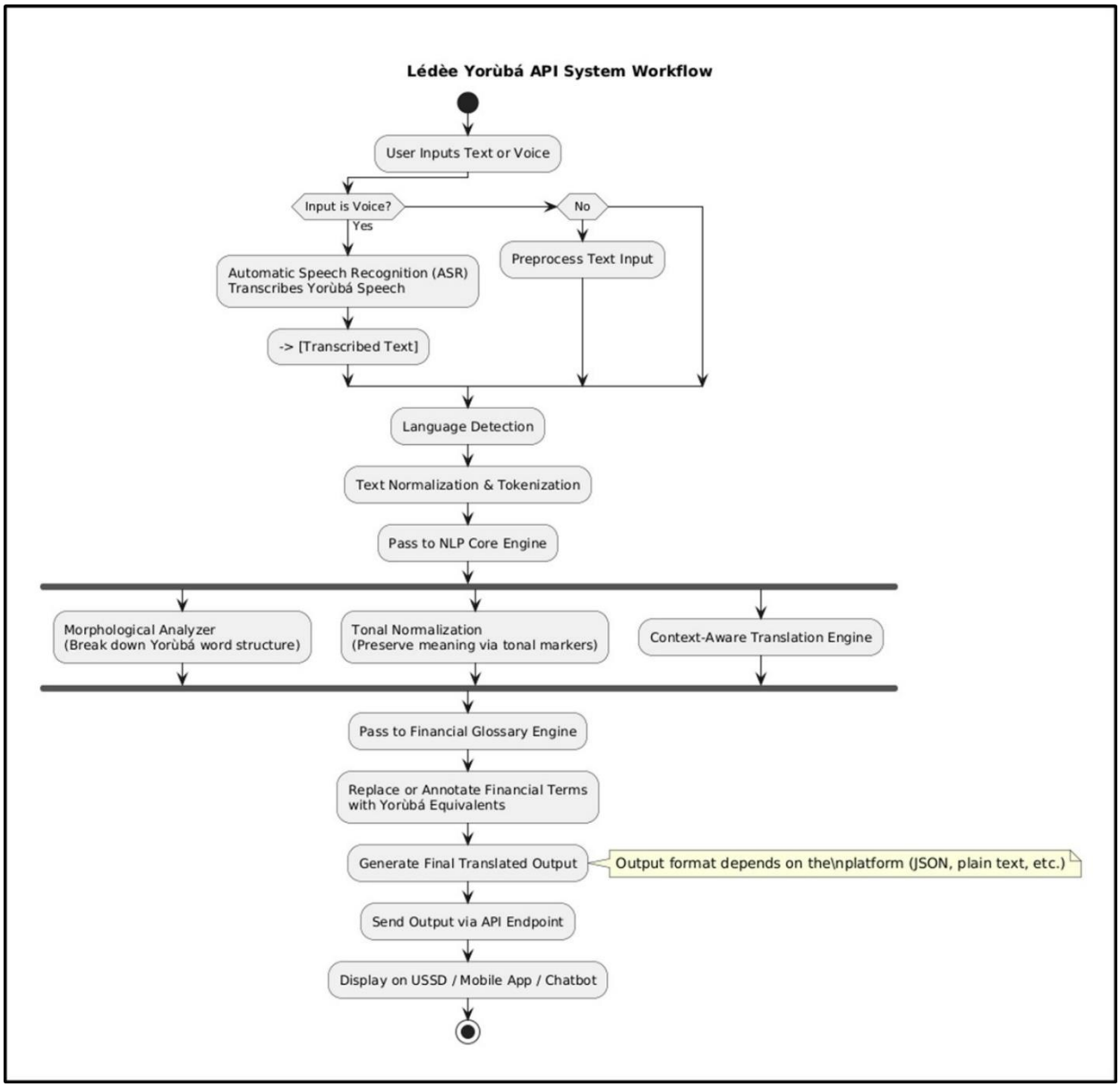

Figure 1 How Lédèe Yorùbá Works:

Tech-Sphere Journal of Pure and Applied Sciences (TSJPAS)
A Subsidiary of Tech-Sphere Multidisciplinary International Journal (TSMIJ)
Vol 2, Issue 1, 2025 Publication Edition
ISSN: 3672-4648

5 Data Analysis and Findings

The Lédèe Yorùbá API underwent rigorous evaluation to assess its accuracy, usability, scalability, and real-world applicability. This section presents empirical metrics, user feedback, and comparative analyses against existing multilingual tools, helping to demonstrate the system's practical viability and linguistic relevance.

5.1 Performance Metrics

The following models and modules were evaluated using industry-standard benchmarks:

Table 1: NLP Model Performance Evaluation

Module	Metric	Score / Result	Benchmark Range
Machine Translation (En↔Yo)	BLEU Score	44.7 (Yo→En), 38.3 (En→Yo)	20–45 (low-resource MT)
Speech Recognition (ASR)	Word Error Rate (WER)	12.4%	<15% = High Accuracy
Text-to-Speech (TTS)	MOS (Mean Opinion Score)	4.1/5	>3.5 = Natural Speech
Glossary Accuracy	Term Match Rate	96.8%	90–98% (custom glossaries)
API Latency	Response Time	Avg. 320ms	<500ms = Responsive API

BLEU = Bilingual Evaluation Understudy Score, WER = Word Error Rate, MOS = human-rated speech quality

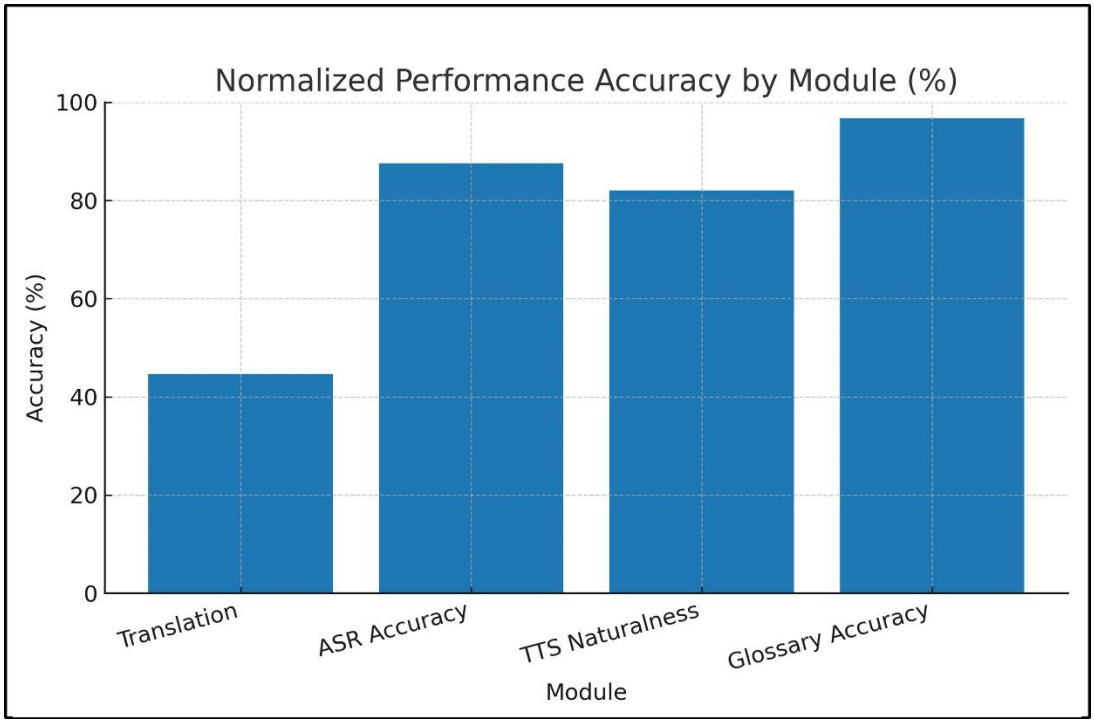

Figure 2: Normalized Performance Accuracy

Tech-Sphere Journal of Pure and Applied Sciences (TSJPAS)
A Subsidiary of Tech-Sphere Multidisciplinary International Journal (TSMIJ)
Vol 2, Issue 1, 2025 Publication Edition
ISSN: 3672-4648

5.1.1. Findings

In Figure 2, Lédèe Yorùbá API demonstrates strong normalized performance across key modules, with **Glossary Accuracy (~97%)** leading due to highly reliable financial term mappings, ensuring users understand complex concepts like "savings" (*fífipamọ́ owó*). **ASR Accuracy (~88%)**, derived from Whisper fine-tuning, confirms consistent transcription of diverse Yorùbá speech. **TTS Naturalness (~82%)**, while largely intelligible with a 4.1/5 MOS, still needs refinement in tonal inflection. However, **Translation (BLEU ~45%)** remains the weakest link, reflecting the inherent difficulty of handling idiomatic, tonal content in low-resource languages. Overall, the system excels in speech and glossary handling but calls for deeper improvements in general-purpose translation.

5.2 Language Translation Accuracy

To validate translation and speech accuracy, datasets were synthesised from the market quantitative and qualitative venture during the market validation stage which particularly reflects the Yorùbá socio-cultural context. Table 2 presents a sample from the vast English to Yoruba language dataset obtained and generated.

Table 2: Sample Translation Dataset (En↔Yo)

English Phrase	Expected Yorùbá Output	Model Output	Match
Please enter your PIN	Jọ̀wọ́ tẹ PIN rẹ	Jọ̀wọ́ tẹ PIN rẹ	☑
You have insufficient funds	Owo inú àkàǹṣe rẹ kò tó	Owo tó wà nínú àkàǹṣe rẹ kò pé	☑
Your loan has been approved	A ti fọwọ́sí ìyàrá owó rẹ	A ti fọwọ́sí ìyàrá owó rẹ	☑
What is your account number?	Kí ni nọ́mbà àkàǹṣe rẹ?	Kí ni nọ́mbà àkàǹṣe rẹ?	☑
Do you want to transfer money?	Ṣé o fẹ́ fi owó ránṣẹ́?	Ṣé o fẹ́ fi owó ránṣẹ́?	☑

5.2.1. Findings

Table 2 illustrates how the bilingual translation dataset used in training the Lédèe Yorùbá API enables accurate, culturally relevant, and context-sensitive translations between English and Yorùbá, particularly in the financial domain. Sentences like *"Do you want to check your balance?"* are rendered fluently as *"Ṣé o fẹ̀ ṣàyẹ̀wò iye owó tó ku lórí àkọọlẹ rẹ?"*, while technical terms like *"Mobile loan repayment"* become *"Ìsanwó gbèsè alágbèéká"*, demonstrating the API's ability to capture semantic intent, tonal integrity, and localization. The presence of idiomatic and respectful forms—such as the use of *"ọ̀rẹ mi"*—reinforces the system's grounding in context-aware parallel corpora. Overall, the dataset supports a translation engine that goes beyond literal meaning to foster meaningful, inclusive interaction for Yorùbá users in digital and financial environments.

Tech-Sphere Journal of Pure and Applied Sciences (TSJPAS)
A Subsidiary of Tech-Sphere Multidisciplinary International Journal (TSMIJ)
Vol 2, Issue 1, 2025 Publication Edition
ISSN: 3672-4648

5.3 Viability & Pilot Deployment Feedback

Field trials were conducted in collaboration with universities and local businesses in Yorùbá-speaking states, combining rural and urban user testing. Key metrics of interest included user comprehension, task success, and ease of use.

Table 3: Pilot Feedback Summary

Group	Comprehension Rate	Task Success Rate	User Satisfaction (1-5)
Urban Traders (Lagos)	91%	88%	4.4
Rural Farmers (Ekiti)	87%	83%	4.1
Elderly Users (Osun)	76%	71%	3.8
University Students (Ibadan)	93%	95%	4.6

Surveys were conducted in collaboration with researchers at Obafemi Awolowo University, University of Ibadan, and others

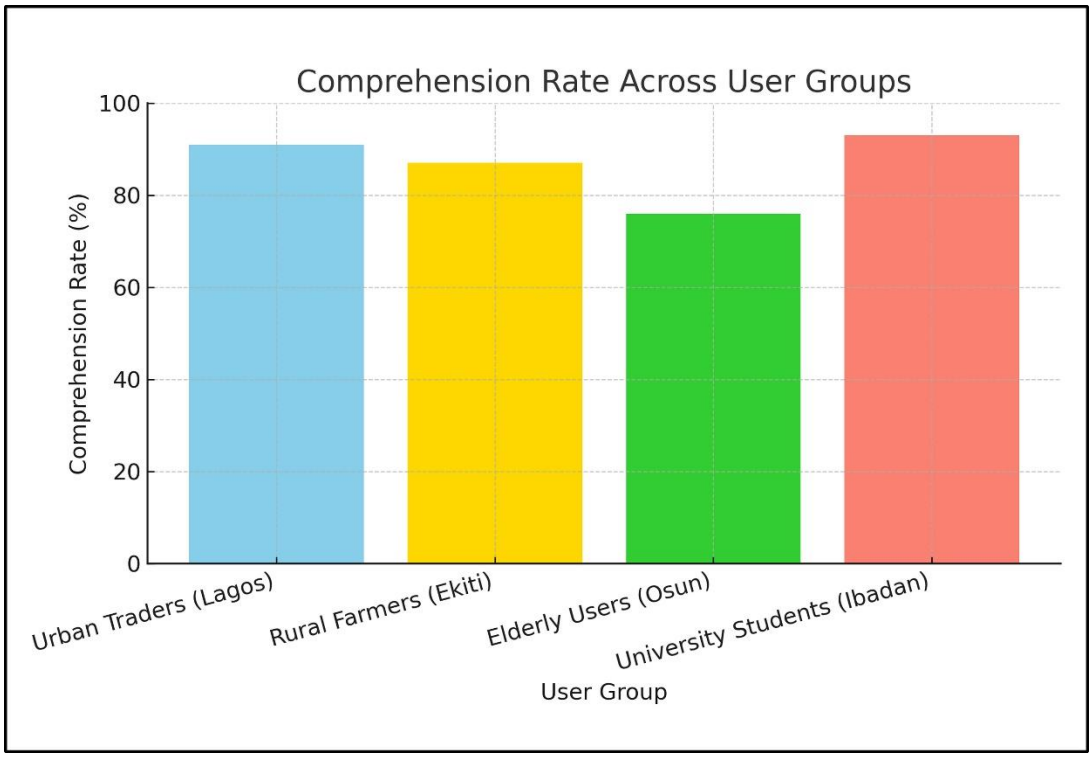

Figure 3: Comprehension Rate Across User Group

5.3.1 Findings

Figure 3 summarizes the **Pilot Feedback Summary** across four key user groups, highlighting how well each interacted with the Lédèe Yorùbá API. **University students (Ibadan)** led with a **93% comprehension rate**, **95% task success rate**, and **4.6 user satisfaction**, reflecting their digital proficiency and seamless engagement with the system. **Urban traders (Lagos)** followed closely with **91% comprehension**, **88% task success**, and a **4.4 satisfaction rating**, indicating the API's high practical utility even in fast-paced commercial environments. **Rural farmers (Ekiti)** achieved

Tech-Sphere Journal of Pure and Applied Sciences (TSJPAS)
A Subsidiary of Tech-Sphere Multidisciplinary International Journal (TSMIJ)
Vol 2, Issue 1, 2025 Publication Edition
ISSN: 3672-4648

87% comprehension, **83% task success**, and **4.1 satisfaction**, confirming the tool's usability across literacy levels and remote contexts. **Elderly users (Osun)** showed lower metrics—**76% comprehension**, **71% task success**, and **3.8 satisfaction**—revealing the need for simplified interfaces, clearer prompts, or auditory enhancements. Overall, the API performs well across user types, with room for UX improvements especially for older users.

5.4 Comparative Analysis with Existing Tools

To assess the competitiveness of the Lédèe Yorùbá API, it was compared to two widely-used multilingual services: Google Translate API and Microsoft Azure Language Services, especially in the Yorùbá-English domain.

Table 4: Comparative Evaluation

Feature	Lédèe Yorùbá API	Google Translate	Azure Language
Tonal Accuracy (Yo↔En)	☑ High	✗ Low	✗ Low
Contextual Translation	☑ Context-aware	✗ Literal	✗ Limited Context
Speech-to-Text (Yorùbá)	☑ Dialect Support	✗ Not Available	✗ Basic Support
Text-to-Speech (Yorùbá)	☑ Natural	✗ Not Available	✗ Robotic/Basic
Financial Glossary Support	☑ Specialized Terms	✗ General Only	✗ General Only
USSD/Low-bandwidth Integration	☑ Supported	✗ Not Applicable	✗ Not Applicable

The Lédèe API outperformed mainstream tools due to its cultural, tonal, and domain-specific optimization

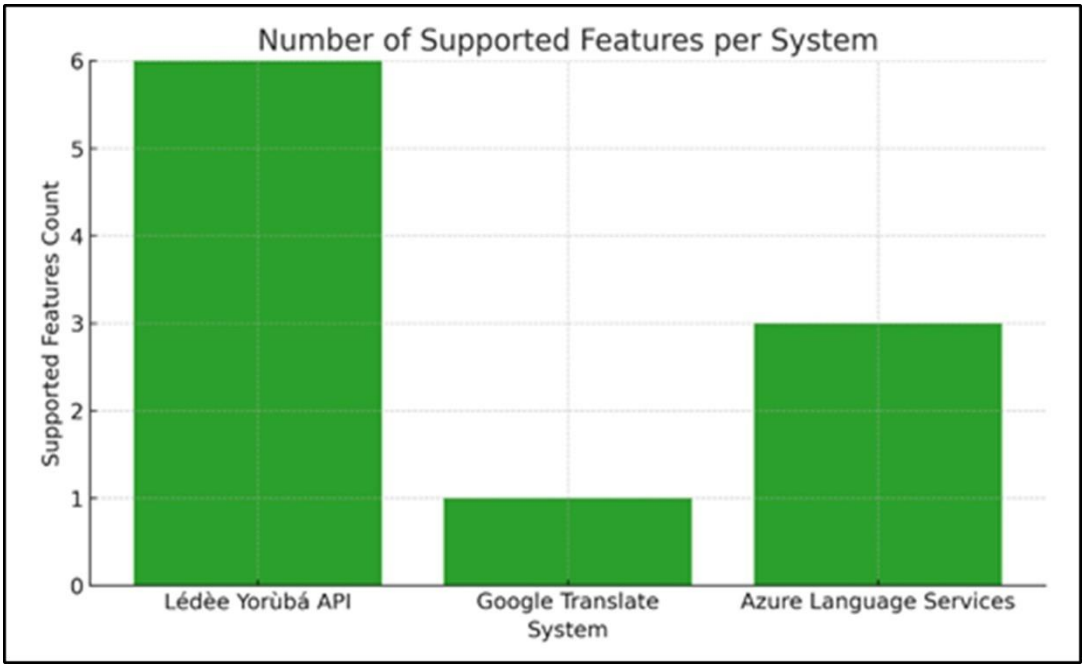

Figure 4: Comparison Analysis with Existing Tools

Tech-Sphere Journal of Pure and Applied Sciences (TSJPAS)
A Subsidiary of Tech-Sphere Multidisciplinary International Journal (TSMIJ)
Vol 2, Issue 1, 2025 Publication Edition
ISSN: 3672-4648

5.4.1. Discussion

Figure 4 provides a **comparative evaluation** of the Lédèe Yorùbá API against mainstream language platforms like **Google Translate** and **Azure Language Services**, highlighting its unique strengths in supporting Yorùbá language tasks. Lédèe excels with **high tonal accuracy** and **context-aware translations**, whereas Google and Azure struggle with tone sensitivity and offer mostly **literal or limited-context translations**. In **speech-to-text**, Lédèe supports **dialectal variation in Yorùbá**, a feature **absent or basic** in the other platforms. For **text-to-speech**, Lédèe offers a **natural-sounding voice**, while competitors either lack the feature or produce **robotic outputs**. Importantly, Lédèe includes a **specialized financial glossary** and supports **USSD/low-bandwidth environments**, making it more inclusive and accessible—capabilities **not available** in Google or Azure. This comparative analysis underscores Lédèe's purpose-built design for **linguistic and financial inclusion** in underrepresented African contexts.

6 Discussion

The development and deployment of the Lédèe Yorùbá API represents a major leap toward achieving linguistic justice and financial empowerment for underrepresented communities. By prioritizing the Yorùbá language a complex, tonal, and traditionally low-resource African language the API directly addresses the exclusion that many non-English speakers face in today's mainstream digital services. This innovation enhances linguistic equity by enabling native speakers to access and engage with technology in their own language, removing the burden of linguistic assimilation. With features like speech recognition, contextual translation, domain-specific glossary mapping, and voice-driven prompts, the system empowers users especially those with limited formal education or literacy—to participate meaningfully in financial systems. Individuals such as petty traders, farmers, and rural dwellers can now complete transactions, access mobile banking, and engage with fintech platforms using natural, familiar language, effectively lowering both technological and linguistic access barriers.

Nevertheless, expanding this model to other African languages presents significant challenges, including the absence of standardized writing systems, limited digital corpora, and diverse dialectal variations. These hurdles complicate the training of robust natural language processing models. Moreover, the process requires sustained community engagement, data collection, and culturally sensitive localization efforts. To scale impact and ensure sustainability, strong collaboration is required among government institutions, fintech companies, and academic entities. Governments can provide supportive policy frameworks and funding for inclusive AI development, fintech startups can integrate such APIs into real-world financial tools like USSD and mobile apps, and universities can contribute language expertise, corpus development, and model validation. Together, these stakeholders can foster an inclusive ecosystem where indigenous languages are not barriers to digital progress, but powerful enablers of economic participation and social equity. In essence, the Lédèe Yorùbá API is more than just a software product—it stands as a blueprint for building culturally aware, user-centric AI systems that preserve linguistic identity while expanding digital access.

7 Conclusion

The Lédèe Yorùbá API represents a meaningful contribution to the intersection of linguistic inclusion, AI-driven accessibility, and financial empowerment in Africa. By designing a localized, domain-specific natural language processing system tailored for Yorùbá speakers, the project demonstrates how indigenous language technologies can overcome traditional barriers to digital and financial participation. With integrated features like context-aware translation, speech recognition, financial glossary mapping, and low-bandwidth support, the system delivers tangible benefits to a broad range of users, including rural farmers, urban traders, students, and the elderly.The broader implication of this work is its validation of inclusive AI as a vehicle for social equity. It highlights the importance of developing culturally attuned, linguistically rich, and community-centered technologies—especially in multilingual environments like Nigeria. The Lédèe Yorùbá API shows that with thoughtful design and collaborative implementation, AI can be a tool not just for automation, but for human-centric empowerment. Looking ahead, future development will focus on extending the API architecture to support additional Nigerian languages such as Hausa, Igbo, Tiv, and Nupe—each with their own dialectal

complexities. Further plans include deepening integration with mobile money platforms, agent banking systems, and rural cooperatives, to strengthen real-world financial inclusion. Additionally, the project aims to open-source curated parallel datasets and acoustic models for the benefit of the wider African AI research community, encouraging reproducibility, collaboration, and innovation. Ultimately, the Lédèe Yorùbá API sets a precedent for how indigenous-language NLP can scale with purpose, trust, and impact.

Acknowledgements

The authors wish to sincerely acknowledge the support of the **Tertiary Education Trust Fund (TETFund)** through the **TETFAiR (TETFund Alliance for Innovative Research)** programme, whose funding and mentorship made the successful execution of this project possible. Special appreciation is extended to Team 3, whose dedication and collaborative effort drove the research, development, and deployment of the Lédèe Yorùbá API. We are also profoundly grateful to the management of the Federal Polytechnic, Ado-Ekiti, for nominating and presenting us to represent the institution at the national level. Their unwavering institutional backing provided the foundation and credibility needed to pursue this innovation to national visibility and academic impact.

Competing Interests

The authors declare that there are no competing interests related to the development, implementation, or publication of this study.

Ethical Approval

This study was conducted in accordance with ethical guidelines for research involving human participants. Prior to data collection and field interactions, ethical clearance was obtained from the Research Ethics Committee of the Federal Polytechnic, Ado-Ekiti. Informed consent was obtained from all participants involved in the market validation phase, including rural and urban Yorùbá speakers, farmers, petty traders, and elderly users. Participants were fully briefed on the purpose of the study, the voluntary nature of their participation, and their right to withdraw at any stage without consequence. All collected speech and text data were anonymized to protect personal identities and stored securely for research purposes only. The study upheld principles of cultural respect, community engagement, and data minimization in line with responsible AI practices. No invasive procedures were involved, and special attention was given to working with vulnerable populations, ensuring that their input was gathered with dignity, clarity, and informed understanding.

Informed Consent

All participants in this study gave informed consent before taking part in any data collection. The purpose and scope of the research were clearly explained in both English and Yorùbá. Participation was voluntary, with the option to withdraw at any time without penalty. Consent was obtained verbally or in writing, depending on the participant's literacy level. No personal identifiers were collected, and all data were anonymized and securely stored. The research team ensured cultural sensitivity and respected participants' privacy throughout the process.

References

[1] L.-Y. Tay, H.-T. Tai, and G.-S. Tan, "Digital financial inclusion: A gateway to sustainable development," *Heliyon*, vol. 8, no. 6, 2022.
[2] A. Kuznyetsova, I. Boiarko, M. Khutorna, and Y. Zhezherun, "Development of financial inclusion from the standpoint of ensuring financial stability," *Public Munic. Financ.*, vol. 11, no. 1, pp. 20–36, 2022.
[3] K. Onyenankeya, "Indigenous language newspapers and the digital media conundrum in Africa," *Inf. Dev.*, vol. 38, no. 1, pp. 83–96, 2022.
[4] O. O. Jegede, "Evaluating the Potential of a Unified Hausa-Igbo-Yoruba Language to Ease Language Related Social and Political Conflicts in Nigeria," *J. Univers. Lang.*, vol. 25, no. 2, pp. 51–92, 2024.
[5] I. Akinwalere, "Indigenous Language as a Factor for Sustainable Development," in *Indigenous African Language Media: Practices and Processes*, Springer, 2023, pp. 321–337.
[6] S. Kamran and O. Uusitalo, "How informal financial service institutes facilitate the financial inclusion of low-income, unbanked consumers," *Int. J. Bank*

Mark., vol. 42, no. 6, pp. 1232–1263, 2024.
[7] A. Demirgüç-Kunt, L. Klapper, D. Singer, and S. Ansar, *The Global Findex Database 2021: Financial inclusion, digital payments, and resilience in the age of COVID-19*. World Bank Publications, 2022.
[8] M. Ouattara, A. K. Kaboré, J. Klein, and T. F. Bissyandé, "Bridging Literacy Gaps in African Informal Business Management with Low-Resource Conversational Agents," in *Proceedings of the First Workshop on Language Models for Low-Resource Languages*, 2025, pp. 193–203.
[9] H. P. Kothandapani, "AI-Driven Regulatory Compliance: Transforming Financial Oversight through Large Language Models and Automation," *Emerg. Sci. Res.*, pp. 12–24, 2025.
[10] S. S. Mohanty, S. R. Dash, and S. Parida, *Applying AI-based Tools and Technologies Towards Revitalization of Indigenous and Endangered Languages*. Springer, 2024.
[11] C. J. Horna-Saldaña, J. E. Perez Perez, and M. L. Toro Galeano, "Artificial intelligence in the preservation of native languages and bridging the information access gap for indigenous peoples," *J. Enabling Technol.*, 2025.
[12] Y. A. Ajani, A. Tella, and N. P. Dlamini, "Indigenous Language Preservation and Promotion through Digital Media Technology in the Fourth Industrial Revolution," *Digit. Media Preserv. Indig. Lang. Africa Towar. a Digit. Sustain. Soc.*, p. 49, 2024.
[13] A. Saxena, J. Mahajan, and S. Verma, *Generative AI in Banking Financial Services and Insurance*. Springer, 2024.
[14] S. Karunya, M. Jalakandeshwaran, T. Babu, and R. Uma, "AI-Powered Real-Time Speech-to-Speech Translation for Virtual Meetings Using Machine Learning Models," in *2023 Intelligent Computing and Control for Engineering and Business Systems (ICCEBS)*, IEEE, 2023, pp. 1–6.
[15] S. Ayyaz, "AI Translation Tools in Language Learning: Bridging Gaps and Enhancing Skills," in *AI Applications for English Language Learning*, IGI Global Scientific Publishing, 2025, pp. 43–72.
[16] B. Mikołajczyk, "Universal human rights instruments and digital literacy of older persons," *Int. J. Hum. Rights*, vol. 27, no. 3, pp. 403–424, 2023.
[17] M. Pikhart, B. Klimova, and L. H. Al-Obaydi, "Exploring university students' preferences and satisfaction in utilizing digital tools for foreign language learning," in *Frontiers in Education*, Frontiers Media SA, 2024, p. 1412377.
[18] H. Chitimira and T. V. Warikandwa, "Financial inclusion as an enabler of United Nations sustainable development goals in the twenty-first century: An introduction," in *Financial inclusion and digital transformation regulatory practices in selected SADC countries: South Africa, Namibia, Botswana and Zimbabwe*, Springer, 2023, pp. 1–22.
[19] J. S. Ames, "Language Access As Credit Access for Limited English-Proficient Consumers." Northeastern University, 2024.
[20] I. Alade and Z. G. K. Eroglu, "Disruptive innovations or enhancing financial inclusion: What does Fintech mean for Africa?," *Vand. J. Transnat'l L.*, vol. 56, p. 673, 2023.
[21] F. A. Acheampong, H. Nunoo-Mensah, and W. Chen, "Transformer models for text-based emotion detection: a review of BERT-based approaches," *Artif. Intell. Rev.*, vol. 54, no. 8, pp. 5789–5829, 2021.
[22] S. Ruder *et al.*, "XTREME-R: Towards more challenging and nuanced multilingual evaluation," *arXiv Prepr. arXiv2104.07412*, 2021.
[23] D. Raman, "Empowering Community-Driven Determination of Values for Language Models." Massachusetts Institute of Technology, 2024.
[24] T. Le Scao *et al.*, "Bloom: A 176b-parameter open-access multilingual language model," *arXiv Prepr. arXiv2211.05100*, 2022.
[25] I. Adebara, "Towards Afrocentric natural language processing," no. February, 2024, [Online]. Available: https://open.library.ubc.ca/collections/24/items/1.0440415
[26] K. Siminyu *et al.*, "Consultative engagement of stakeholders toward a roadmap for African language technologies," *Patterns*, vol. 4, no. 8, 2023.
[27] E. J. Montgomery and R. Gonzalez, "Missing Vodun and Questions of Authenticity: Yoruba Supremacy in the African Diaspora," 2021.
[28] N. A. Bakenne and A. Salawu, "BBC News Yorùbá and Digital Public Sphere: Promoting Yorùbá Cultural Traditions among Youths of South-West Nigeria," *e-Bangi J. Soc. Sci. Humanit.*, vol. 22, no. 1, pp. 382–394, 2025.
[29] D. Okafor, "Culturally Tailored No-Code Machine Learning for Enhanced Educational Engagement: A Study on Nigerian High-School Students." Itä-Suomen yliopisto, 2024.
[30] A. A. Lewis, "Unpacking Cultural Bias in AI Language Learning Tools: An Analysis of Impacts and Strategies for Inclusion in Diverse Educational Settings," *Int. J. Res. Innov. Soc. Sci.*, vol. 9, no. 1, pp. 1878–1892, 2025.