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**INVESTIGATION OF BIODIVERSITY RESOURCE USE IN BIOLOGY
TEACHING AND LEARNING AT LOWER SECONDARY SCHOOLS IN
OYAM DISTRICT**

BY

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Declaration

I, **Akullu Esther** hereby declare that this dissertation entitled "*Investigation of Biodiversity Resource Use in Biology Teaching and Learning at Lower Secondary Schools in Oyam District*" is my original work and has never been submitted to any university or institution for the award of a master's degree.

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Approval

This dissertation has been submitted for the award of a Degree of Master of Education in Science Education with my approval as a university supervisor.

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Dedication

This dissertation is dedicated to my beloved parents Mr Anthony Owani and Mrs Jenty Owani (RIP), whose special guidance, support, love, care and encouragement have been the foundation of all my achievements.

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List of Acronyms

CBD	-	Convention on Biological Diversity
BES	-	Biodiversity Education and Sustainability
NEMA	-	National Environment Management Authority
NGOs	-	Non-Governmental Organizations
SPSS	-	Statistical Package for the Social Sciences
JSTOR	-	Journal Storage
IDS	-	Institute of Development Studies
TBC	-	Textbook Collection
STEM	-	Science, Technology, Engineering, and Mathematics
UNESCO	-	United Nations Educational, Scientific and Cultural Organization
UGX	-	Uganda Shillings
ICT	-	Information and Communication Technology
SBS	-	School-Based Survey
UNEP	-	United Nations Environment Programme
NEPC	-	National Environmental Protection Council
UNDP	-	United Nations Development Programme
UNADAN	-	Uganda's National Agricultural Development Assistance Network
PBL	-	Problem-Based Learning
FAO	-	Food and Agriculture Organization

AEB	-	African Education Bureau
PCK	-	Pedagogical Content Knowledge.
CBC	-	Competence Based Curriculum.
UNEB	-	Uganda National Examinations Board
UNCDC	-	Uganda National Curriculum Development Centre
BD	-	Biodiversity
NDP1V	-	National Development Plan Four.
SDGS	-	Sustainable Development Goals

Abstract

Biodiversity resources are essential for contextual, hands-on, and competency-based biology education, especially in rural settings. However, their effective utilization remains under examined in Ugandan schools. This study investigated the use of biodiversity resources in biology teaching and learning at lower secondary schools in Oyam District, Uganda. Specifically, it aimed to identify the types of biodiversity resources used, evaluate students' perceptions of their impact on understanding and confidence in biology, and explore the challenges faced by teachers and learners in utilizing these resources. A descriptive cross-sectional survey design was employed, combining quantitative and qualitative approaches. A total of 143 participants—including biology teachers, head teachers, and Senior Four students were selected using purposive, and simple random, sampling across 11 secondary schools. Data was collected using questionnaires and interviews, analyzed using SPSS (version 22), and subjected to descriptive statistics, correlation analysis, and multivariate logistic regression. Thematic analysis was applied to qualitative data. Findings revealed that 95% of teachers used tangible biodiversity resources such as preserved specimens, water samples, and local animals, while only 42% reported using digital tools. Students reported improved conceptual understanding (99%), critical thinking (83%), and confidence (90%) through biodiversity-based instruction and fieldwork. However, challenges included limited ICT access, curriculum rigidity, large class sizes, inadequate teacher training, and minimal community engagement. The study concludes that while biodiversity resources significantly enhance biology learning outcomes, their potential is constrained by systemic and logistical barriers. Strengthening teacher capacity, promoting community involvement, and investing in low-cost innovations and ICT infrastructure are essential. Education stakeholders should integrate biodiversity into national curriculum frameworks and support its implementation through coordinated policy and resource allocation.

Key words: *Biodiversity Resource, Biology Teaching and Learning, Lower Secondary Schools, Oyam District*

CHAPTER ONE

BACKGROUND

1.0 Introduction

This chapter focused on the background of the study, mainly; historical perspectives, theoretical perspective, conceptual framework, contextual perspectives, problem statement, study objectives, hypothesis, significance of the study, study justification, and the study's scope.

This study investigated the integration of biodiversity resources in biology teaching and learning at lower secondary schools in Oyam District, Uganda. Biology is one of the most important science subjects learnt in most education sector worldwide (Srinivasacharl, 2019) since it lays foundation for many career pathways. The rationale for this inquiry, therefore stemmed from the increasing recognition of biodiversity resources as a pedagogical asset capable of enriching biology instruction and enhancing learner outcomes (Siu, 2020). The use of biodiversity resources could lead to improvement in performance in biology at national examination as well as improving student's attitude towards biodiversity conservation.

Biodiversity is defined as the variability among living organisms within species, between species and of ecosystems (Convention on Biological Diversity, 1992). This definition was adopted by the United Nations Convention on Biological Diversity (CBD), which was signed by 150 governments at the 1992 Rio Earth Summit and was dedicated to promoting sustainable development. The Convention recognized that "biological diversity" is just more than plants, animals, micro-organisms and their ecosystems – it is about people and their need for food security, medicines, fresh air, water and shelter, a clean and healthy environment in which we live" (Ulbrich, *et al.*, 2010)

Biodiversity resources plays a crucial role in enhancing the teaching and learning of biology by providing practical, real-world experiences for students. The use of living organisms, ecological interactions, and natural habitats in secondary school biology education helps to improve students' understanding of key biological concepts (Field Studies Council, 2020) FSC. However, despite the rich biodiversity in Uganda, there is limited integration of biodiversity resources into classroom instruction, and limited exposure to field studies, particularly in rural districts such as Oyam. According to the United Nations Educational, Scientific and Cultural Organization

(UNESCO, 2016), Global Education monitoring report there was need to transform our world, the 2030 Agenda for sustainable development. In the same way, Sustainable Development Goal 15 (SDG15), states that education and training increases skills and capacity to underpin sustainable livelihood and to conserve natural resources and biodiversity particularly in threatened environment. These are key global issues identified by development partners to integrate biodiversity in our educational curriculum.

Biology is a practical subject that requires students to interact with the environment and living organisms to understand key concepts such as classification, adaptations, ecosystems, and conservation. According to (FSC, 2020& UNESCO, 2021), incorporating biodiversity resources into teaching helps students develop critical thinking and problem-solving skills, fostering a deeper understanding of ecological relationships. Despite the presence of diverse flora and fauna in Uganda, secondary schools in rural areas, Oyam district inclusive, performance in biology in national examinations remains poor (UNEB, 2024). It was not clear whether inadequate use of biodiversity resources in teaching and learning contributed to the poor performance in the biology subject.

This study therefore, investigated the types of biodiversity resources utilized in biology teaching and learning in secondary schools in Oyam District. The study also assessed student's perceptions of how the use of biodiversity resources impacts their understanding and confidence in biology, and identified challenges affecting the use of biodiversity resources. This research aimed to contribute to the enhancement of biology education through biodiversity-based learning approaches.

1.1.1 Historical Perspective

This section focuses on historical perspectives, especially on the use of biodiversity resources in biology teaching and learning. This involves direct use of plants, animals, and microorganisms. The use of biodiversity in education dates back to early civilizations, where nature served as the primary source of learning. Ancient Greek scholars such as Aristotle and Theophrastus studied plants and animals to understand biological concepts (Glick, 2010). During the Renaissance, naturalists like Carl Linnaeus developed classification systems that are still used today in modern biology education (Mayr, 1982). The term 'biodiversity' is not new, rather has a long history, but 'biological diversity' came into use in scientific literature only in the 1980s. The term was first

coined by Lovejoy who however did not provide any formal definition to it, but considered it as only the number of species (Lovejoy, 1980). Rosen (1985) used the term 'biodiversity' in the first planning conference on the 'National Forum on Biodiversity', Washington D.C., 1986.

Wilson (1988) edited the proceedings of the conference titled Biodiversity and this popularized the concept. The Convention on Biological Diversity in June 1992 constituted a historical commitment by many nations of the world. For the first time, biodiversity was comprehensively addressed in this global treaty. At the same time the genetic diversity was considered and conservation of biodiversity was accepted as the common concern for the cause of human welfare (Gaston, 1998). Research into biodiversity resources use in secondary schools in Hong Kong dates back to 1960s and it contends that use of biodiversity resources in teaching and learning biology improves performance and attitudes towards conservation among students (Siu, 2020). In the 19th and 20th centuries, hands-on learning gained prominence with the advent of field studies and laboratory-based instruction. Studies done in Germany found out that it was imperative to expose students to the use of living organisms to promote intrinsic motivation to learn biology (Moritz & Jones, 2022). Research has demonstrated that practical, hands-on learning enhances knowledge retention and student engagement in science subjects. In developed countries, schools have access to well-equipped laboratories, botanical gardens, and natural reserves that support experiential learning. Studies in UK by Field Studies Council (FSC, 2004) emphasized the need for field work to expose learners to the living world. However, in many developing countries, including Uganda, theoretical teaching methods have dominated due to resource limitations (UNESCO, 2021). Studies in Tanzania indicated that biodiversity concept was less captured in the biology syllabus and biology was taught theoretically (Kumar, 2017)

Empirical evidence supports the integration of biodiversity education in schools. A study involving 180 secondary school students in Tanzania demonstrated that biodiversity education program significantly improved students' knowledge and attitudes towards ecosystem services and biodiversity conservation (Hagen *et al.*, 2022).

In developing countries, limited access to biodiversity resources has limited the effective utilization of biodiversity resources in classrooms. Teachers in rural districts often face logistical challenges, making it difficult to conduct field-based activities that expose students to real-world biological phenomena.

In Uganda, the National Curriculum Development Centre (NCDC 2020) encourages practical learning approaches, emphasizing that science education should not be limited to textbook-based instruction. The Ugandan education policy recommends outdoor learning experiences, yet many schools lack the necessary infrastructure, such as school gardens, aquariums, and laboratory resources, to support such initiatives. Additionally, studies suggest that teachers' attitudes towards biodiversity-based learning influence their willingness to incorporate such methods into their teaching strategies (Ministry of Education and Sports, 2020).

1.1.2 Theoretical Perspective

This study was guided by Pedagogical Content Knowledge (PCK) theory, developed by Lee Shulman in 1986. Lee introduced the idea of PCK to highlight that effective teaching requires more than just knowing the subject that is content knowledge or knowing how to teach, that is pedagogical knowledge but it is about the intersection of the two that makes teaching effective (Lee, 1986).

This theory informed this study that PCK concept offers valuable insights for examining the integration of biodiversity resources in biology teaching and learning. The PCK emphasizes the fusion of subject matter expertise with the pedagogical strategies designed to suit student's needs and learning environment (Auerbach, & Andrews, 2018). The PCK theory emphasizes that teachers should possess a deep understanding of biodiversity concepts, encompassing genetic diversity, species diversity, ecosystem diversity and ecological relationships.

Pedagogical content knowledge theory suggests that effective teaching strategies includes: inquiry-based learning, field studies, and experiential activities like hands-on use of local plants, animals, micro-organisms and ecosystems resources that connect students with natural environment.

1.1.3 Conceptual Perspective

This study focused on understanding the role and significance of biodiversity resources (living organisms and natural environments) in biology education at the lower secondary school level, in Oyam district. **Biodiversity** is the variety of life on Earth. It includes all the different kinds of plants, animals, fungi, and microorganisms, as well as the genetic differences within these species and the ecosystems they create (Verma, 2016). Biodiversity is essential because it helps

keep nature balanced, provides resources and services that support life, and helps us understand the interconnectedness of all living things. In education, utilizing biodiversity as a teaching tool helps students understand the complexity and interconnectedness of life on Earth (Amalia, 2024).

A **biodiversity resource** is any natural living thing or component from the environment that can be used for educational, scientific, or practical purposes (Gadgil, 2000) . This includes plants, animals, fungi, microorganisms, as well as ecosystems, genetic materials, and biological samples. These resources are important tools in teaching biology because they allow students to have hands-on experiences, observe real-life organisms, and develop a deeper understanding and appreciation of nature.

Biodiversity resource use refers to how these natural resources are accessed, used, and managed. In schools, this might involve collecting specimens for study, observing animals and plants in their natural habitats, or using biological materials for experiments and demonstrations (Arevalo & Reyes, 2025). It's important to use these resources responsibly, conserving them and ensuring they are available for future learning and environmental health. This responsible use supports both education and the sustainability of ecosystems.

Biology Education involves the teaching and learning processes aimed at imparting knowledge about living organisms and their environments (D'Avanzo, 2008). At the lower secondary school level, biology education is designed to introduce students to fundamental biological principles, including the structure and functions of organisms, ecosystems, and the importance of conserving biodiversity. Effective biology education relies on engaging instructional methods that utilize available resources, including biodiversity resources, to foster curiosity, understanding, and a sense of environmental stewardship among learners.

In Uganda, **lower secondary schools** cater to students aged 13 to 16, covering four years of study (Senior 1 to 4). During this stage, students learn through a curriculum that emphasizes practical and skills-based learning (known as the Competency-Based Curriculum, launched in 2020). These schools are crucial because they introduce students to core science concepts, including biology. The quality of biology teaching in these schools greatly influences students' interest in science, their understanding of environmental issues, and their potential careers in science and conservation.

This study conceptualizes biodiversity resources as essential educational tools that, when effectively incorporated into biology teaching, can significantly improve learning outcomes at the lower secondary school level.

1.1.4 Contextual Perspective

In Uganda, biodiversity education is included in the lower secondary school biology curriculum, but its implementation varies across schools (NCDC, 2020). Urban schools have access to better facilities such as laboratories and botanical gardens, whereas rural schools, including those in Oyam District, often struggle with inadequate resources. According to the Ministry of Education and Sports (2020), only 35% of secondary schools in rural Uganda have functional laboratories and access to biodiversity-related teaching aids. Limited exposure of young students to biodiversity resources in real world cripples their knowledge and interest about importance of using biodiversity resources in understanding biological concepts. This leads to reduced interest, theoretical teaching and poor performance in the subject (UNEB, 2024 & FSC, 2020). This research investigated how teachers in Oyam District navigate these challenges and identified ways to improve biodiversity-based learning in resource-limited settings. This study involved all the eleven secondary schools in Oyam District (9 government aided schools and 2 private schools). Student respondents were senior four candidates who have covered much of lower competence-based curriculum.

1.2 Problem Statement

Globally, biodiversity resources are recognized as vital tools for enriching biology education by providing tangible, real-world experiences that help students better understand biological concepts, promote environmental awareness, and foster conservation (Siu, 2020; Krell & Schmidt, 2022). Incorporating local biodiversity into biology teaching—through specimens, field trips, and direct engagement with biological diversity—enhances experiential learning, improves student engagement and performance, and aligns with competency-based curricula designed to develop practical scientific skills. Utilizing these authentic biological resources makes learning more relevant, facilitates hands-on understanding, and encourages appreciation of nature.

In Uganda, however, biology instruction predominantly relies on theoretical content, with limited integration of practical, biodiversity-based experiences. This overemphasis on instructional materials without sufficient utilization of real biological diversity may contribute to the persistent

poor performance in biology at the lower secondary school level (Harriet & Kibedi, 2025; NCDC, 2020). Notably, Oyam District recorded poor results in biology during the 2024 CBC examinations (UNEB, 2024), highlighting a significant challenge in science education within the region.

Poor performance in biology hampers progress toward achieving Sustainable Development Goal (SDG) 4, which emphasizes quality education, and undermines Uganda's national educational goals outlined in the National Development Plan IV (NDPIV). These goals prioritize enhancing scientific literacy, fostering innovation, and promoting environmental stewardship among learners to support national development.

Despite the recognized importance of integrating biodiversity resources into biology education, there is limited information on how these resources—such as specimens and field experiences—are utilized at the lower secondary level in Uganda, particularly in Oyam District. This study aimed to investigate the extent to which biodiversity resources are incorporated into biology teaching, to identify pedagogical challenges faced by educators, and to propose strategies for more effective utilization of these resources, with the ultimate goal of improving student learning outcomes and science performance.

1.3 Purpose of the Study

The main purpose of this study was to investigate the use of biodiversity resources in biology teaching and learning in Oyam District, focusing on their types, students' perceptions and challenges affecting their integration.

1.3.1 Specific Objectives

- i. To identify the types of biodiversity resources used in biology teaching and learning in lower secondary schools within Oyam District.
- ii. To assess students' perceptions of how biodiversity resources, impact their understanding of biology concepts and confidence in learning.
- iii. To explore the challenges faced by teachers and students in the use of biodiversity resources in biology education.

1.4 Research questions

1. What are the types of biodiversity resources used in biology teaching and learning in lower secondary schools in Oyam District?
2. How do students perceive the impact of biodiversity resources on their understanding and confidence in biology?
3. What challenges do teachers and students face in using biodiversity resources in biology education?

1.5 Conceptual Framework

The Conceptual Model for Investigating the Integration and Impact of Biodiversity resources' use in Biology Teaching and Learning in Secondary Schools was adapted from the theory of Pedagogical Content Knowledge by Lee Shulman. This theory states that effective teaching requires teachers to possess deep knowledge of both content and pedagogical skills (Lee, 1986). Guided by this perspective, the study examined how biodiversity resources are incorporated into biology teaching and their impact on student learning in secondary schools. The independent variables include the extent of biodiversity integration into instructional materials, the teaching strategies employed, such as hands-on activities and inquiry-based methods, and the level of teacher training and content knowledge. These factors influence student outcomes, which encompass understanding of biological concepts, engagement and interest, and the practical application of local biodiversity in learning. Extraneous variables, such as teacher competence, qualification, experience, class size, and school environment, were controlled to isolate the effects of biodiversity resource use. The framework (Fig. 1) highlights that effective use of biodiversity resources, supported by teachers' pedagogical and content knowledge, enhances student learning in biology.

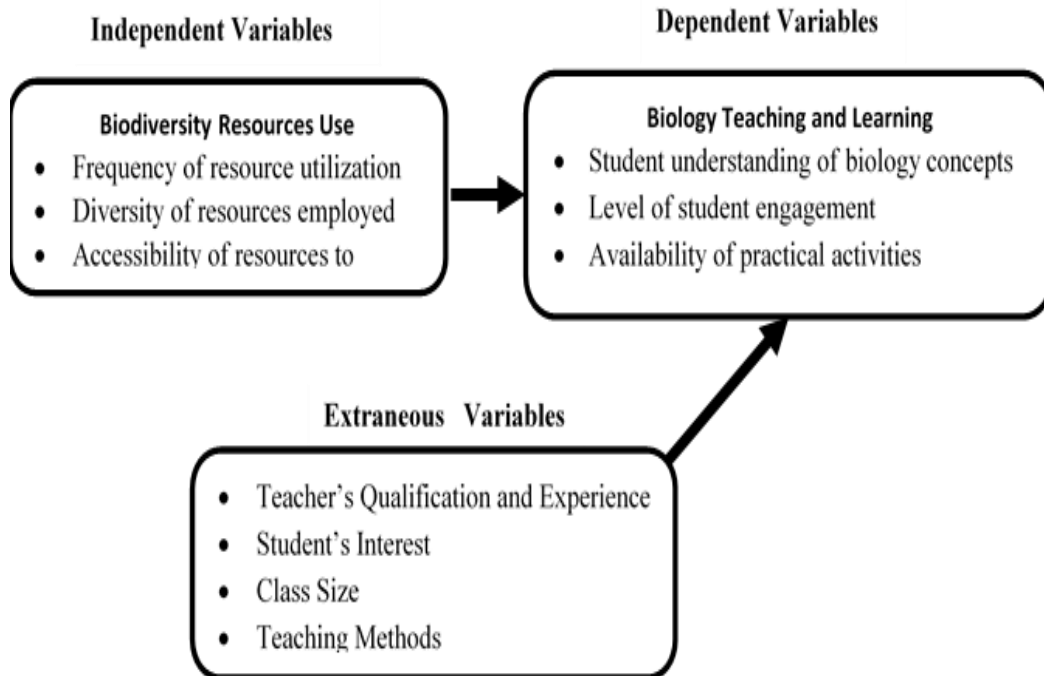


Figure 1: Conceptual Framework

Source: Adapted from Lee (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, as modified by the researcher

1.6 Justification of the Study

Integrating biodiversity resources in biology teaching and learning is essential for fostering environmental awareness and promoting conservation efforts among students. Research indicates that educational programs can significantly enhance students' understanding of ecosystem services and biodiversity, leading to more positive attitudes towards conservation (Hagen *et al.*, 2022). Moreover, biodiversity plays a crucial role in maintaining a balanced ecosystem which directly impact human health by regulating disease spread (WHO, 2023). Therefore, integrating use of biodiversity resources into the curriculum is vital for understanding biological concepts & equipping students with the knowledge necessary to address environmental challenges. Additionally, research has shown that biodiversity education can enhance students' environmental concerns and sustainability (Schild, 2016). These findings underscore the effectiveness of biodiversity education in fostering environmental stewardship among students.

1.7 Significance of the Study

This study provides insights into the current use of biodiversity resources in biology teaching and learning at lower secondary schools in Oyam District. Understanding how these resources are incorporated into the curriculum can help identify strengths and gaps in instructional practices. The findings may guide educators in adopting more effective teaching methods that use local biodiversity, thereby improving students' comprehension of biological concepts. The study will inform school administrators and policymakers on how to better support biology education through the appropriate use of biodiversity resources, to enhance the quality of science education in the district.

1.8 Scope of the Study

This study focused on investigating the integration of biodiversity resources in biology teaching and learning in secondary schools in Oyam District. It examined how biodiversity concepts are incorporated into instructional materials, teaching practices, and their impact on students' learning outcomes. The study was conducted in all the 11 secondary schools within the district and targeted biology teachers, senior four students and school administrators as key respondents. This study involved 143 sample respondents from the eleven secondary schools in Oyam District.

1.8.1 Content Scope

The study covered the following key areas:

- The extent to which biodiversity resources are integrated into biology instructional materials.
- The methods and strategies used by biology teachers to incorporate biodiversity resources in their lessons.
- The assessment of students' perceptions of learning biology through the use of biodiversity resources.

1.8.2 Geographical Scope

The study was conducted in Oyam District, Uganda, and focused on Lower Secondary Schools. Oyam District was chosen due to its diverse ecological environment, like Murchison falls national park which provides a rich context for studying biodiversity resources use in teaching and learning biology.

1.8.3 Time Scope

The study covered a period from 2020 to 2024, focusing on recent trends and practices in biodiversity education over the last five years. This timeframe ensures that the findings reflect the current state of biodiversity resources integration into Lower secondary school competence-based biology curriculum.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter presents a review of existing literature relevant to the study on integrating biodiversity resources in biology teaching and learning in secondary schools in Oyam District. The chapter also examined previous studies on biodiversity education, its impact on students' learning outcomes, and best practices in integrating biodiversity resources into the curriculum.

2.1 Theoretical Framework: Pedagogical Content Knowledge (PCK)

This study was guided by Pedagogical Content Knowledge (PCK) theory, developed by Lee (1986). Lee (1986) introduced the idea of PCK to highlight that effective teaching requires more than just knowing the subject that is content knowledge or knowing how to teach, that is pedagogical knowledge but it is about the intersection of the two that makes teaching effective. This theory is relevant to this study in that PCK concept offers valuable insights for examining the integration of biodiversity resources in biology teaching and learning. The PCK emphasizes the fusion of subject matter expertise with the pedagogical strategies designed to suit student's needs and learning environment (Auerbach, & Andrews, 2018)

The PCK theory emphasizes that teachers should possess a deep understanding of biodiversity concepts, encompassing genetic diversity, species diversity, ecosystem diversity and ecological relationships. Pedagogical Content knowledge theory suggests that effective teaching strategies includes: inquiry-based learning, field studies, and experiential activities like hands-on use of local plants, animals, micro-organisms and ecosystems resources that connect students with natural environment

Lee (1987) also argues that teaching requires the teacher to be equipped with both content knowledge (CK) and pedagogical content. Studies into science teaching shows that when teachers possess subject CK expertise and the ability to represent this to their pupils using sound Pedagogical Knowledge, they engross in class activities that enable learning to occur, for example, being able to proficiently lead free-ranging class discussions of content (Garnett & Tobin, 1988; Roth *et al.*, 1987; Tobin & Fraser, 1990). Such teachers have ample awareness of

common alternative conceptions and scientific models that provide rich opportunities for their learners (Kaifa, 2023)

2.2 The Concept and Educational importance of Biodiversity

The Biological Diversity education and awareness campaign embraces the diversity of species, ecosystems, and genetic variation across the global environment. Biodiversity is therefore a dynamic and vital component of life on Earth, influencing ecosystem functions, human survival, and the resilience of the planet. The earth where biological lives of animals and plants are sustained is covered by 70 % of water bodies and related aquatic life and the other 30 % is composed of land with terrestrial lives of diverse landforms. Diverse landforms have fostered an even greater diversity of ecosystems and survival.

However, because of the need for human survival on the planet earth, humankind has altered and obstructed the normal ecosystems, creating a variety of environmental and social diversity ranging from natural, nearly undisturbed ecosystems to ecosystems highly affected by humans. Today many people live in unnatural and constructed urban and city centers, but they subconsciously seek to co-exist with the rest of life and this deep affiliation with nature might be rooted in our biology (Wilson 1993) as in Ulbrich, *et al.*, (2010).

Biology is one of the most important science subjects learnt in most education systems. As a subject Biology enhances resourcefulness, productivity and provides many career opportunities at different institutions (Srinivasachari, 2019). It's therefore imperative that students should have interest in learning the subject through hands-on activities.

Biodiversity, the variety and variability of life on Earth, is one of the most crucial concepts in the field of biology. As a tool in teaching and learning biology, biodiversity serves as a powerful bridge connecting theory with real-world applications. It offers a holistic understanding of life and its processes, helping students to appreciate the complexities of life forms and the importance of safeguarding the ecosystem. Education in biodiversity conservation programs can improve knowledge, skills, and lead to critical thinking, although knowledge per se does not necessarily lead to changes to more environmentally conscious behavior (Jensen 2002; Urban & Martin 2015).

2.3 Integration of Biodiversity in Biology Instructional Materials

The study examined the biology curriculum used in lower secondary schools within Oyam District. This involved reviewing Curriculum documents like syllabi, teachers' guides, and subject-specific textbooks, to assess the explicit inclusion of biodiversity resources. Previous studies have shown that the incorporation of biodiversity into national curricula often varies, with some curricula emphasizing it more than others (Mogaka & Ochieng, 2016). The inclusion of biodiversity in national and regional curricula has been found to be critical for fostering students' understanding of environmental science (Barrett, 2019).

Any recommendations or guidelines provided for teachers to integrate biodiversity resources into their lessons, as outlined by curriculum developers (Ochieng & Nyamwange, 2020), would involve analysis of the biology textbooks and other instructional materials used by biology teachers in secondary schools.

A content analysis of the biology textbooks to evaluate how biodiversity is presented was done and focused on specific topics related to ecosystems, conservation, and species diversity. Studies have shown that textbooks are a primary resource for delivering biodiversity content in schools (Iro, 2021). The inclusion of visual aids such as diagrams, charts, and images to represent biodiversity resources, as visual content, is often effective in helping students grasp complex concepts (Greenwood & Steed, 2017). The clarity of language and terminology used to describe biodiversity is important for ensuring accessibility for secondary school students (Olson *et al.*, 2018).

Teachers' perceptions and teaching practices were explored by administering structured questionnaires to biology teachers to understand how they view the integration of biodiversity resources into their teaching. Research indicates that teachers' attitudes toward environmental education significantly influence how topics like biodiversity are taught (Adedayo & Ladan, 2020). Teachers can incorporate biodiversity resources into their teaching methods, like discussions, practical activities, and projects. Studies show that active teaching strategies like field-based learning enhance students' understanding of biodiversity and biology concepts (Lee & Greene, 2019). The use of multimedia and internet resources has been shown to increase engagement and comprehension of environmental topics (Nguyen *et al.*, 2020).

Classroom observations were conducted in the schools in order to have direct assessment of how biodiversity content was delivered and biodiversity resources utilized. Observing lessons on biodiversity resources use helps to assess how much emphasis is placed on biodiversity topics. According to Huber (2017), active lesson plans that incorporate biodiversity resources in real-world contexts engage students more effectively. The teaching methods used to deliver biodiversity content, such as hands-on activities, group discussions, or multimedia presentations (Eisner, 2021) improves understanding of biological concepts.

The study also assessed how students engage with biodiversity content and resources through structured questionnaires to determine students' understanding of biodiversity concepts, as their knowledge is directly related to the extent and quality of biodiversity content presented (Harrison & Kivunja, 2018). Performance assessment included analysing students' projects, active participation during lessons, and their stories about how they use biodiversity resources in their learning activities. Studies have shown that assessment outcomes provide an accurate reflection of how well students understand biodiversity topics (Snyder & Lee, 2017).

The study compared the extent of biodiversity incorporation in biology instructional materials across different secondary schools in Oyam District, and examined resource availability like textbooks, online resources, teaching aids, presence of botanical gardens and aquariums. Studies indicate that it's important to know the quality of instructional materials available for teaching biology using biodiversity resources among schools with different levels of resource availability (Sharma & Singh, 2018).

2.4 Teaching Strategies and Methods for Incorporating Biodiversity Resources

This section investigated the methods biology teachers use to present biology concepts in a structured and efficient manner. It covers the use of explanations, definitions, and classifications to help students grasp the importance of biodiversity in ecological balance (Mogaka & Ochieng, 2016). The application of discussion-based methods, where teachers encourage students' participation by prompting discussions on environmental issues related to biodiversity resources use and conservation strategies is very important.

Student-centered method focuses on actively engaging students in their learning, allowing them to construct knowledge collaboratively rather than simply absorbing knowledge given by the

teacher (Capuc, 2024). This section explored how Competence Based Curriculum adopts a learner-centered pedagogy, formative and authentic assessment approaches that emphasizes on the development of competencies and application of knowledge in real life context (Sifuna & Obonyo, 2019). It also assessed group work and peer learning activities where students collaborate to research and present topics related to biodiversity, encouraging deeper understanding of biological concepts through group interactions.

The use of project-based learning (PBL), where students work on hands-on projects, such as researching on local species or investigating biodiversity resources in nearby ecosystems. This method has been shown to enhance engagement and retention of biodiversity concepts (Harrison & Kivunja, 2018). Inquiry-based learning, where students are encouraged to ask questions and investigate biodiversity-related issues through experiments, data collection, and analysis should be emphasized together with Practical activities and field trips which are essential components of teaching biology using biodiversity resources.

Field trips to local ecosystems, nature reserves, or botanical gardens, where students observe biodiversity first hand, makes learning experiences more tangible (Lee & Greene, 2019). This study discovered that practical experiments, such as studying soil samples, observing local species in their natural habitats, or conducting biodiversity surveys within the school environment improves students' understanding of biological concepts. Outdoor learning activities, where students interact with the environment, fostering a connection with biodiversity while applying classroom knowledge to real-world scenarios, was reported by learners to be very effective in making them understand biological concepts.

The use of videos, documentaries, and animations that visually illustrate complex biodiversity concepts, making them more accessible to students, was noted to be very important in promoting active learning (Nguyen *et al.*, 2020). Interactive apps and websites that provide virtual tours of ecosystems, showcase endangered species, or demonstrate ecological processes, enhance students' understanding and engagement. The use of multimedia presentations such as PowerPoint slides or interactive whiteboards enhances lessons with visual and auditory elements, helping students to better understand biodiversity topics (Greenwood & Steed, 2017). However, this study noted that most secondary schools in Oyam District have limited access to these digital

tools. This hinders effective learning and could be one of the causes of poor performance in the biology subject in Oyam secondary schools.

Given that students have varying levels of understanding and learning styles, differentiated teaching methods may be employed. Differentiated instruction, where teachers tailor lessons to meet the diverse needs of students, ensures that all students, regardless of their background or abilities, can grasp biological concepts using biodiversity resources. This can be achieved through adaptation of materials, using simple language for beginners while incorporating more complex scientific terms and concepts for advanced students (Olson *et al.*, 2018).

The study investigated whether biology teachers in Oyam District have access to training or professional development opportunities focused on integrating biodiversity resources into teaching. This includes; workshops, seminars, and conferences focused on biodiversity education, where teachers can learn new strategies, resources, methodologies and collaborations with environmental organizations, where teachers are introduced to external experts and resources that enhance their ability to teach biology concepts effectively.

Variety and effectiveness of methods used to teach biological concepts such as field-based learning, group work, multimedia, and the frequency of practical activities and field trips incorporated into the teaching of biology was used to evaluate the teaching strategies employed by biology teachers in Oyam District.

2.5 Effects of Biodiversity Resources Use on Student Learning Outcomes

The study assessed how the integration of biodiversity resources in biology education influences students' academic performance in biology, specifically focusing on topics related to ecology. The study also explored how teachers assess students' understanding of biological concepts using biodiversity resources. Formative assessments, such as quizzes, class participation, and discussions, used throughout the teaching process to monitor student understanding of biology concepts. Previous research has shown that targeted environmental education can significantly enhance students' academic performance (Snyder & Lee, 2017). The study examined whether students who receive more comprehensive biodiversity education perform better in projects covering topics like ecosystems, species diversity, and conservation (Adedayo & Ladan, 2020).

Class participation and engagement, involving evaluating students' active participation in biodiversity - related lessons, group discussions, assignments, and projects was also examined. Active engagement has been linked to improved academic performance in environmental education (Huber, 2017). The study investigated how well students understand key ecological concepts related to biodiversity, such as ecosystems, species interactions, and conservation. Knowledge retention is determined through measuring how well students can recall and apply biodiversity-related concepts learned in class, including understanding the relationships between species, their environments, and the importance of biodiversity conservation (Barrett, 2019).

Assessing students' ability to apply theoretical knowledge of biodiversity in real-life scenarios, such as designing conservation projects or analysing local biodiversity (Olson *et al.*, 2018) is key in the implementation of biology competence based curriculum. There is also need to identify any common misconceptions about biodiversity and ecology that students may have and determining how effectively these can be addressed through biodiversity education.

Student attitudes about the use of biodiversity resources in learning biological concepts was determined by administering structured questionnaires. Positive attitudes towards biodiversity have been shown to correlate with better understanding and academic performance (Harrison & Kivunja, 2018). Assessing students' intrinsic and extrinsic motivation to learn about biodiversity and its implications for the environment is also important. Studies indicate that motivated students tend to perform better academically (Greenwood & Steed, 2017). The study explored whether biodiversity education sparks an interest in further studies in environmental sciences, ecology, or related fields.

Use of multimedia and interactive resources may improve students' understanding of biological concepts. Evaluating how the use of videos, animations, and interactive online resources influences students' understanding of biodiversity is key (Nguyen *et al.*, 2020). Investigating the role of hands-on learning through field trips, laboratory experiments, and outdoor activities in enhancing students' understanding of biodiversity and ecological concepts is equally important (Lee & Greene, 2019).

The study assessed the impact of teacher expertise and the support provided to students in learning biodiversity concepts. Teachers who are well-trained in biodiversity education have

been found to significantly improve students' understanding (Mogaka & Ochieng, 2016). Comparing schools that have access to a wide range of teaching materials, including textbooks, multimedia resources, and field trip opportunities, against those that have limited resources is important (Snyder & Lee, 2017). Studies show that it's important to analyse how professional development in biodiversity education impacts teaching effectiveness and, in turn, students' academic performance (Sharma & Singh, 2018).

In the same vein analysing how biodiversity resources are integrated into biology curriculum is important. Comparing schools that fully integrate biodiversity education into the curriculum versus those that cover it in limited detail is key (Ochieng & Nyamwange, 2020). Beyond immediate academic performance, the study also explored the impact of biodiversity education on students' environmental awareness and behaviour, measuring whether biodiversity education fosters a sense of responsibility and activism towards environmental protection and sustainability (Huber, 2017).

2.6 Challenges and Support for Integrating Biodiversity Resources

Biology teachers may not have received adequate training on teaching biodiversity and its resources use or may lack comprehensive knowledge of the subject. This affects their ability to effectively communicate complex ecological concepts to students (Olson *et al.*, 2018). Limited access to teaching resources was reported, in many secondary schools in Oyam District. This study noted that there is limited teaching materials, such as textbooks, multimedia resources, and visual aids, which incorporate biodiversity topics. The absence of such resources makes it difficult for teachers to explain biodiversity-related concepts effectively (Nguyen *et al.*, 2020).

Curriculum constraints, the biology curriculum may be overcrowded with topics, leading to limited time allocated for teaching biodiversity -related topics in-depth. Teachers often find themselves focusing on examination-oriented content, leaving little room to emphasize environmental and biodiversity education (Iro, 2021).

Limited Field-Based Learning Opportunities, teaching biodiversity effectively often requires hands-on field-based experiences to observe ecosystems in real life. However, most of the teachers interviewed during this study reported that they face challenges such as lack of funding,

transportation, and support for organizing field trips to natural areas where students can experience biodiversity resources first-hand (Lee & Greene, 2019).

Student Engagement and Motivation: Some students may not recognize the relevance of biodiversity to their daily lives, leading to low engagement and interest in the subject. Teachers struggle to make the topic appealing, especially when students perceive it as abstract or irrelevant to their immediate concerns (Harrison & Kivunja, 2018).

Resource Constraints, even if teachers are committed to integrating biodiversity resources into their lessons, they often face limitations in terms of classroom resources, such as audiovisual equipment or biodiversity-related tools (Greenwood & Steed, 2017). These constraints can limit the teacher's ability to use engaging, effective methods like hands-on activities, interactive multimedia or virtual laboratory.

Teacher Training and Professional Development, continuous professional development programs are needed to equip teachers with the knowledge and skills to teach biodiversity effectively. This includes both theoretical understanding and practical teaching strategies for integrating biodiversity resources into the curriculum (Sharma & Singh, 2018). However, this study noted that teachers in Oyam District have limited access to continuous professional development. The researcher therefore, suggests that all the stake holders should design mitigation measures to fully integrate biodiversity resources' use into biology teaching and learning.

Curricular Reforms and Flexible Schedules: A more flexible curriculum structure that prioritizes environmental and biodiversity education can give teachers the opportunity to dedicate more time to the subject. Curriculum reforms should be designed to ensure that biodiversity is adequately represented as a key area in biology education (Ochieng & Nyamwange, 2020).

Teaching materials and resources, schools need to invest in high-quality teaching resources, such as biodiversity-focused textbooks, multimedia tools, and online resources. This can also include digital tools that allow virtual exploration of ecosystems, making the subject more engaging (Nguyen *et al.*, 2020).

Support for Field-Based Learning provides teachers with opportunities for organizing field trips or hands-on activities that can enhance the learning experiences. These opportunities can help

students understand biodiversity by observing it in natural settings, which is crucial for deepening their knowledge (Lee & Greene, 2019).

Collaboration with NGOs, local wildlife conservation groups, and universities can provide teachers with external resources, guest speakers, and even collaborative learning experiences that enrich the biology curriculum (Huber, 2017).

Student engagement strategies requires teachers to have resources to develop strategies that connect biodiversity to real-world issues that resonate with students. This could involve community-based projects, local environmental conservation efforts, or integration of biodiversity with students' daily lives (Harrison & Kivunja, 2018).

Identifying and addressing the above challenges may provide more effective strategies for integration of biodiversity resources use into the biology curriculum. Teachers should be adequately supported with the necessary resources, training, and curriculum reforms to make biology education engaging and impactful for students. By overcoming these challenges, educators can help students develop a deeper understanding of biological concepts and the importance of biodiversity conservation in sustaining life on Earth.

2.7 Literature Gap

The reviewed studies indicate that most studies conducted in Uganda emphasizes the causes of poor performance in biology at national level without pointing out clearly the relevancy of teaching and learning biology practically using biodiversity resources. Several reports of teacher education programmes totally lack or contain very few sustainability subjects (Alvarez-Garcia *et al.*, 2015). Dikmenli (2010) found out that most student teachers had challenges in understanding what the sustainability of biodiversity means. Regardless of the acknowledged benefits of utilizing local biodiversity as teaching resources in biology, teaching practices in Uganda frequently rely on theoretical content from textbooks and formal laboratory activities (Otto, 2022). Meanwhile, practical teaching of biology is suggested in some studies without clearly pointing out how biodiversity resources could be utilised to promote hands-on learning activities to improve academic performance in biology as well as creating awareness about biodiversity conservation. This gap has led to neglecting the opportunities for experiential learning emphasized in the competence-based curriculum (CBC) that biodiversity resources can

provide (NCDC, 2020), this hampers student's ability to grasp complex biological concepts and diminishes their interest in the subject leading to poor performance.

According to Hellden & Hellden (2008), the most commonly chosen teaching methods to promote the use of BD resources in biology teaching and learning at all educational levels were hands-on instruction and teacher presentation. These are examples of teaching methods through which students can get direct experiences of BD, and they are therefore important ways for developing positive attitude towards sustainability of BD. However most known studies about the use of biodiversity resources in teaching and learning biology at secondary school's level, have been undertaken outside Ugandan context. Therefore, there was need to specifically carry out a study about the use of the available biodiversity resources in biology teaching and learning at secondary school level in rural schools like in Oyam District. This study therefore investigated the impact of biodiversity resources' use in teaching and learning biology on student's learning outcomes basing on the competence-based curriculum.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter covers the research design, geographical study area, study population, sample size and sampling procedures, data collection methods and instruments, data processing, and analysis techniques that were used in this study.

3.1 Research Design

The study adopted a cross-sectional survey with a quantitative and qualitative approach. A survey is a method of securing information concerning the existing phenomenon from all or selected number of respondents of concerned category of people (Kothari, 2004; Bett, *et al.*, 2013) This design was appropriate because it allows for the collection of both quantitative and qualitative data from a large sample (Creswell, 2023), providing a comprehensive understanding of the integration of biodiversity resources into biology education in secondary schools. The descriptive survey design helped in identifying patterns, challenges, and opportunities in the current state of biodiversity resources' use in biology teaching and learning at secondary schools in Oyam District.

The study majorly used qualitative approach of data collection supplemented by quantitative studies.

3.2 Study Area

The study was carried out in Oyam district. The district was purposely selected because of its poor performance in the science subjects particularly biology at O' level UNEB results 2024. Oyam District is bordered by Omoro District to the north, Pader District to the northeast, Kole District to the east, Apac District to the south, Kiryandongo District to the southwest and Nwoya District to the west. The administrative headquarters of the district at Oyam, are located approximately 78 kilometres (48 miles), by road, west of Lira City. Oyam district is within the coordinates of: 02 14N, 32 23E

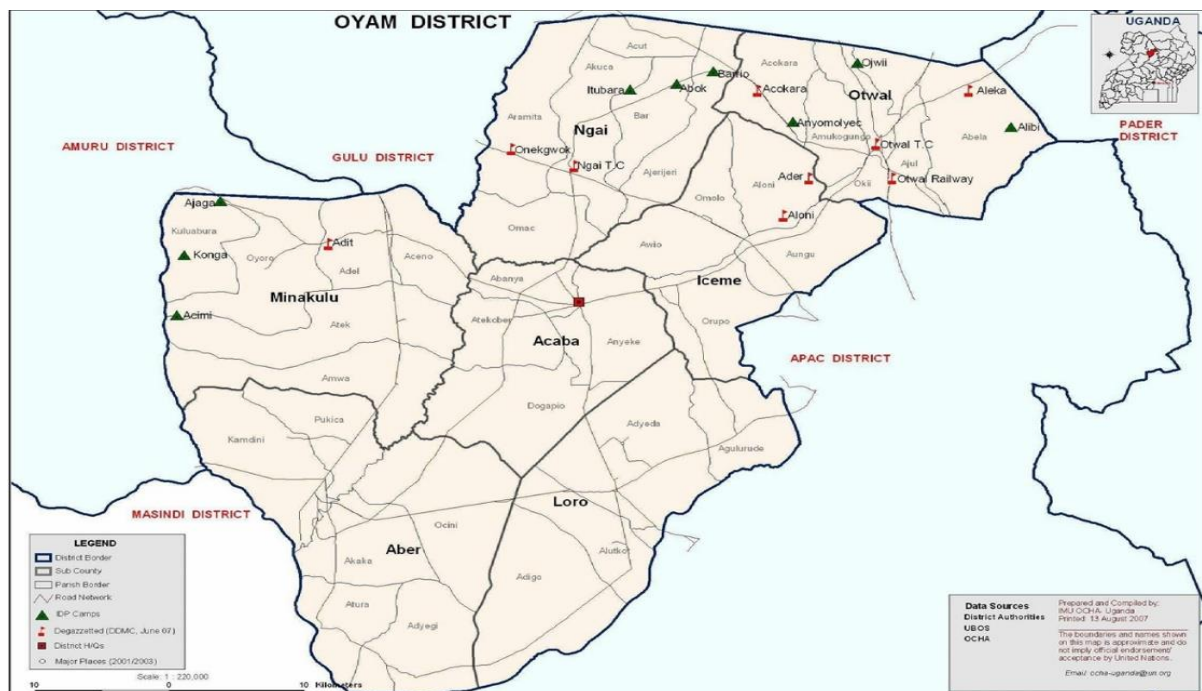


Figure 2: Map of Oyam District highlighting Sub-Countries with Studied Secondary

Table 1: List of Secondary Schools in Oyam District

S/N	NAME OF SCHOOL	SUB-COUNTY	CATEGORY
1	Otwal Secondary School	Otwal	Government Aided
2	Iceme Girls Secondary School	Iceme	Government Aided
3	Ngai Secondary School	Ngai	Government Aided
4	Abok Seed Secondary School	Abok	Government Aided
5	Acaba Secondary School	Acaba	Government Aided
6	Atapara Secondary School	Kamdini	Government Aided
7	Loro Secondary School	Loro	Government Aided
8	Loro Mission Vision School	Loro	Private
9	Everest Girls Secondary School	Loro	Private
10	Dr. Oryang Secondary School	Minakulu	Government Aided
11	Abdallah Anyuru Memorial School	Aber	Government Aided

3.3 Study Population

The study population consisted of the following groups: 22 Biology teachers, 110 senior four students, and 11 head teachers from all the eleven secondary schools in Oyam District giving a total of 143 respondents. The teachers provided insights into the teaching methods used in integrating biodiversity resources' use into biology lessons. Students provided feedback on their understanding of biology concepts involving the use of biodiversity resources and their academic performance. The school head teachers provided contextual information regarding school policies, resources available for teaching, and records of students' performance.

3.4 Sample Size sample determination and sampling procedures

The study population comprised $N = 550$ senior four students across 11 schools. The sample size ($n = 110$) was derived using Cochran's formula for proportions with a conservative estimate $p = 0.5$ at 95% confidence, followed by the finite population correction, which was applied to the standard Fisher's formula to ensure the sample size accurately reflects the smaller population size and maintains statistical validity. The calculations produced an initial $n_0 \approx 137$ and a finite population correction (FPC-adjusted) $n \approx 110$, corresponding to an approximate margin of error of $\pm 8.4\%$ at 95% confidence.

The formula is given as follows;

The standard Fisher's formula (for large populations)

$$n_0 = \frac{Z^2 \cdot p \cdot q}{e^2}$$

Where:

$Z = 1.96$ (for 95% confidence)

$p = 0.5, q = 1 - p = 0.5$

$e = 0.084$ (margin of error chosen so that final FPC-adjusted sample ≈ 110)

$$n_0 = \frac{(1.96)^2 \cdot 0.5 \cdot 0.5}{(0.084)^2} = 137.1$$

- n_0 = initial sample size for an infinite population
- Z = standard normal deviate for the desired confidence level (1.96 for 95% confidence)

- pp = estimated proportion of the attribute in the population (use 0.50 when unknown to maximize required sample size)
- ee = desired margin of error (expressed as a proportion)

Using conservative values:

- $Z=1.96$ (95% confidence)
- $p=0.50$ (maximum variability)
- $e=0.084$ (margin of error chosen so that final FPC-adjusted sample ≈ 110)

Given logistical constraints and resources, the chosen margin ($\approx 8.4\%$) was considered reasonable and transparent.

Step-2: Applying Finite Population Correction (FPC) since the sample size is greater than the study population

$$n_{adj} = \frac{n_0}{1 + \left(\frac{n_0-1}{N}\right)}$$

Where:

n_{adj} is the adjusted sample size, n_0 is the initial sample size (137.1), N estimated population size (550).

$$n = \frac{137.1}{1 + \frac{137.1-1}{550}} \approx 109.9 \approx 110$$

Hence, the sample size is **110**

3.5 Sampling Techniques

A combination of purposive sampling and simple random, was used to select participants. Purposive sampling was used to select biology teachers from each school. Simple random sampling was used to select 10 students from the senior 4 classes using the official class register. Pre-generated reserve lists were used to replace absent or non-consenting students across all eleven secondary schools in Oyam District. Where class sizes differed, weighting was applied during analysis so that estimates represent the population distribution. The rationale was to

ensure representation of each school and to simplify field logistics and comparisons across schools. Census, sampling was used to ensure all the secondary schools (11) and their head teachers were included in the study. Extraneous variables such as teacher competence, qualification, experience, class size, and school environment were controlled through careful sample selection. Participants were chosen in a way that ensured similarity across these variables, minimizing their potential influence on the study outcomes.

3.6 Data Collection Methods

This study adopted a triangulated data collection approach incorporating both quantitative and qualitative methods to effectively address the research objectives. The methods employed included the use of questionnaires and an interview guide.

3.6.1 Questionnaires

Questionnaires were administered to respondents to collect quantitative data on both their experiences and perceptions of biodiversity resources use in biology teaching and learning. The questionnaires consisted of a combination of closed-ended questions and open-ended questions that allowed for more detailed responses. Questionnaires are advantageous in collecting data from a large sample in a standardized manner, thus facilitating statistical analysis and comparison (Creswell, 2014; Cohen, *et al.*, 2018). This method is particularly relevant to addressing the second research objective: To evaluate students' perceptions of how biodiversity resources influence their understanding and confidence in biology concepts.

3.6.2 Semi-Structured Interviews

Interviews were conducted with respondents to explore in-depth the types of biodiversity resources used in teaching, as well as the challenges encountered in their implementation. An interview guide was developed, containing open-ended questions aligned with the study objectives, but allowing for flexibility to probe further into emerging themes or responses. The interview method was ideal for capturing detailed, contextual insights and personal experiences which may not be easily captured through structured questionnaires (Kvale & Brinkmann, 2015). This method was directly used to address the first and third research objectives.

3.7 Data Collection Tools

Questionnaires and interview guides were used as data collection tools. Individual questionnaires were administered by three research assistants under the supervision of the researcher to gather quantitative data from respondents to address objective two. An interview guide was designed to collect qualitative data to address objectives one and three. The three research assistants recruited also conducted interviews with respondents who gave insights into the institutional challenges and support needed for biodiversity-teaching. Additionally, relevant school documents, such as syllabi, lesson plans, and instructional materials, were also analysed to determine how biodiversity resources' use is integrated into the curriculum.

3.8 Data Quality Control

3.8.1 Validity and Reliability of Instruments

In order to ensure reliability, the internal consistency check was done. The researcher conducted a pre-test of the instruments on selected samples of 12 respondents (5 teachers, 5 students, and 2 head teachers) from similar non-participating schools in Lira city. Lira city was purposively selected because of convenience in getting the volunteer respondents, and being far from the study area of Oyam district. The responses from the samples were then subjected to Cronbach's alpha coefficient test, using a computer-based Statistical Package for Social Sciences (SPSS), version 22 and an alpha coefficient of above 0.7 was deemed to be good enough to measure the intended construct in the actual data collection since it was within the acceptable reliability score of 0.7 or higher but not exceeding 1.0 (Heale & Twycross, 2017).

3.9 Data Processing and Analysis

The data for objective two was analysed using the quantitative data analysis method. To ensure proper analysis, the quantitative data from the field were entered into the Statistical Package for Social Sciences (SPSS) version 22 and cleaned according to each variable of the study. The quantitative data were then analysed using descriptive statistics (frequencies and percentages). Inferential statistics analysis (multivariate logistic regression) was employed. Adjusted odds ratios (AORs) and 95% CIs were reported to measure the strength and direction of associations between dependent and independent variables. This provided a better understanding of the integration and impact of biodiversity resources use in biology teaching and learning at secondary schools in Oyam District. Results were presented using figures, charts, and tables of

frequencies, percentages, and means to summarize the information. Logistic regression was used to determine the relationship between independent and dependent variables.

The qualitative data for Objectives One and Three were processed and analyzed using thematic analysis. Data from interviews were first transcribed, cleaned, and organized into codes according to responses. A combination of deductive and inductive coding was used to identify recurring ideas related to the types of biodiversity resources used in biology education and the challenges faced in their utilization. Themes were then developed to categorize the different resources. The research findings were then presented narratively, supported by direct quotes (Braun & Clarke, 2006).

3.10 Ethical Considerations

Ethical considerations are central to ensuring the integrity of the research process, therefore the researcher followed the required procedures and rules governing the ethics of research work.

Permission to conduct the study was sought from the College of Education and External Studies (CEES), Makerere University, which was accompanied by a letter of introduction.

Permission was also sought from the local authorities where the study was conducted.

All the respondents consented and signed the consent forms voluntarily.

Data was handled with confidentiality and only codes were used instead of names to ensure anonymity. During the interviews with respondents, the research assistants ensured that there was adequate privacy to allow the respondents express their opinions without fear. The research assistants also ensured that they asked questions clearly and recorded the responses accurately without being bias.

3.11 Limitations of the Study

The study encountered some limitations:

- The study was limited by time frame that was available for data collection. The researcher collected data within a period of two months, from June to July 2025.
- Some teachers and students were hesitant to provide honest responses due to the sensitivity of the questions regarding teaching practices and their engagement with biodiversity.
- There were some variations in the quality and reliability of some secondary data from curriculum documents, textbooks, and teaching materials across the eleven secondary schools in Oyam District.

However, the researcher contends that these limitations did not compromise the quality of research findings.

CHAPTER FOUR

RESULTS

4.0 Introduction

This chapter presents the findings of the study on Use of Biodiversity Resources in Biology Teaching and Learning in lower secondary school in Oyam District. It combines qualitative data from interviews and quantitative data from questionnaires filled by teachers and students. The results are structured in line with the study objectives which include: (i) To identify the types of biodiversity resources used in biology teaching and learning. (ii) To evaluate students' perceptions of how biodiversity resources, influence their understanding and confidence in biology concepts. (iii) To explore the challenges faced by teachers and students in utilizing biodiversity resources in biology education. These findings form the empirical foundation for the interpretation and discussion of results presented in Chapter Five.

4.1 Biodiversity resources used in biology teaching and learning

4.1.1 Quantitative results

Table 2: Biodiversity resources used in biology teaching and learning

Variables	Teachers use local plants		We interact with community experts		We visit local ecosystems		We use digital tools		Teachers use local animals	
	<i>F</i>	<i>%</i>	<i>F</i>	<i>%</i>	<i>F</i>	<i>%</i>	<i>F</i>	<i>%</i>	<i>F</i>	<i>%</i>
Never	17	15.3	22	19.8	18	16.2	19	17.1	18	16.2
Rarely	9	8.1	15	13.5	27	24.3	29	26.1	19	17.1
Sometimes	22	19.8	31	27.9	39	35.1	23	20.7	22	19.8
Often	10	9.0	19	17.1	11	9.9	7	6.3	16	14.4
Always	53	47.7	24	21.6	16	14.4	33	29.7	36	32.4

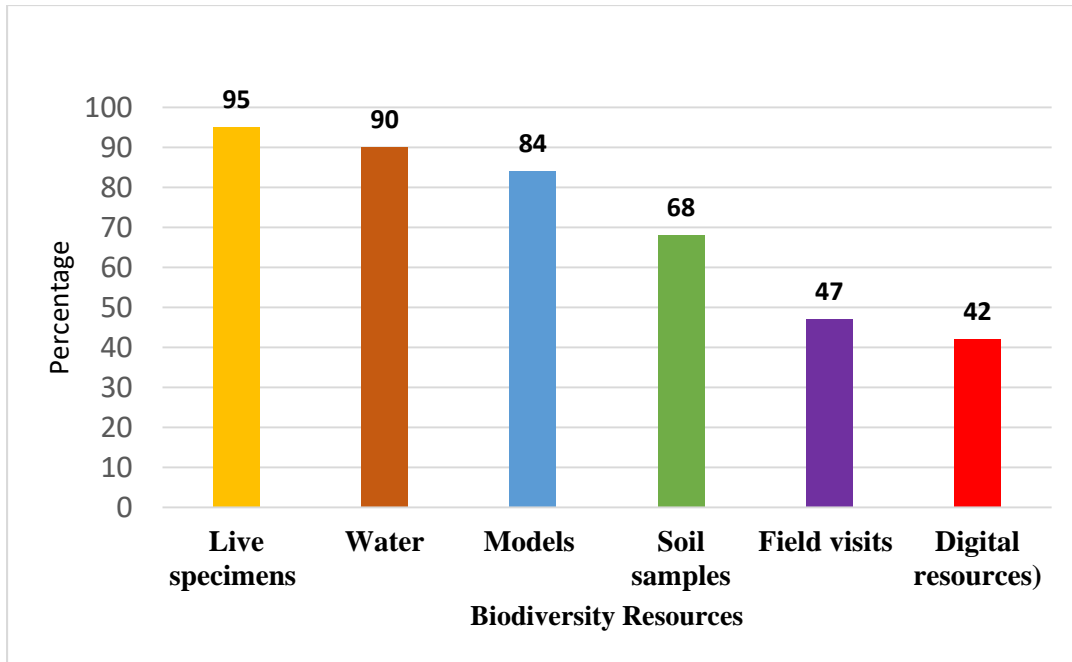


Figure 3: Types of Biodiversity Resources Used in Biology Lessons

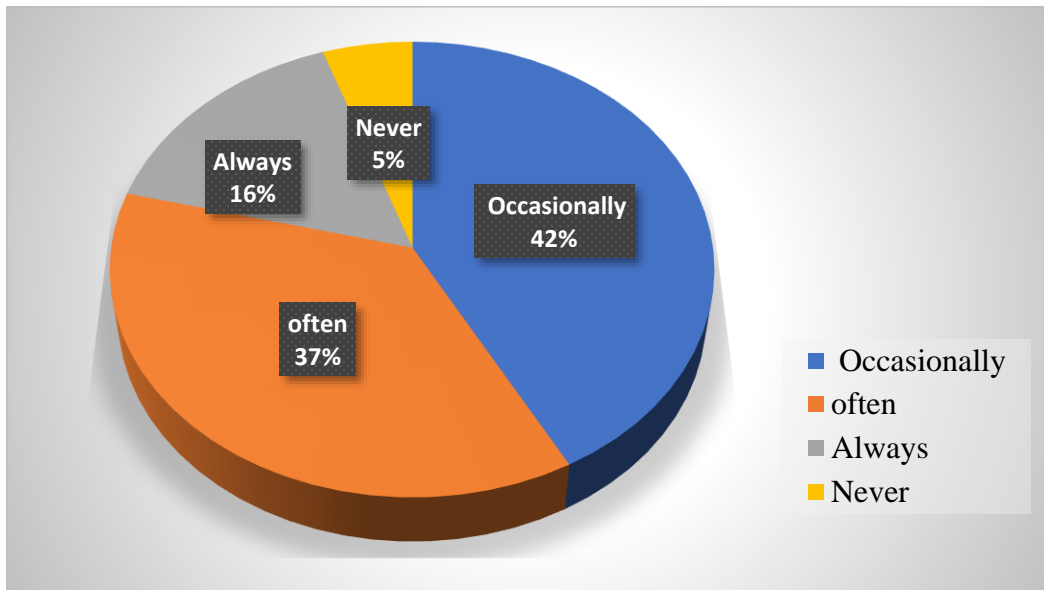


Figure 4: Teachers' frequency of using biodiversity resources in biology lessons

Table 3: Observed use of biodiversity specimens by teachers in different schools

Observed areas during teaching and learning	Frequency	Percent
Teacher uses of biodiversity specimens		
Yes	12	100.0
No	0	0
The Context of Use		
Field	3	25.0
Laboratory	7	58.3
Class	2	16.7
Learners' Extent of Engagement		
Low	1	8.3
Moderate	3	25.0
High	8	66.7
Teachers' Links Lesson to Real-Life Biodiversity		
Yes	10	100
No	9.1	0

The findings in Table 2 indicate that biodiversity resources are integrated into biology teaching to varying degrees across schools. Results revealed that local plants were the most consistently utilized, with nearly half of the students (47.7%) reporting that teachers always used them, while local animals were also relatively well integrated (32.4%). By contrast, interactions with

community experts, field visits, and digital resources were employed less consistently, with many students reporting these as rarely or never used.

Figure 4, results on analysis of specific biodiversity resources in further supported these trends: live specimens (95%), water (90%), and instructional models (84%) were the most frequently applied teaching aids, while soil samples (68%), field visits (47%), and digital resources (42%) were considerably less common. This highlights a preference for readily available, tangible teaching materials over more resource-intensive or technologically mediated approaches.

Classroom observation data (Table 3) confirmed the centrality of biodiversity specimens in instruction, with all teachers (100%) observed using them. Most of this use occurred in laboratory settings (58.3%), followed by the field (25%) and classroom (16.7%). Learner engagement was generally high, with two-thirds of students (66.7%) showing strong involvement in specimen-based activities, and all teachers explicitly linking lessons to real-life biodiversity applications.

The frequency of overall resource integration, as reflected in teacher reports, further demonstrated this variability. As shown in the pie chart (Figure 5), the majority of teachers reported using biodiversity resources occasionally (42%) or often (37%), while fewer indicated always (16%), and a very small proportion (5%) reported never doing so. Taken together, these results suggest that while biodiversity resources are widely acknowledged and incorporated in biology teaching, their use remains somewhat irregular. Strong reliance on plants, animals, and live specimens demonstrates alignment with experiential learning goals, yet the limited and inconsistent use of field visits, community expertise, and digital tools points to missed opportunities for deeper contextual and technology-enhanced learning as envisioned in the competency-based curriculum (CBC).

Table 4:Qualitative results on Biodiversity resources used in biology teaching and learning

Theme	Subtheme
Teaching Practices and Integration of Biodiversity Resources	Use of Local Plants in Classroom Teaching
	Application of Local Animals in Learning
	Field Visits and Outdoor Learning
	Use of Live Specimens, Models, and Digital Resources

Theme: Teaching Practices and Integration of Biodiversity Resources

The findings show that both students and teachers frequently use various biodiversity resources in biology lessons, though the frequency and context differ.

Use of local plants was the most common used resource by teachers in class. One student said, *“We were able to observe and identify features on plants like leaves, roots, stems, and flowers.”* This shows how plants are used to teach topics like plant parts, reproduction, and classification.

Use of local animals, both students and Teachers confirmed these findings. As, teacher (1) shared, *“I obtained these organisms from the environment, which was aimed at developing the observation skills.”* Another, Teachers (3) said, *“I used the anthill and the nearby swamp to explain to the students the meaning of the terms used in ecology.”* These examples show that teachers not only brought biodiversity into class, but they also took students outside to observe ecosystems in real life.

Use of field visits, students said they “sometimes” visited local ecosystems. This suggests that field visits are used, but not regularly. In support, a teacher (2) explained, *“Learners observed insects... and used the observed features to distinguish and identify them using the flow diagram and dichotomous key.”* This hands-on activity develops scientific classification skills.

A teacher (3) noted, *“In my lesson plan I had the termites, fish, and frog as my teaching aids,”* highlighting the types of animals most commonly used. These are all native, affordable, and scientifically useful specimens. Students appreciated these efforts. They mentioned learning through active participation, such as digging anthills or singing songs. One student shared, *“The songs we sing during the activity... we use those songs in passing exams.”* This indicates that biodiversity is not only used for hands-on learning but also for making learning enjoyable and memorable. Teacher (1) said, *“I have preserved earthworms and other insects in the lab to show how I integrate biodiversity in my lessons.”* This shows that teachers use both live and preserved specimens. These materials allow for repeated use and can be used in multiple classes, especially when fresh samples are unavailable. A teacher (3) also confirmed, *“The most useful aspect was how to assess the learners... and lesson plan,”* emphasizing that biodiversity use is built into assessment and planning.

Students confirmed that teachers prepare them before practical work. One student noted, *“They always prepare us well before using biodiversity resources by teaching us theory first in class.”* This is important for CBC because it shows integration of knowledge and practice. However, challenges still exist. As one student said, *“Yes, lack of reagents to be used during practical,”* pointing to shortages of lab tools like chemicals and magnifiers.

4.2 Students’ Perceptions of How Biodiversity Resources Influence Their Understanding and Confidence in Biology Concepts

This section looks at what students think about using biodiversity resources like local plants, animals, real environments, and digital tools in their biology lessons. It shows how these resources help students understand biology better and feel more confident when answering questions in class or exams.

4.2.1 Quantitative results

Table 5: Showing students perception-based statements

Variables	Yes		No	
	F	%	F	%
I can apply knowledge to protect local ecosystems (CBC: Environmental Stewardship)	98	89.1	12	10.9
Using biodiversity resources improves my problem-solving skills (CBC: Critical Thinking)	91	82.7	19	17.3
Biodiversity in teaching improves my exam performance	100	99.1	8	7.4
Fieldwork makes me confident in designing investigations (CBC: Scientific Inquiry)	101	90.9	9	8.2
I understand biology topics better when we use biodiversity.	99	90.0	11	10.0
I enjoy biology more with biodiversity examples.	104	94.5	6	5.5
I feel more confident in biology when biodiversity is used	96	87.3	14	12.7
Using real plants and animals helped me understand biology better	108	97.3	3	2.7
Average	99.6	91.4	10.3	9.34

The results from Table 5 reveal that students expressed overwhelmingly positive perceptions regarding the use of biodiversity resources in learning biology. Most students indicated that engaging with biodiversity enhanced their ability to apply knowledge toward protecting local ecosystems, promoted problem-solving, and strengthened their confidence in scientific inquiry. A large proportion also emphasized that biodiversity-based approaches improved their understanding of biology topics, boosted their enjoyment of the subject, and enhanced their performance in examinations. Furthermore, the integration of real plants and animals into lessons was strongly associated with greater comprehension and confidence in learning biology. Collectively, these findings suggest that biodiversity resources are perceived as highly effective in promoting deeper learning, motivation, and skill development among students, consistent with the core competencies emphasized in the Competency-Based Curriculum (CBC), including environmental stewardship, critical thinking, and scientific inquiry.

Table 6: Showing a multivariate logistic regression of determinants of Understanding and Confidence in Biology Concepts

Variables		B	Sig.	Exp. (B)	95% Confidence Interval for Exp. (B)	
					LB	UB
Teachers use local plants (e.g., millet, cassava, medicinal herbs)	Low	-.773	.345	.462	.093	2.294
	moderate	.134	.850	1.144	.286	4.581
	High	0 ^b	.	.	.	.
Teachers use local animals (e.g., goats, weaverbirds, ants)	Low	1.624	.018	5.072	1.322	19.456
	moderate	.372	.635	1.451	.313	6.738
	High	0 ^b	.	.	.	.
We visit local ecosystems (e.g., wetlands, forests, farmlands)	Low	1.287	.085	3.622	.838	15.659
	moderate	-.145	.857	.865	.179	4.185
	High	0 ^b	.	.	.	.
We interact with community experts (e.g., farmers, elders)	Low	-2.171	.019	.114	.019	.699
	moderate	.362	.575	1.436	.405	5.088
	High	0 ^b	.	.	.	.
We use digital tools (e.g., biodiversity apps, videos, phones, radio, TVs)	Low	.122	.855	1.129	.307	4.155
	moderate	.741	.325	2.098	.480	9.162
	High	0 ^b	.	.	.	.

In step two, a multivariate logistic regression analysis was conducted to examine how students' exposure to various biodiversity resources influenced their confidence and understanding biology concepts. Predictor variables included students' reported frequency of engagement with different types of biodiversity resources, categorized into "low," "moderate," and "high" exposure levels. The "high" category served as the reference group in each comparison. The model's goodness-of-fit and explanatory power were also assessed.

Model Fit and Explanatory Power

The model demonstrated a good fit to the data. The Pearson Chi-square test ($\chi^2 (58) = 62.163, p = .330$) and Deviance test ($\chi^2 (58) = 59.782, p = .411$) both indicated that the model was not significantly different from the observed data, suggesting acceptable fit. The pseudo-R-square values Cox and Snell $R^2 = .208$, Nagelkerke $R^2 = .317$, and McFadden $R^2 = .218$ further indicated that the model explains a moderate proportion of the variance in students' confidence in understanding biology concepts.

The multivariate logistic regression analysis (Table 6) shows that certain teaching practices significantly influenced students' understanding and confidence in biology concepts. Specifically, students who reported low exposure to local animals in lessons were over five times more likely to express limited understanding and confidence compared to those with high exposure, indicating that integrating local fauna plays a crucial role in enhancing learning.

On the other hand, limited interaction with community experts was strongly associated with reduced understanding and confidence, suggesting that expert engagement provides unique, context-specific insights that enrich classroom learning. Other factors, including the use of local plants, visits to ecosystems, and digital tools, did not show statistically significant effects, though some trends indicated potential positive contributions.

4.2.2 Qualitative results

Table 7: students’ perceptions of how biodiversity resources influence their understanding

Themes	Dimensions
Understanding Biodiversity and Protecting Ecosystems	<ul style="list-style-type: none"> - Using real plants and animals helped students understand caring for nature and protecting the environment. - Application of biology knowledge to protect local ecosystems. - Outdoor activities connected classroom learning to real-life practices like farming and environmental care.
Problem-Solving and Critical Thinking Skills	<p>Biodiversity improved problem-solving skills.</p> <ul style="list-style-type: none"> - Hands-on activities enhanced critical thinking and curiosity. - Students' exposure to local animals (ants, goats, birds) made them feel more confident and capable in biology.
Improved Confidence through Real-Life Learning (Scientific Inquiry)	<ul style="list-style-type: none"> - confidence in designing biology investigations through fieldwork. - Using real plants/animals improved understanding. - Seeing real specimens (e.g., a termite with antennae) had a long-lasting impact and boosted confidence.
Importance of Learning from Community Experts	<ul style="list-style-type: none"> - Students valued learning from local farmers/elders. - Involving experts would make lessons useful and enjoyable.” - Community experts made learning engaging, relatable, and fun

Understanding Biodiversity and Protecting Ecosystems

Many students said that using real plants and animals in class helped them understand how to care for nature and protect their environment.

Students also gave examples of how biodiversity helped them understand nature better. One student said, *“We got a frog from the compound and we put it in water and also on land... it has two breathing systems, the lungs and the skin”* (student 6). This outdoor activity made the topic of amphibians clearer and helped students understand how some animals live both on land and in water. Another student described testing soil, saying, *“Topic: soil... Students will be able to analyze the experiment physically and draw their own conclusion.”* These activities connect classroom learning to real-life applications, such as farming and environmental care.

Problem-Solving and Critical Thinking Skills

The CBC encourages learners to think deeply and solve problems. students believed that using biodiversity in biology lessons improved their problem-solving skills. This means biodiversity-based teaching helps students think critically, not just memorize facts.

From the student interviews, learners explained how seeing and touching real plants made them think more clearly. For example, one student explained how they observed a bougainvillea flower to understand self-pollination, stating, *“We opened the pedicles... we found the stamen/anthers were shorter than the pistil and they were attached to one another to ease pollination. We really enjoyed the lesson that day”* (Student). These hands-on lessons made students more curious and encouraged scientific thinking.

Improved Confidence through Real-Life Learning (CBC: Scientific Inquiry)

Confidence in biology comes when students do things themselves. students said they feel more confident designing biology investigations when doing fieldwork, when using real plants and animals helped them understand biology better.

During interviews, students shared how these experiences stick in their minds. One student said, *“The teacher brought a termite and showed us the body parts and a pair of antennae... I saw it, and it had a long-lasting impact on my brain. This has helped me to understand classification of insects, and I am confident while classifying”* (student 5). This quote shows how confidence grows when students actually see and touch the things they are learning about.

Importance of Learning from Community Experts

Learning from people in the community, like farmers or elders, helps students see how biology is used in real life. This aligns with the CBC’s focus on contextual learning. Students themselves also said they would love to learn from local people. They suggested, *“Involving experts would make the lessons more useful and enjoyable”* (student 1 and 4). Another said, *“It would look like a drama, but so informative and educational.”* This shows how community involvement makes learning more fun and real for students.

Digital Tools – Limited but with Potential

Using videos, apps, phones, or radios can also help students learn about biodiversity, but in this study, digital tools were not found to be very useful. Only a few students mentioned using digital resources, and some even said they lacked access to the internet or multimedia tools. This means that while digital tools could be helpful, many students don't yet have the chance to use them properly. More investment in digital materials might help future learners, especially in rural areas.

Overall Student Enjoyment and Academic Benefits

Students who enjoy learning tend to perform better. From the interviews, many students confirmed this. One said, *“I observed and have experience with them. When it comes to exams, I pass because I saw it.”* Another said, *“We were able to observe and identify features on plants like leaves, roots, stems, and flowers”*—this made biology feel real and understandable.

4.3 The challenges faced by students in utilizing biodiversity

4.3.1 Quantitative results

Table 8: Students Ranking of Challenges in Using Biodiversity Resources in Biology Lessons

Challenge	Frequency (n)	Percentage (%)	(n=111)
Limited tools (e.g., magnifying glass)	79	71.2%	
Lack of time for outdoor activities	74	66.7%	
Safety concerns (e.g., snakes)	60	54.1%	
No access to ecosystem near school	59	53.2%	
Teachers skip practical to focus on exams	35	31.5%	
Lessons feel disorganized	26	23.4%	

The results in Table 8 indicate that the most commonly reported challenge to the use of biodiversity resources in biology lessons was the limited availability of tools such as magnifying glasses, cited by 79 students (71.2%). This was followed closely by lack of time for outdoor activities, reported by 74 (66.7%), and safety concerns such as encounters with snakes, mentioned by 60, (54.1%). Similarly, over half of the respondents (53.2%) identified lack of access to nearby ecosystems as a barrier to integrating

biodiversity resources in teaching. Less frequently reported challenges included teachers skipping practical lessons to focus on examinations (31.5%) and lessons feeling disorganized when biodiversity resources were used (23.4%). These findings suggest that both logistical constraints (tools, time, and access) and contextual concerns (safety and exam pressures) substantially hinder the effective use of biodiversity resources in biology education.

4.3.2 Qualitative results on Challenges faced by teachers (TRS)

Table 9: Challenges faced by TRS in the use of biodiversity resources in biology education

THEME	DIMESIONS
Implementation Challenges	<p>Large class sizes that overwhelm small laboratory spaces.</p> <p>Financial constraints are preventing the purchase of biodiversity resources.</p> <p>Transport and weather-related difficulties in organizing outdoor learning.</p> <p>Safety concerns (e.g., dangerous organisms, student fears).</p> <p>Difficulty in identifying and classifying similar organisms without expert support.</p> <p>Lack of community cooperation, as some communities expect monetary benefits to provide support.</p> <p>Absence of nearby ecosystems (forests, wetlands) for real-world learning.</p>
Curriculum Limitations	<p>Lack of sufficient time in the Competency-Based Curriculum (CBC) to allow for research, presentations, and outdoor activities.</p> <p>Overcrowded classrooms that limit participation and make hands-on work difficult.</p> <p>Inadequate teaching resources such as textbooks, the internet, lab equipment, live specimens, and biodiversity tools.</p>
Training on CBC Pedagogy	<p>Limited confidence in teaching biology using biodiversity resources due to limited access to specimens and digital tools.</p>

Theme 1: Implementation Challenges

Many challenges come up when trying to actually use biodiversity in class. First, the class sizes are too big. Teacher (1) shared, *“The small laboratory room cannot accommodate all the 120 students... sometimes I am forced to conduct the lesson in shifts.”* This makes it hard to let everyone touch or observe real organisms. Students can’t all fit or share the few resources that exist.

Money is another problem. Teachers said they cannot afford to buy even local biodiversity resources. Teachers (3) and (2) said, *“Lack of finance to afford those locally available.”* Students also said they sometimes can’t go out to learn because they lack transport or permission from school. These practical problems stop them from experiencing biodiversity in real places.

The weather is also an issue. Teacher (3) said, *“Weather changes, lack of transport facilitation to the market.”* When it rains or when it’s too hot, it’s not safe or easy to go outside and collect things like insects or leaves.

Safety is a big worry for both students and teachers. In the student said they are scared of things like snakes. One student said, *“Some learners are scared of contact with some organisms.”* This fear makes students avoid hands-on learning. Others said they get confused when trying to classify organisms that look alike. Without help from teachers or experts, they don’t know the difference between, say, a grasshopper and a cricket.

Finally, both teachers and students said there’s not enough help from professionals. Students said they get confused *“due to lack of guidance from the professional,”* and teachers feel disappointed by the community. A teacher said, *“The community has failed to support me because they refer to every request in terms of monetary benefit.”* This shows that communities don’t help unless they’re paid, which is a big problem.

Theme 2: Curriculum Limitations

One of the biggest challenges for both teachers and students is a lack of time. Teachers say the CBC (Competency-Based Curriculum) wants students to explore and present what they learn, but this takes a lot of time. Teachers (1) and (2) said, *“The only limitation in CBC is the time; students need a lot of time to research and make a clear presentation.”* Students said there is not

enough time for outdoor activities. This shows that tight lesson schedules are a major problem for learning through real-world biodiversity.

Another issue is overcrowded classrooms. A teacher (3) explained, *“Few resources like books and apparatus; large classes.”* When there are too many students and not enough materials, it becomes difficult for every student to do hands-on work. One student said they couldn't participate well because the class was too crowded. And they don't have the tools they need, like magnifying glasses, to observe small organisms closely. This lack of tools makes real learning about biodiversity almost impossible.

Also, both teachers and students mentioned that many schools lack essential materials, such as internet access, lab equipment, and even live plants or animals for observation. The CBC encourages active, hands-on learning, but many schools are not ready for this kind of teaching. Students even said their lessons sometimes feel disorganized which makes it harder to learn properly.

Theme 3: Training on CBC Pedagogy

Teachers said they had received some training in CBC, especially in using ICT and planning lessons. A teacher (1) said, *“The most useful aspect was the integration of ICT and the use of locally available materials.”* This means teachers are learning to be creative with what they have. However, they still lack access to enough biodiversity specimens, which makes them unsure about doing practical lessons. As A teacher, (1) admitted, *“I am 50% confident... because not all required plants and animal specimens can be accessed.”*

Students feel more prepared when their teachers give early instructions and help them get ready for practical work. One student said, *“Precautions are always given early,”* which shows that good preparation helps students feel safe. Still, teachers (3) said more training is needed, especially training that teaches how to find or make biodiversity materials when schools do not have much money.

4.4 Resolutions suggested to combat Challenges in Using Biodiversity Resources

Table 10 Suggested Solutions to Challenges in Using Biodiversity Resources

Theme	Subthemes
Support Needed	Creation of in-school biodiversity sites Teacher-led creative initiatives Curriculum time and pedagogical support Expert involvement in teaching School–community partnerships
Institutional Changes	School-based biodiversity conservation Government and district support
Community Contributions	Environmental protection by communities Limited student perception of community role

Theme 1: Support Needed

Teachers and students both shared good ideas for fixing the problems. One idea is to build special places in schools, like botanical gardens, seed banks, and aquariums. A teacher (1) said, *“Schools should set up conservation sites... for example seed bank, a botanical garden, and an aquarium.”* This would allow students to study biodiversity right at school. Some teachers have already started doing creative things. A teacher (1) shared, *“I tried maintaining the rare species on the school compound as ornamentals.”* These small steps help bring biodiversity closer to the classroom. Students also want more time in class and better instructions to help them understand biodiversity. One student said simply, *“Involving experts,”* meaning they want adults who know biology to come teach them outdoors. Teachers also said schools should work with the

community to lower costs. A teacher (1) stressed, *“I need to establish a community partnership to help acquire the necessities at low cost.”* Working together could solve many problems, like lack of money, materials, and space.

Theme 2: Institutional Changes

Teachers believe that big changes are needed to make things better. One idea is to rear and plant rare species in schools. A teacher (1) said, *“Several changes like planting and rearing rare species are needed in schools.”* This would help students always have access to biodiversity materials. But teachers also said they need help from the government. A teacher (1) explained, *“The district and ministry should provide financial support and a local biodiversity teaching policy, toolkit or resource manual.”* Schools can’t do everything by themselves—they need money, tools, and official guidance from education leaders.

Theme 3: Community Contributions

Teachers believe communities can help by protecting nature, like swamps and forests, because these places are homes for biodiversity. A teacher (i) said, *“The community should protect the environment because those are the habitats for local biodiversity.”* This support is important for making learning real and useful. However, students did not talk much about community help, showing that communities are not very involved in biodiversity education. This is a big gap. Without local support, students may not see the value of biodiversity in their own environment.

Summary of the findings

The study reveals that the use of live, local biodiversity resources in biology instruction is both extensive and pedagogically impactful, particularly in fostering hands-on, contextualized learning. While teachers demonstrate strong planning aligned with the Competency-Based Curriculum, actual implementation is often hindered by systemic challenges such as overcrowded classrooms, limited time, and inadequate resources. Community-based learning and the use of localized materials were found to significantly enhance students' confidence and the relevance of lessons, emphasizing the value of integrating indigenous knowledge into formal education. However, the study also identifies a critical digital gap in that digital biodiversity tools are severely underutilized, not due to a lack of pedagogical value, but because of

infrastructural limitations and low digital literacy among teachers and students. Overall, biodiversity-based teaching was shown to improve student engagement, academic performance, critical thinking, and environmental stewardship. Importantly, the study highlights often overlooked barriers to effective implementation, including students' fear of handling certain specimens and weak community involvement, which collectively point to the need for more comprehensive, context-responsive support systems in rural science education.

CHAPTER FIVE

DISCUSSION AND CONCLUSION

5.0 Introduction

This chapter discusses the key findings of the study regarding the types and usage of biodiversity resources in biology teaching and learning in lower secondary schools in Oyam District. The results are interpreted in light of existing literature to highlight areas of convergence, divergence, and educational significance.

5.1 Biodiversity Resources Used in Biology Teaching and Learning

5.1.1 Diverse Use of Local Biodiversity in Biology Lessons

The study found that nearly half of the students reported frequent use of local biodiversity resources, especially plants and animals, during biology lessons. These resources supported hands-on learning about plant anatomy, classification, and ecological relationships. This finding aligns with Loinaz (2017), who emphasized the effectiveness of integrating local biodiversity to promote experiential and contextual learning. Similarly, Doup (2018) found that using local flora and fauna increases environmental awareness and nurtures eco-responsible behavior among students. These findings suggest that incorporating local biodiversity bridges the gap between textbook knowledge and real-world environmental understanding. It enables learners to observe, question, and appreciate biodiversity within their immediate surroundings. The implication is that biology education should intentionally leverage the availability of indigenous species to enrich learning, promote environmental ethics, and enhance relevance, especially in rural settings where such resources are abundant and accessible.

5.1.2 Field-Based Learning and Ecosystem Visits

Despite the reported low frequency of student visits to local ecosystems, the study found that field-based learning significantly enhanced conceptual understanding and promoted environmental stewardship. Students who participated in activities like insect classification using dichotomous keys demonstrated improved scientific inquiry and critical thinking. These outcomes are supported by Nwokocha (2024), who reported that field experiences allow students to apply theoretical knowledge in real-life contexts. Coppens (2024) also highlighted the role of structured outdoor programs in deepening learning and engagement. This means students accessed valuable experiential learning opportunities. The findings imply a need for schools,

communities, and policymakers to invest in affordable and sustainable models for field-based instruction. Initiatives such as local conservation partnerships and low-cost excursion programs can help integrate ecosystem visits into the curriculum more regularly.

5.1.3 Types of Biodiversity Resources in Practice

This study found that tangible biodiversity resources, such as live and preserved specimen, water samples, and local fauna like frogs, termites, and earthworms, were widely used in classroom instruction. These findings are consistent with Babou *et al.*, (2023), who found that in rural and low-resource settings, teachers often prefer practical and cost-effective materials drawn from the local environment. The use of models, diagrams, and geological samples further complemented these practices. Notably, digital biodiversity tools were underutilized, with only a few of the teachers reporting their use. Similar findings by Alonso and Gutiérrez (2017) emphasized that biodiversity education should include an understanding of ecosystem services, especially provisioning services. Meanwhile, Monfils *et al.*, (2017) highlighted the significance of natural history collections, both physical and digitized, as valuable educational tools for enriching biodiversity understanding. These findings highlight the dual importance of hands-on and digital resources in biodiversity education. While physical specimens are indispensable for sensory and inquiry-based learning, digital tools expand access to global biodiversity knowledge. The implication is that schools should aim for a blended approach, where both traditional and digital materials are integrated to offer diverse and comprehensive learning experiences.

5.1.4 Contexts and Settings for Biodiversity Resource Use

The study showed that biodiversity resources were predominantly used in laboratories and during fieldwork, with lesser use in regular classrooms and minimal use of digital environments. Observations confirmed that all lessons involved the use of biodiversity specimens, especially in lab settings. These findings echo that of Scott *et al.*, (2012) who reported similar utilization patterns of laboratory and field settings for science instruction. Hamilton, (2017) found that students demonstrated more enthusiasm and comprehension during outdoor tasks compared to indoor classroom learning. Teachers in this study also linked their lessons to real-life biodiversity, aligning with the principles of the Competency-Based Curriculum, which promotes relevance and application in learning. With above, average of the students rating their engagement as "high" during such activities, the implication is that varied and context-specific settings foster deeper learning. To improve practice, curriculum implementers should strengthen

support for lab and field resources, while also encouraging innovation in classroom-based biodiversity instruction, especially where infrastructure is limited.

5.1.5 Digital Integration and Infrastructure

The study revealed critical gaps in digital resource use, with less than fifteen percent of the students and teachers frequently using digital biodiversity tools and incorporating apps/digital media respectively. This low integration rate mirrors findings by Hew and Brush (2007) and Sansanwal and Yadav, (2023), who attributed such gaps to limited infrastructure, training, and connectivity. In Uganda, Ndibalema (2025) identified poor ICT access and lack of digital literacy as barriers to digital learning in rural areas. Canonizado (2024) also found that teachers often lack the skills and confidence needed to adopt educational technologies effectively.

While digital tools have the potential to enhance learning, especially when ecological constraints limit field access, the current infrastructural challenges hinder their adoption. This means that to achieve successful integration of educational technology, it requires a systemic investment in equipment, internet access, teacher capacity-building, and curriculum redesign.

The implication is that education policymakers and development partners should prioritize digital equity in rural science education. Expanding ICT infrastructure, embedding biodiversity-related digital tools into teacher training, and promoting digital content co-creation at the school level can help close the gap and modernize biology instruction.

5.2 Students' Perceptions of How Biodiversity Resources Influence Their Understanding and Confidence in Biology Concepts.

5.2.1 Environmental Stewardship through Biodiversity Resources Integration

The study found that students exposed to biodiversity-rich learning environments demonstrated a stronger sense of environmental responsibility and awareness of ecological interdependence. Such students were more likely to express appreciation for the role of biodiversity in sustaining ecosystems and expressed increased motivation to protect the environment. These findings align with those of Kuo *et al.*, (2019), who observed that nature-based instruction cultivates environmental stewardship by strengthening students' emotional connections to natural settings. Similarly, Balan (2024) emphasized that early exposure to local flora and fauna enhances pro-ecological attitudes and fosters a lasting commitment to sustainability. These results also reflect

the value of place-based education, which links scientific learning to the students' local environment, thereby reinforcing the relevance of ecological conservation and long-term behavioral change and community involvement in conservation.

The implication of this finding is that biodiversity integration is not only an instructional strategy but also a transformative approach that prepares learners to become active participants in ecological sustainability. Therefore, curriculum developers and education stakeholders should prioritize biodiversity-oriented pedagogies as essential tools for environmental education.

5.2.2 Biodiversity Enhances Critical Thinking and Problem-Solving

The findings revealed that majority of students believed biodiversity-based instruction improved their critical thinking and problem-solving skills. Students who regularly engaged with real biological specimens, such as local animals or plant dissection, demonstrated improved analytical reasoning and confidence in scientific problem-solving. This supports Wals' (1999) findings, which showed that interaction with local biodiversity fosters cognitive development by encouraging inquiry and reflection. Ahuja, (2021), found similar results when students dissected flowers and documented findings, leading to more meaningful conceptual understanding. Furthermore, Rachmawati, *et al.*, (2022) demonstrated the effectiveness of local biodiversity e-booklets in developing critical thinking.

The implication is that incorporating biodiversity resources into instruction enables active learning, where students form hypotheses, make observations, and draw conclusions, skills that are central to science education and relevant to real-world decision-making. It also suggests the need for teachers to receive targeted training in designing inquiry-based lessons that utilize biodiversity resources effectively.

5.2.3 Scientific Inquiry through Fieldwork Strengthens Confidence

Field-based learning emerged as a major contributor to students' scientific confidence. The majority of students reported increased self-assurance in conducting investigations and understanding biology concepts after participating in fieldwork activities. These experiences provided authentic engagement with natural ecosystems, which not only facilitated content mastery but also strengthened students' identity as competent learners. This is consistent with Chitty and Hesp (2024), who found that field experiences enhance academic performance and

personal development, particularly in biology education. Pratiwi *et al.*, (2024) also observed that students gained deeper conceptual understanding through zoological field studies, while Kassim *et al.*, (2024) emphasized that fieldwork promotes resilience, teamwork, and independent thinking.

The implication is clear: fieldwork remains a powerful instructional method that complements classroom learning and builds scientific confidence. Despite financial and logistical constraints, especially in rural areas, education stakeholders must prioritize investment in field-based experiences to support competency-based learning.

5.2.4 Learning from Community Experts Boosts Relevance and Confidence

Students who learned from community experts such as local farmers, herbalists, and elders were found to be nearly nine times more confident in their understanding of biology concepts than those who did not engage with such sources. This reflects the pedagogical value of integrating local knowledge systems into formal education. The findings align with Ervin-Kassab and Drouin (2021) who noted that community-based learning enhances relevance and promotes student engagement. Similarly, Moore *et al.*, (2023) also emphasized that such engagement humanizes science education, contextualizes learning, and fosters cultural identity. The findings emphasize that incorporating indigenous ecological knowledge can deepen understanding and reinforce environmental ethics.

This implies that curriculum developers should systematically incorporate community knowledge into biology instruction, not only to boost confidence and comprehension but also to foster cultural continuity and mutual respect between schools and communities.

5.2.5 Impact of using Digital Tools

While digital tools hold promises for enhancing science education, their impact in this study was limited. Only 6% of students reported regularly using digital biodiversity applications, and the majority did not associate them with improved understanding or confidence. The barriers included limited ICT infrastructure, unreliable internet connectivity, and insufficient teacher training.

These findings are consistent with those of Bancroft *et al.*, (2024), who highlighted the absence of a shared digital pedagogy in many education systems. Similarly, Ningsih (2024) and Topal

and Geçer (2024) identified socio-economic disparities and digital literacy gaps as key impediments to equitable access. Maziane *et al.*, (2023) further pointed out that most available tools are teacher-centered, limiting student autonomy and engagement.

This implies a need for strategic investment in digital education infrastructure, particularly in rural and underserved schools. Additionally, professional development programs should equip teachers with the skills to integrate digital biodiversity tools in learner-centered ways.

5.3 Challenges in Utilizing Biodiversity in Biology Teaching in Uganda

5.3.1 Curriculum Constraints and Resource Limitations

Findings from the study revealed that the implementation of the Competency-Based Curriculum (CBC) in lower secondary schools in Oyam District is significantly constrained by limited resources and inflexible curriculum conditions. Teachers cited inadequate tools, insufficient time for outdoor lessons, and inaccessibility of nearby ecosystems as major barriers to the effective use of biodiversity resources in teaching. Overcrowded classrooms further compound these challenges, restricting the capacity for learner-centered, experiential learning.

These findings align with previous research by Mpate (2023), which highlighted similar issues of inadequate instructional materials and time constraints under CBC implementation in rural Ugandan schools. Additionally, Cheruiyot (2024) and Najjuma (2024) noted that high student-teacher ratios severely hamper the delivery of practical biology lessons, often resulting in disengaged learners.

The convergence of findings suggests systemic structural limitations that undermine CBC's experiential focus, especially in biodiversity education. The inability to access outdoor learning spaces and relevant materials reduces the authenticity of biodiversity-based lessons. This implies a need for a more flexible, context-responsive curriculum framework that accommodates diverse school environments and fosters innovative resource use.

5.3.2 Gaps in Teacher Training and Confidence

Although some teachers reported receiving CBC and ICT training, many acknowledged limited knowledge and inadequate preparation in biodiversity pedagogy. One teacher expressed only being “50% confident” due to the absence of key specimens, while students highlighted the importance of early, structured preparation in enhancing learning readiness. Mpate (2023)

similarly observed that partial training and resource scarcity reduce teachers' confidence and capacity to deliver meaningful biodiversity instruction. These findings also echo Wambi *et al.* (2024), who emphasized that effective environmental education hinges on well-trained, confident teachers capable of adapting content to local contexts.

The findings reveal that training alone is insufficient unless it is continuous, practical, and contextualized to teachers' environments. This implies the need for targeted retooling for professional development programs that empower teachers with adaptive strategies for integrating biodiversity using locally available resources.

5.3.3 Practical Implementation Barriers

Practical constraints such as large class sizes, laboratory limitations, safety concerns, and weak community support further hinder the implementation of biodiversity-based lessons. Teachers reported managing up to 120 students in spaces meant for fewer than 40, while more than half of the students expressed fear of handling certain biological specimens. Additionally, community stakeholders often viewed requests for assistance through a "monetary lens," weakening school-community collaboration.

These barriers mirror those highlighted by Mpate (2023), who found similar overcrowding and safety concerns in CBC delivery. Moreover, research by De Azevedo (2022) emphasized that fear of certain animals and limited teacher control over large groups can reduce the effectiveness of hands-on biology education. The findings point to deeper structural and psychosocial limitations in CBC implementation. This implies a need for differentiated instructional strategies, such as shift-based lab sessions, safety-oriented biodiversity kits, and community sensitization, to enhance learner participation and support.

5.3.4 Limited Community Engagement

The study also revealed weak community engagement, with limited involvement of local stakeholders in biodiversity education. Teachers reported that many community members expect monetary compensation for support, while few are involved in co-teaching or resource provision.

These findings are in line with Wals (1999), who observed that school-community partnerships are often underutilized in environmental education. Babou *et al.*, (2023) further recommend

engaging communities through collaborative projects that promote shared responsibility for local ecosystem conservation.

This lack of engagement reflects a missed opportunity to harness community biodiversity knowledge and resources. The implication is that schools must actively develop outreach strategies such as open field days, biodiversity clubs, and participatory conservation projects, to involve parents, local leaders, and experts in education.

5.4 Suggested Solutions to Challenges in Using Biodiversity Resources

Establish School-Based Innovations

Despite numerous barriers, both teachers and students proposed school-based innovations, such as biodiversity gardens, aquariums, and conservation sites, to support biodiversity learning. Students also advocated for clearer instructions and more practical time. Teachers emphasized collaboration with local biodiversity experts and use of natural habitats within school grounds.

These suggestions align with recommendations from Gonçalves (2021), who identified school gardens and ponds as effective tools for biodiversity education in resource-constrained settings. Cimi and Campbell (2016) further noted that integrating local biodiversity into curriculum delivery enhances learner engagement and contextual understanding.

These findings highlight the agency of teachers and learners in co-creating solutions to biodiversity education challenges. The implication is that school-based innovations, if institutionally supported, can fill resource gaps and provide low-cost yet effective alternatives for experiential learning.

Institutional frame works and Policy Needs

Teachers consistently called for stronger institutional frameworks to support biodiversity-based teaching. They emphasized the need for financial assistance, curriculum toolkits, and clear policy guidelines from the Ministry of Education. One teacher remarked, “The district and ministry should provide financial support and a local biodiversity teaching policy.”

This call mirrors findings by Loinaz (2017), who stressed the role of institutional policy and financing in sustaining environmental education programs. Babou *et al.* (2023) similarly

advocated for national biodiversity toolkits and structured curriculum integration to ensure consistency across schools.

The findings suggest that biodiversity education cannot rely solely on school-level initiatives. Rather, it requires coordinated national strategies that provide technical, financial, and curricular guidance to ensure equitable implementation of CBC. The implication is that policy makers must embed biodiversity as a core theme within national education policy, supported by adequate budgeting and monitoring.

5.5 Conclusion

This study set out to investigate the use of biodiversity resources in the teaching and learning of biology under the Competency-Based Curriculum (CBC) in Uganda, with a specific focus on (i) identifying the types of biodiversity resources used, (ii) evaluating students' perceptions of their influence on understanding and confidence in biology learning and (iii) exploring the challenges faced in their utilization. Based on the data collected through surveys, interviews, lesson observations, the following conclusions can be drawn:

- The findings revealed that a wide range of biodiversity resources both biotic and abiotic are actively utilized in biology lessons across secondary schools. These include local flora and fauna (e.g., frogs, termites, and plant specimens), preserved specimens, water and soil samples, and ecological field sites such as swamps and anthills. Learning environments for biodiversity engagement span from school laboratories and field excursions to less frequently used classrooms and digital platforms. The intentional inclusion of biodiversity in lesson plans, objectives, and assessment strategies reflects strong alignment with CBC pedagogical principles, emphasizing hands-on, contextual, and learner-centered instruction. However, digital biodiversity tools remain underutilized due to infrastructural and training deficits, highlighting a critical area for development.
- Students overwhelmingly reported that biodiversity-based teaching positively influenced their comprehension, confidence, and academic performance in biology. Interaction with real organisms and ecosystems facilitated critical thinking, scientific inquiry, and environmental stewardship, consistent with CBC competencies. Quantitative analyses showed statistically significant relationships between exposures to biodiversity resources especially local

animals, ecosystem visits, and community experts and increased student confidence and conceptual clarity. Qualitative responses affirmed that these resources make learning enjoyable, memorable, and meaningful, with students frequently citing improved exam performance and deeper engagement with biology content. However, digital tools were perceived to have a minimal impact, largely due to lack of access, rather than pedagogical inefficacy.

- Despite the pedagogical value of biodiversity resources, their utilization is constrained by curriculum limitations, logistical barriers, teacher preparedness, and community disengagement. Key obstacles include limited time for fieldwork, overcrowded classrooms, shortages of practical tools, safety concerns, and a lack of structured support from local communities. Teachers cited insufficient training and inconsistent access to biodiversity materials, which undermines their confidence in fully executing CBC-aligned strategies. While innovative efforts such as setting up school-based conservation areas and involving local experts demonstrate promise, they remain isolated practices in the absence of systemic support. The findings underscore a clear need for institutional reform, including policy guidance, funding mechanisms, infrastructure investment, and community outreach to embed biodiversity education sustainably within Uganda’s CBC framework.

5.6 Recommendations

From objective i:

Curriculum Developers (NCDC) should integrate biodiversity learning goals into biology topics, provide clear guidelines on the identification and use of biodiversity resources, and develop practical teaching materials and case studies to support teachers in resource selection.

From Objective ii:

District Education Offices and School Administrators should foster partnerships with local communities, support the establishment of biodiversity resource centers in schools, and promote student engagement through science fairs, exhibitions, and exchange programs.

Community Leaders, Parents, and Local Experts should contribute local biodiversity knowledge to school programs, assist in creating community-based learning spaces, and collaborate with schools to conserve and utilize biodiversity resources, thereby strengthening students' confidence and the relevance of learning.

From objective iii

The Ministry of Education and Sports (MoES) should allocate adequate funding for biodiversity materials, support regular outdoor learning experiences, and expand access to digital biodiversity tools, particularly in underserved rural schools.

Teacher Training Institutions and CPD Providers should deliver continuous professional development in biodiversity-focused CBC methods, encourage reflective practice.

Students together with their biology teachers should provide local solutions to their challenges like planting rare plant species in the school botanical gardens, using nearby ponds as their aquariums and preserving plant and animal species for repeated use to reduce on over exploitation of the available biodiversity resources

5.7 Areas for future studies

Future research should employ experimental and longitudinal designs to test causal relationships between biodiversity-based instruction and gains in critical thinking, problem-solving, and scientific inquiry skills. Studies could also investigate long-term behavioural outcomes, such as whether exposure to biodiversity-rich instruction fosters lasting pro-environmental behaviour, ecological stewardship, and community engagement in conservation initiatives.

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Appendices

Appendix I: Questionnaire

SECTION A: General Information (To be filled by all respondents)

1. **Gender:**

- Male Female Prefer not to say

2. **Role in the school:**

- Student Teacher School Administrator

3. **Name of school (optional):** _____

4. **Years of experience (teachers/administrators only):**

- Less than 1 year 1–5 years 6–10 years More than 10 years

SECTION B1: For Students Only

Instructions: Tick the answer that best reflects your opinion.

Key:

SA = Strongly Agree A = Agree NS = Not Sure D = Disagree SD = Strongly Disagree

Statement	SA	A	NS	D	SD
1. I enjoy biology more when real-life materials like plants and animals are used.					
2. Biodiversity resources help me understand biology topics better.					
3. I remember biology content more when we use real-life examples and outdoor learning.					
4. I feel more confident answering biology questions after lessons using biodiversity resources.					
5. Fieldwork and nature-based activities help me relate biology to real life.					

Open-Ended Questions:

6. Describe a biology lesson where real plants, animals, or a nature walk were used:

7. How do biodiversity resources make biology easier or harder for you to understand?

SECTION B2: For Teachers Only

Instructions: Tick the answer that best reflects your opinion.

Statement	SA	A	NS	D	SD
1. Students learn biology more effectively when biodiversity resources are integrated into lessons.					
2. Using local biodiversity (e.g., plants, insects) helps students connect theory with real life.					
3. Students are more confident and engaged during lessons that involve biodiversity resources.					
4. Practical activities with biodiversity enhance students' memory and comprehension of biology.					
5. I regularly use biodiversity resources to make biology lessons more interactive.					

Open-Ended Questions:

6. In what ways do you think biodiversity resources affect students' understanding of biology?

7. What limitations do you face in using biodiversity resources effectively?

SECTION B3: For School Administrators Only

Instructions: Tick the answer that best reflects your opinion.

Statement	SA	A	NS	D	SD
1. The school supports the use of biodiversity resources in teaching biology.					
2. Students benefit academically when teachers use real-life biodiversity materials.					
3. Our school encourages outdoor learning activities and nature-based biology teaching.					
4. Investing in biodiversity-based learning enhances students' confidence and performance in science.					
5. The school provides sufficient support for biology teachers to use biodiversity resources.					

Open-Ended Questions:

6. What role does school leadership play in promoting biodiversity-based learning?

7. What challenges do you think hinder effective use of biodiversity resources in your school?

Thank You for Participating

Appendix II: Interview Guide

Dear respondent, I am a Masters student from Makerere University conducting an Investigation into the “Use of Biodiversity Resources in Biology Teaching and Learning at Lower Secondary Schools in Oyam District”. To conduct this study, I humbly request for your participation in completing this interview guide. This information given will be handed with the highest level of confidentiality and utilized exclusively for academic purposes.

Section A: Background Information

Can you please tell me your name (optional), teaching experience, and the classes you currently teach in biology?

Have you received any training or attended any workshops related to the use of biodiversity resources in science teaching?

Section B: Types of Biodiversity Resources Used

What types of biodiversity resources do you currently use when teaching biology in your school?

How do you integrate these biodiversity resources into your lessons or practical activities?

Where do you usually obtain these biodiversity resources from?

In your opinion, how effective are biodiversity resources in enhancing students’ understanding of biology concepts?

Section C: Challenges in Utilizing Biodiversity Resources

What challenges do you face when trying to use biodiversity resources in your teaching?

7. Do you face any resistance from students, parents, or school administration regarding the use of these resources?
8. Are there environmental or infrastructural limitations that hinder the effective use of biodiversity resources in your school?

9. What support or resources would you need to improve the use of biodiversity resources in your teaching?

Section D: Recommendations

11. What recommendations would you make to improve the integration of biodiversity resources into biology teaching in your school or district?
12. Is there anything else you would like to add regarding your experiences with biodiversity resources in biology education?

Thank you for your participation.

Appendix III: Consent form for respondents to participate in the study

Title of the study: Investigation of Biodiversity Resource use in Biology Teaching and Learning at Lower Secondary Schools in Oyam District.

Researcher: Akullu Esther

Institution: Makerere University

Introduction

You are invited to participate in a study conducted by Akullu Esther, a Master's student of Makerere University. This study will be conducted for partial fulfilment of the requirements of the award of a Master of Education (Science Education). The purpose of this study is to investigate the use of biodiversity resources in lower secondary biology teaching and learning in Oyam District. You were selected as a possible participant in this study because you are part of the school. Your identity will not be revealed to anyone as we shall only use codes or pseudo name to identify participants. Information obtained will only be accessible by the researcher.

Statement of consent

.....has described to me what is going to be done. I understand that my decision to participate in this study will not affect me in any way. In the use of this information, my identity will be concealed. I am aware that I may withdraw at any time. I understand that by signing this form, I do not waive at any of my legal rights but merely indicate that I have been informed about the research study in which am voluntarily agreeing to participate. A copy of this form will be provided to me.

Name.....Signature of participant.....Date.....

Name.....Signature of interviewer.....Date.....

Appendix IV: Budget Estimates

Research Title: An Investigation into the Use of Biodiversity Resources in Biology Teaching and Learning at Lower Secondary School Level in Oyam District

The following budget estimate outlines the financial requirements for conducting the research. It includes costs for data collection, materials, transportation, and other essential resources necessary to complete the study.

Budget Breakdown:

Item	Unit Cost (UGX)	Quantity	Total Cost (UGX)
1. Data Collection Tools			
- Printing of Questionnaires, Interview Guides, etc.	500	200 copies	100,000
- Fieldwork Transportation	30,000	10 trips	300,000
- Participant Incentives (e.g., for interviewees)	20,000	50 people	1,000,000
2. Researcher's Travel and Accommodation			
- Travel to Oyam District (round-trip)	50,000	2 trips	100,000
- Accommodation for Researcher (per night)	100,000	10 nights	1,000,000
• Meals	15,000	10 days	150,000
• Transport within	50,000	10days	500,000
3. Data Analysis Software and Tools			
- SPSS or other Statistical Software (license)	200,000	1	200,000
- Miscellaneous Supplies (stationery, printing, etc.)	150,000		150,000
Data coding and entry			1,000,000
Data analyst			1,000,000
4. Research Assistant			
- Assistant stipend (per day)	30,000	10 days	300,000
• Meals	15,000	10 days	150,000
• Transport within	30,000	10 days	300,000
5. Report Printing and Binding			
- Printing and Binding of Final Report	20,000	5 copies	100,000
6. Miscellaneous Costs			
- Miscellaneous expenses (stationery, postage, etc.)	100,000		100,000
Total Estimated Budget			6,350,000