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Hydro-climatic fluctuations and their impact on peatland ecosystems in theItimbiri River Basin, Mongala province, Democratic Republic of Congo (1983-2023)

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ABSTRACT

Peatland ecosystems are highly sensitive to hydro-climatic fluctuations, with changes in temperature, precipitation, and water availability significantly affecting their structure, function, and carbon storage capacity. This article examines the hydro-climatic fluctuations and their impact on peatland ecosystems in the Itimbiri River Basin, Mongala Province, Democratic Republic of Congo, over a forty-year period from 1983 to 2023. The study employed a mixed-methods approach combining analysis of climate data (temperature, precipitation, humidity), hydrological data (water levels and discharge), and land use and land cover change analysis using remote sensing and GIS. Climate data were obtained from NASA's GISTEMP and the Hydrological Reanalysis for the Congo River Basin. Hydrological data were obtained from the Régie des Voies Fluviales. Land use and land cover change was analyzed using Landsat satellite imagery for five time periods (1983, 1993, 2003, 2013, and 2023). Results revealed significant fluctuations in climate variables over the study period. Temperature increased from 23.86°C in 1983 to 26.12°C in 2003, the highest recorded, before declining to 24.68°C in 2023. Precipitation decreased from 1,687.50 mm in 1983 to 1,302.64 mm in 2003, the lowest recorded, before increasing to 2,028.79 mm in 2023. The year 2003 exhibited the most significant climatic perturbation, with the highest temperature, lowest precipitation, and corresponding declines in water surface area (from 237 km² in 1983 to 191 km² in 2003) and vegetation indices (NDVI, NDWI, SAVI). The analysis of hydrological data revealed an overall decline in water levels and discharge over the study period, with the most significant declines observed in the last two decades. The standardized precipitation index indicated moderate to extreme drought conditions in 2003. The study found a strong correlation between climate fluctuations and land cover change, with the period of highest temperature and lowest precipitation (2003) coinciding with the most dramatic land cover changes, including a loss of 16,937 km² of primary forest and an expansion of bare soil and agricultural land. The study concludes that hydro-climatic fluctuations have a significant impact on the structure and function of peatland ecosystems in the Itimbiri River Basin. The observed climate trends, particularly the increasing temperatures and decreasing water availability, pose significant threats to the long-term sustainability of these ecosystems. The study recommends the establishment of a comprehensive monitoring network for climate and hydrological variables in the Congo Basin and the development of adaptation strategies to mitigate the impacts of climate change on peatland ecosystems..

Keywords: Hydro-climatology, Peatlands, Climate Change, Itimbiri River Basin, Water Availability, Drought, Deforestation, Congo Basin, Mongala Province

RESUME

Les écosystèmes de tourbières sont très sensibles aux fluctuations hydro-climatiques, les changements de température, de précipitations et de disponibilité en eau affectant significativement leur structure, leur fonction et leur capacité de stockage du carbone. Cet article examine les fluctuations hydro-climatiques et leur impact sur les écosystèmes de tourbières dans le bassin de la rivière Itimbiri, province de la Mongala, République Démocratique

du Congo, sur une période de quarante ans de 1983 à 2023. L'étude a employé une approche mixte combinant l'analyse des données climatiques (température, précipitations, humidité), des données hydrologiques (hauteurs d'eau et débits) et de l'analyse du changement d'occupation et d'utilisation des sols utilisant la télédétection et les SIG. Les données climatiques ont été obtenues de NASA GISTEMP et de la Réanalyse Hydrologique du Bassin du Congo. Les données hydrologiques ont été obtenues de la Régie des Voies Fluviales. Le changement d'occupation et d'utilisation des sols a été analysé en utilisant des images satellites Landsat pour cinq périodes (1983, 1993, 2003, 2013 et 2023). Les résultats ont révélé des fluctuations significatives des variables climatiques sur la période d'étude. La température a augmenté de 23,86°C en 1983 à 26,12°C en 2003, la plus élevée enregistrée, avant de diminuer à 24,68°C en 2023. Les précipitations ont diminué de 1 687,50 mm en 1983 à 1 302,64 mm en 2003, la plus faible enregistrée, avant d'augmenter à 2 028,79 mm en 2023. L'année 2003 a présenté la perturbation climatique la plus significative, avec la température la plus élevée, les précipitations les plus faibles, et les déclins correspondants de la superficie de l'eau (de 237 km² en 1983 à 191 km² en 2003) et des indices de végétation (NDVI, NDWI, SAVI). L'analyse des données hydrologiques a révélé un déclin global des hauteurs d'eau et des débits sur la période d'étude, avec les déclins les plus significatifs observés dans les deux dernières décennies. L'indice standardisé de précipitations a indiqué des conditions de sécheresse modérée à extrême en 2003. L'étude a trouvé une forte corrélation entre les fluctuations climatiques et le changement de couverture terrestre, la période de température la plus élevée et de précipitations les plus faibles (2003) coïncidant avec les changements de couverture terrestre les plus dramatiques, incluant une perte de 16 937 km² de forêt primaire et une expansion du sol nu et des terres agricoles. L'étude conclut que les fluctuations hydro-climatiques ont un impact significatif sur la structure et la fonction des écosystèmes de tourbières dans le bassin de la rivière Itimbiri. Les tendances climatiques observées, en particulier l'augmentation des températures et la diminution de la disponibilité en eau, constituent des menaces significatives pour la durabilité à long terme de ces écosystèmes. L'étude recommande l'établissement d'un réseau de surveillance complet des variables climatiques et hydrologiques dans le bassin du Congo et le développement de stratégies d'adaptation pour atténuer les impacts du changement climatique sur les écosystèmes de tourbières.

Mots-clés : Hydro-climatologie, Tourbières, Changement Climatique, Bassin de la Rivière Itimbiri, Disponibilité en Eau, Sécheresse, Déforestation, Bassin du Congo, Province de la Mongala

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1. INTRODUCTION

Financial audit plays a critical role in ensuring good governance and accountability in public utility establishments. Through independent examination of financial statements and internal controls, financial audit provides assurance on the regularity and sincerity of accounts, identifies weaknesses, and makes recommendations for improvement. The concept of governance refers to the structures, processes, and practices through which organizations are directed and controlled, focusing on the relationship between stakeholders, boards, and management (OECD, 2015).

In the Democratic Republic of Congo, the reform of public financial management has emphasized the importance of audit in ensuring good governance and accountability. The Loi relative aux Finances Publiques (LOFIP) of 2011 established a framework for public financial management that includes external oversight mechanisms. The Inspection Générale des Finances (IGF) serves as the supreme financial oversight body, while external auditors provide independent assurance on the financial statements of public entities.

Public utility establishments, such as the Performance-Based Financing Public Utility Establishment (EUP-FBP) in the Mongala Province, are subject to the same governance and accountability requirements as other public entities. These organizations receive public funds and are accountable to stakeholders for the use of those funds. Financial audit provides a mechanism for ensuring that funds are used effectively and in accordance with applicable regulations.

The concept of governance in public sector organizations is grounded in several key principles: accountability, transparency, participation, rule of law, effectiveness and efficiency, responsiveness, and consensus orientation (OECD, 2015). Financial audit supports these principles by providing independent assurance on the use of public funds and the performance of public entities.

This article examines the impact of financial audit on governance and performance in public utility establishments, using the EUP-FBP in the Mongala Province as a case study. The study specifically addresses the question of what impact financial audit has on governance and performance in public utility establishments, testing the hypothesis that financial audit has a positive impact on governance and performance.

2. METHODOLOGY

2.1 Research Design

This study employed a qualitative case study design, using documentary analysis of financial statements, budgets, and audit reports for the period 2019 to 2023. The case study approach was chosen because it allows for in-depth analysis of the governance structures and processes within a specific organizational context, and the impact of financial audit on these structures and processes.

2.2 Data Sources

Data for this study were drawn from multiple sources to ensure triangulation and validity of findings. First, the governance documents of the EUP-FBP were obtained, including the statutes, the organizational chart, and the board composition. Second, financial documents for the period 2019 to 2023 were analyzed, including summary cash books, table of employment and resources, budget execution tables, bank books and reconciliations, personnel situation, and inventory situation. Third, the external audit report for the fiscal year 2022 was analyzed, which included the audit opinion, financial statements, notes annexes, and recommendations on internal control. Fourth, semi-structured interviews were conducted with key personnel including the Director, the Administrative and Financial Manager, and the Accountant, to gather qualitative insights on the impact of audit on governance and performance.

2.3 Data Analysis

The analysis employed thematic content analysis of the documents and interview transcripts. Themes identified included governance structures, board composition and functions, internal control systems, audit findings, and the impact of audit on governance and performance. The analysis followed a systematic process: first, the documents were read thoroughly to gain an overall understanding of the content; second, key passages were identified and coded according to the themes; third, the coded passages were organized into broader categories; and fourth, the relationships between the categories were analyzed to develop a comprehensive understanding of the audit impact.

2.4 Study Setting

The study was conducted at the Établissement d'Utilité Publique en Financement Basé sur la Performance de la Province de la Mongala (EUP-FBP/MGL), a public utility establishment created to ensure the verification and certification of quantitative and

qualitative performance achieved by service providers in the health sector and other social domains. The EUP-FBP/MGL is a legal entity with juridical personality, with a social and philanthropic purpose, and an indefinite duration. Its headquarters are located at 206, Avenue YEMO, Quartier Mgr Nganga, Commune Bolikango, Lisala, Province de Mongala, Democratic Republic of Congo.

3. THEORETICAL FRAMEWORK

3.1 Corporate Governance Theory

Corporate governance theory deals with how enterprises are directed and controlled, focusing on the relationship between shareholders, directors, and management. In the context of public utility establishments, governance theory applies to the relationship between stakeholders (including the government, partners, and beneficiaries), the Board of Directors, and management.

The key principles of good governance include accountability (ensuring that decision-makers are answerable for their actions), transparency (ensuring that decisions and actions are open to scrutiny), participation (ensuring that stakeholders have a voice in decision-making), rule of law (ensuring that decisions and actions are based on laws and regulations), effectiveness and efficiency (ensuring that resources are used to achieve objectives), responsiveness (ensuring that the organization responds to the needs of stakeholders), and consensus orientation (ensuring that decisions reflect the broad consensus of stakeholders). These principles are reflected in the governance structures and processes of public utility establishments.

3.2 Internal Control and Governance

Internal control is a key component of governance, providing the mechanisms through which organizations ensure that their activities are conducted effectively, efficiently, and in compliance with applicable laws and regulations. The internal control framework includes control environment (the foundation of the internal control system), risk assessment (the identification and analysis of risks), control activities (the policies and procedures that ensure management directives are carried out), information and communication (the systems that capture and communicate relevant information), and monitoring activities (the ongoing assessment of the internal control system) (COSO, 2013).

The internal audit function is an important element of the internal control system, providing independent assurance on the effectiveness of controls and making recommendations for improvement. Internal audit also supports governance by providing assurance on the reliability of financial and operational information. The Institute of Internal Auditors (2020) defines internal audit as "an independent, objective assurance and consulting activity designed to add value and improve an organization's operations."

3.3 External Audit and Accountability

External audit provides independent assurance on the financial statements of an organization, confirming whether they present a true and fair view of its financial position. External audit also examines the organization's internal controls and makes recommendations for improvement. Through the audit report, the auditor communicates findings and recommendations to stakeholders, supporting accountability and transparency.

The external audit process follows international standards (ISA) and includes several stages: acceptance of the mission (assessing the reputation of the client, determining competence, and ensuring independence), planning (understanding the entity and its environment, assessing audit risks, and defining the audit approach), implementation of work (executing the work planned using various techniques), completion (reviewing additional evidence, following up on findings, and reviewing subsequent events), reporting (preparing the audit report expressing the auditor's opinion), and post-audit work (archiving the audit file).

The audit report includes the auditor's opinion on the financial statements, which may be unqualified (clean), qualified, adverse, or a disclaimer of opinion. An unqualified opinion indicates that the financial statements present a true and fair view of the organization's financial position. The audit report also includes a letter of management with observations and recommendations on the internal control system.

3.4 Organizational Audit

Organizational audit is a method of analyzing the strengths and weaknesses of a company in all their dimensions: size, division of labor, information and communication circuits, number of hierarchical levels, procedures and rules for operating activities, etc. Organizational audit highlights the strengths and areas for improvement within a company to evolve towards more optimization. Organizational audit is very widely used in large companies to analyze operating procedures and remedy dysfunctions. It involves identifying what can be removed, added, or modified to lighten the structure, reduce reaction time, and increase productivity. It can be implemented when a company encounters problems of efficiency, productivity, or when it needs to restructure profoundly.

4. RESULTS

4.1 Governance Structure of the EUP-FBP

The EUP-FBP has a governance structure comprising two organs: the Board of Directors and the Directorate.

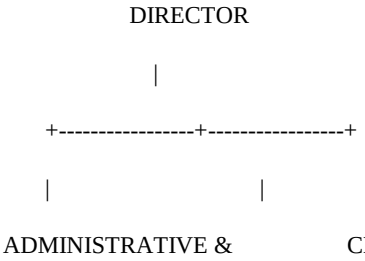
Board of Directors: The Board of Directors is the governing body of the EUP-FBP, responsible for setting strategic direction and overseeing management. According to the statutes (Article 5), the Board comprises nine members: three representatives of public authorities (provincial ministries of health, finance, and planning), four representatives of civil society from non-profit associations or public utility establishments active in the health sector, and two representatives of technical and financial partners. However, the audit identified a contradiction in the statutes, with Article 36 citing 11 members for dissolution purposes.

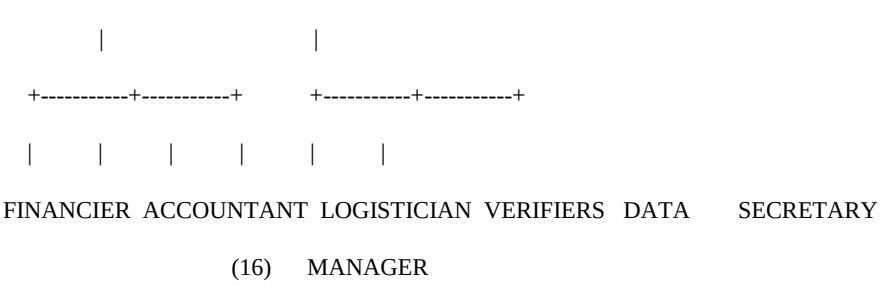
The Board of Directors has several functions: defining the general policy of the EUP-FBP, approving the budget and work plans, supervising the activities of the Directorate, and ensuring compliance with applicable laws and regulations. The Board meets regularly to review the organization's performance and provide guidance to the Directorate.

Directorate: The Directorate is the executive organ of the EUP-FBP, responsible for day-to-day management. The Director is appointed by the Board of Directors and is responsible for implementing Board decisions. The Directorate has several functions: managing the day-to-day operations of the EUP-FBP, preparing budget proposals, periodic reports, and financial statements for Board approval, and implementing decisions of the Board.

The organizational chart of the EUP-FBP shows the following structure: Director, Administrative and Financial Manager, Chargé de Programme, Verifiers, Data Manager, Accountant, Logistician, Secretary, and support staff.

Figure 1: Organizational Chart of EUP-FBP





Source: EUP-FBP Organizational Chart

4.2 Governance Weaknesses Identified

The external audit identified several governance weaknesses in the EUP-FBP:

Statutory Contradictions: A contradiction was identified in the statutes, with Article 5, paragraph 1 specifying that the Board of Directors has 9 members, while Article 36 on dissolution cites 11 members. This contradiction creates legal uncertainty and could affect the validity of Board decisions. The audit noted that "Article 5, paragraph 1 of the statutes specifies that the members of the Board of Directors are 9 in number detailing the composition, while Article 36 on dissolution sets this number at 11."

Naming of Specific Individuals: Article 5, paragraph 3 names specific individuals as members of the Board of Directors, who are mandataries of ministries (Health, Planning, and Finance) and are subject to change by decision of their hierarchy or in case of ministerial reshuffle at the provincial level. This creates a situation where the composition of the Board may not reflect the current ministerial appointments.

Personnel Mismatches: The audit noted that the Chargé de Programme does not have the profile defined in the statutes (Article 20) and Internal Regulations (Article 50). This suggests a lack of adherence to established procedures and could affect the effectiveness of program implementation. The audit noted that "the Chargé de Programme does not have the profile defined in the statutes of the institution."

Absence of Double-Entry Accounting: The EUP-FBP maintains a cash-based accounting system without double-entry, using Excel spreadsheets. This does not comply with OHADA accounting system provisions and affects the reliability of financial information. The audit noted that "EUP-FBP MGL maintains a cash-based accounting without double-entry on Excel sheets."

Non-Valuation of Fixed Assets: Fixed assets acquired through various projects are not valued in the financial statements. This affects the accuracy and completeness of the balance sheet. The audit noted that "fixed assets acquired under different projects are not valued."

Internal Control Deficiencies: The audit identified several internal control weaknesses, including stock management discrepancies (negative difference of 165 liters for the generator and 500 liters for the vehicle), inappropriate banking practices (receiving funds through money transfer agencies rather than directly into the bank account), and lack of proper documentation.

4.3 Financial Audit Findings

Audit Opinion: The external audit resulted in an unqualified (clean) opinion, stating that the accounts and financial statements reflect a true and fair view of the financial performance of the exercise. This indicates that the EUP-FBP's financial statements are reliable and that funds have been used in accordance with the approved budget. The audit opinion stated: "In our opinion, the

accounts and financial statements of the annual exercise closed on December 31, 2022, reflect a true and fair view of the financial performance of the exercise closed on that same date."

Financial Performance: The audit confirmed that all funds received from the PDSS (646,811 USD) were recorded and used in accordance with the approved budget. The budget execution rate was 67%, with significant under-consumption in several categories. The audit confirmed that "all resources of the EUP-FBP MGL come from its partner PDSS for an amount of 729,694.58 USD, with 975 USD from reimbursements from third parties."

Internal Control: The audit identified significant internal control weaknesses and made recommendations for improvement. The audit report included a letter of management with observations and recommendations on the internal control system. The audit noted that "the internal control system put in place by the EUP-FBP MGL is limited to ensure the reliability of financial statements and the security of the project's assets."

Recommendations: The audit made several recommendations for improving governance and performance, including implementing double-entry accounting, valuing fixed assets, improving stock management, requiring direct bank transfers, ensuring that recruitment respects basic texts, and revising the statutes to eliminate contradictions.

4.4 Impact of Audit on Governance

The analysis identified several ways in which financial audit has impacted governance at the EUP-FBP:

Enhanced Transparency: The audit has enhanced transparency by providing independent assurance on the financial statements and making the findings publicly available through the audit report. The audit report provides stakeholders with information on the financial management and performance of the EUP-FBP. The report includes detailed financial statements, notes annexes, and recommendations that are accessible to all stakeholders.

Improved Accountability: The audit has improved accountability by holding management responsible for the use of funds and the achievement of objectives. The audit findings and recommendations provide a basis for holding management accountable and for taking corrective action. The letter of affirmation signed by management confirms their responsibility for the financial statements and their commitment to implementing audit recommendations.

Strengthened Compliance: The audit has strengthened compliance with applicable laws and regulations by identifying non-compliance and recommending corrective action. The audit's review of procurement, accounting, and other processes helps ensure that the EUP-FBP operates within the legal framework. The audit identified non-compliance with OHADA accounting standards and made recommendations for compliance.

Identified Weaknesses: The audit has identified weaknesses in the governance structure and processes, including statutory contradictions, personnel mismatches, and internal control deficiencies. These findings provide a basis for strengthening governance. The audit identified 10 specific weaknesses and made 12 recommendations for improvement.

Provided Recommendations: The audit has provided recommendations for improving governance, including revising the statutes, ensuring proper recruitment, and strengthening internal control systems. The implementation of these recommendations can improve governance and performance. The audit report includes detailed recommendations with priorities and timelines for implementation.

4.5 Impact of Audit on Performance

The analysis identified several ways in which financial audit has impacted performance at the EUP-FBP:

Improved Financial Management: The audit has identified weaknesses in financial management and made recommendations for improvement. The implementation of these recommendations can improve the efficiency and effectiveness of financial management. The audit's review of the accounting system identified the need to move from cash-based to double-entry accounting, which would improve the quality of financial information.

Enhanced Internal Controls: The audit has identified internal control weaknesses and made recommendations for strengthening controls. Stronger internal controls can reduce the risk of fraud and errors and improve the reliability of financial information. The audit's recommendations on stock management, banking practices, and asset management would strengthen the internal control system.

Better Risk Management: The audit has identified risks to the organization and made recommendations for managing them. Better risk management can help the organization avoid problems and achieve its objectives more effectively. The audit identified risks related to accounting, procurement, and internal controls and made recommendations for managing these risks.

Increased Efficiency: The audit has identified inefficiencies in operations and made recommendations for improving efficiency. The implementation of these recommendations can reduce waste and improve the cost-effectiveness of activities. The audit's review of budget execution identified areas of under-consumption that could be addressed to improve efficiency.

Improved Decision-Making: The audit has provided information that can support better decision-making by the Board of Directors and management. The audit findings and recommendations provide a basis for making informed decisions about resource allocation and strategic direction. The audit report provides a comprehensive assessment of the organization's financial position and performance.

5. DISCUSSION

The findings of this study demonstrate that financial audit has a positive impact on governance and performance in public utility establishments. The unqualified opinion issued by the external auditor confirms the regularity and sincerity of the accounts, providing assurance to stakeholders that the EUP-FBP is managing funds effectively. This confirms the third hypothesis that financial audit has an impact on governance and performance.

The positive impact of audit on governance is evident in several areas. Enhanced transparency through the audit report provides stakeholders with information on financial management and performance. Improved accountability is achieved by holding management responsible for the use of funds and the achievement of objectives. Strengthened compliance with applicable laws and regulations is achieved through the identification of non-compliance and recommendation of corrective action. The identification of weaknesses in governance provides a basis for strengthening governance structures and processes.

The positive impact of audit on performance is evident in improved financial management, enhanced internal controls, better risk management, increased efficiency, and improved decision-making. These improvements are consistent with the findings of other studies on the contribution of audit to public sector performance. Sahmi and Boudjemia (2022) found that audit contributes to the promotion of public service efficiency by identifying deficiencies and recommending corrective actions. Ngirabega et al. (2011) found that audit helps improve the management of public hospitals by identifying weaknesses and recommending improvements.

However, the impact of audit depends on the implementation of recommendations and the strengthening of internal control systems. The study found that while the audit identified several weaknesses and made recommendations, the extent to which these

recommendations have been implemented is unclear. This is a common challenge in audit practice, as highlighted by the World Bank (2019), which found that the lack of follow-up on audit recommendations limits the impact of audit on performance.

The governance weaknesses identified in the study are significant and need to be addressed to strengthen the governance framework of the EUP-FBP. The contradiction in the statutes regarding the size of the Board of Directors and the naming of specific individuals as members creates legal uncertainty and could lead to governance issues. The statutes should be revised to eliminate this contradiction and to ensure that the composition of the Board of Directors is clearly defined in a way that allows for changes in ministerial appointments without requiring statutory amendments.

The personnel mismatches identified in the study also need to be addressed to improve the effectiveness of program implementation. The Chargé de Programme does not have the profile defined in the statutes, which could affect the quality of program implementation. The recommendation to ensure that the recruitment of executives respects the basic texts of the EUP is therefore important for strengthening organizational effectiveness.

The internal control weaknesses identified in the study, including the absence of double-entry accounting, non-valuation of fixed assets, and stock management discrepancies, need to be addressed to strengthen the internal control system and improve the reliability of financial information. The implementation of the audit recommendations on these issues would strengthen the internal control system and improve governance and performance.

The absence of a double-entry accounting system is a significant weakness that affects the reliability of financial information. The transition to double-entry accounting in accordance with OHADA standards would improve the quality of financial information and facilitate the preparation of reliable financial statements. The acquisition of dedicated accounting software would also automate accounting processes and reduce the risk of errors.

The non-valuation of fixed assets affects the completeness and accuracy of the financial statements. The valuation of fixed assets at acquisition cost and depreciation over useful lives would provide a more accurate picture of the organization's assets and financial position. The coding and identification of fixed assets would also facilitate tracking and verification.

6. CONCLUSION

This study examined the impact of financial audit on governance and performance in public utility establishments, using the EUP-FBP in the Mongala Province as a case study. The findings confirm the hypothesis that financial audit has an impact on governance and performance.

The audit had a positive impact on governance by enhancing transparency, improving accountability, strengthening compliance, identifying weaknesses, and providing recommendations. The audit also had a positive impact on performance by improving financial management, enhancing internal controls, better risk management, increasing efficiency, and improving decision-making.

However, the impact of audit depends on the implementation of recommendations and the strengthening of internal control systems. The governance weaknesses identified in the study, including statutory contradictions and personnel mismatches, need to be addressed to strengthen the governance framework of the EUP-FBP. The internal control weaknesses identified need to be addressed to strengthen the internal control system and improve the reliability of financial information.

Based on these findings, the following recommendations are made: the statutes should be revised to eliminate contradictions; the recruitment of executives should respect the basic texts; the EUP-FBP should implement a double-entry accounting system; fixed

assets should be valued and properly tracked; stock management procedures should be improved; and direct bank transfers should be required from partners. The implementation of these recommendations would strengthen governance and improve performance at the EUP-FBP.

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