REPUBLIC OF TURKEY

OSTİM TECHNICAL UNIVERSITY

AI-POWERED CARBON FOOTPRINT TRACKING IN GREEN BANKING: A BENCHMARKING ANALYSIS OF QNB FINANSBANK

GRADUATION PROJECT

BARAA AKASHA

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This graduation project titled “AI-Powered Carbon Footprint Tracking in Green Banking: A Benchmarking Analysis of QNB Finansbank” by Baraa Akasha (Economics Department) has been reviewed and approved as a graduation project by the faculty members listed below.

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[Second Jury Member] .....

[Third Jury Member] .....

[Fourth Jury Member] .....

ABSTRACT

AI-Powered Carbon Footprint Tracking in Green Banking: A Benchmarking Analysis of QNB Finansbank

With specific reference to QNB Finansbank, this article explains how artificial intelligence (AI) can aid digital sustainability in banking. As green banking becomes increasingly strategically important globally, banks must include AI-enabled features that raise consumer environmental awareness. Most notably due to the lack of technology like carbon footprint trackers, AI-powered ESG dashboards, and real-time consumer sustainability data, the researcher's internship with QNB Finansbank disclosed a strategic gap in the bank's digital sustainability performance.

The QNB Finansbank green digital features implementation was quantified based on a weighted benchmarking methodology and compared against the other banks, Garanti BBVA, ING, and HSBC. Based on the data, QNB Finansbank has achieved just 4 of the overall weighted 13 points, and Garanti BBVA is the leader with complete implementation of all six of the benchmarked features.

To close this strategic gap, the report argues that QNB Finansbank must accord the highest priority to the deployment of AI-powered solutions on its mobile and internet channels. The recommendations are to integrate with ESG sources, to build in-house innovation capabilities, and to implement consumer-facing digital initiatives on sustainability. This article provides QNB Finansbank and other banks with an insightful and equitable method for quantifying digital ESG performance

KEYWORDS: GREEN BANKING, ARTIFICIAL INTELLIGENCE, SUSTAINABILITY, BENCHMARKING, QNB FINANSBANK

ACKNOWLEDGMENT

To the Nile that taught me to flow forward, I would like to dedicate this work to my dear country, Sudan. This project is a modest contribution to its advancement and prospects, and all that I have learned and achieved during this has been motivated by the need to make a meaningful contribution to the realization of a better and sustainable Sudan.

I thank my family for their relentless support and constant motivation. To my mother, Marwa Elmubark, and my father, Waeil Akasha, thank you from the bottom of my heart for trusting me and being with me despite all the hardships.

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This is a culmination of all the learning, love, and inspiration that I have been blessed to receive, and I offer it with pride and optimism for what is to come.

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1. INTRODUCTION

Targeting QNB Finansbank and applying artificial intelligence-based technology, this project aims to raise digital sustainability in the financial industry. Green banks are supposed to provide their customers with digital tools aimed at enabling them to understand and reduce their carbon footprints. This responds to the growing worries about greenhouse gas emissions. Many establishments have demonstrated their support for such strategies. By combining digital sustainability initiatives of QNB Finansbank with those of Garanti BBVA, ING, and HSBC, this project intends to close this gap. Despite implying necessary corrections, it seeks to highlight strategic weaknesses in the services offered by the QNB Finansbank.

The author's internship at QNB Finansbank made it rather clear that the company had officially adopted some environmental, social, and governance (ESG) concepts. On the other hand, the bank did not offer customers direct digital tools, including mobile carbon footprint tracking, eco-friendly calculators supported by artificial intelligence, and real-time sustainability feedback. Though it has internal sustainability requirements, the bank does not have any public, interactive, or instructive materials open to view. This makes it more challenging for the bank to aim to increase the number of end consumers involved in environmental projects. Most social, environmental, and government initiatives are internal; their impact on the user experience is rather negligible.

How could artificial intelligence-driven solutions enable QNB Finansbank to enhance its digital banking operations concerning environmental sustainability? The environmental features of the selected universities were assessed using a weighted benchmarking method.

Moreover, this method transcends simple checklists and disclosure comparisons by assigning weights to characteristics depending on the relevance of those criteria. This method helps financial institutions evaluate the services they provide as well as the degree of strategic significance of the digital sustainability solutions they provide.

This approach distinguishes itself from others by stressing customer-centric, technologically related, and high-impact characteristics more than more conventional ESG assessments. On the other hand, the older research equally valued all environmental, social, and governmental (ESG) aspects. Alternatively, this work separates the baseline and advanced sustainability features. It

is necessary to be better aware of the need for both before either strategic investment or creativity can occur. Academic studies on digital banking, green finance, and innovation diffusion theory guide the benchmarking effort aiming at evaluating the performance of six basic sustainability criteria by the selected institutions.

This subject was chosen since it relates to the goals of world sustainability as well as the strategic orientation that financial institutions are now following. This shows how artificial intelligence, consumer experience, and environmental sustainability are aiming at a common goal. The approach was selected depending on accurate and quantitative criteria to support the formulation of answers. This is so since it presents a strategic flaw objective diagnosis. The major objective of this project is to develop a strategy for QNB Finansbank to add digital sustainability solutions built on artificial intelligence into its mobile and online platforms. This will enable the bank and its customers to carry out action plans aimed at stopping climate change.

The relevance of this result cannot be underlined for companies located in developing nations like Turkey, where issues regarding sustainability are growing, yet digital transformation, however, displays unequal distribution. Furthermore, it demonstrates the institutional shift toward innovation motivated by the consumer, a field where compliance-based sustainability projects typically fail. On top of adding to the scholarly debate on digital innovation and sustainable finance, the outcomes give QNB Finansbank and other financial institutions significant fresh insights that will help them increase their confidence among stakeholders, compliance with regulatory criteria, and competitiveness. Should the company combine digital strategy with sustainability, it stands to lead in ethical innovation.

2. LITERATURE REVIEW

2.1 INTRODUCTION

Climate change and environmental damage have led the global banking sector to rethink sustainability. In response, banks and other financial institutions are progressively applying green banking approaches and initiatives that match environmental aims by merging financial goods and banking operations. Strategies included in green finance are sponsoring ecologically sustainable projects, lowering operating emissions, and providing sustainability-linked loans (Zioło, 2024; Özbek, 2024). These projects are driven by legislative needs, shifting stakeholder expectations, and the continuous financial gains linked with the reduction of environmental risks. Along with the growth of green finance, artificial intelligence (AI) has created fresh reporting possibilities on sustainability. Artificial intelligence technologies provide a scalable and effective method for evaluating environmental impacts, especially via data-driven instruments estimating carbon footprints (Martini, 2023). Artificial intelligence and green finance together are altering how businesses assess emissions and involve consumers in ecologically good actions. Emphasizing consumer-centric technology like mobile apps, this literature study looks at how artificial intelligence can enable the banking industry to track carbon footprints. The article gives a case study after looking at QNB Finansbank's present sustainability policy and proposes to include an AI-assisted carbon tracking capability in their mobile platform. This work intends to reveal excellent practices and problems in the digital transformation of green finance by integrating theoretical ideas with pragmatic applications.

2.2 THEORETICAL AND CONCEPTUAL FOUNDATIONS

Three linked theoretical models, ESG, IDT, and Stakeholder, help this article examine initiatives at digital sustainability in the banking sector. Every model demonstrates how artificial intelligence (AI) might be applied in several ways to gauge carbon footprints.

The Environmental, Social, and Governance (ESG) framework is becoming rather significant for evaluating the non-financial performance of a corporation. This is particularly true considering their effects on governance, social life, and the surroundings. Using ESG indicators, which come from responsible investing, financial institutions examine sustainability risks and ensure that companies satisfy their social and environmental targets. Particularly concerning carbon emissions and green money, the framework supports openness policies and strategic

decisions. Using artificial intelligence in environmental, social, and governance (ESG) reports, Barnabas and Owen (2025) claim makes the data more reliable, guarantees that laws are obeyed, and increases the availability. Mostly, this is about tracking carbon emissions.

Published in 1962, Everett Rogers' Innovation Diffusion Theory (IDT) clarifies how institutions accept and propagate innovative ideas. This case develops upon the first one. IDT claims that how value people believe technologies run by AI to be, how well they interact with other technologies, how difficult they are, how easily they might be tested, and how easily they could be seen. Examining how banks categorize themselves into innovators, early adopters, early majority, late majority, and laggards will help one to grasp how the banking sector has embraced artificial intelligence-enabled sustainability solutions. This point of view clarifies the constraints and possibilities influencing the acceptance of digital technology beneficial for the environment by financial businesses.

From a corporate as well as a social standpoint, Freeman's (1984) Stakeholder Theory emphasizes how crucial it is for a corporation to engage outside stakeholders in its decision-making process. From this point of view, institutional initiatives meant to make banks more ecologically friendly should consider the preferences and values of many other stakeholder groups. Among these are green citizens, legislators, consumers, and employees. Artificial intelligence and other digital sustainability initiatives, as well as carbon tracking, respond to regulations and stakeholders' increasing need for environmental responsibility and openness. According to new research, institutional stakeholders, especially investors, have both positive and negative consequences. Puspitasari and Firmansyah (2025) claim that the short-term financial objectives of these parties could contradict sustainability over the long run.

These models, taken together, provide a decent framework for considering where and how AI-based banking carbon footprint tracking technologies are applied. The ESG framework lays performance criteria; the IDT clarifies how new ideas are embraced; and the stakeholder theory supports the moral and strategic justifications for including them. This article assesses, in terms of digital sustainability, the developments achieved by QNB Finansbank and others using these conceptual concepts.

2.3 THE ROLE OF SUSTAINABILITY IN MODERN BANKING

For all the financial institutions out there, including sustainability in banking operations, it has become a strategic need. As climate change gets more severe and legal systems evolve, banks are more obligated to relate their activities to environmental, social, and governance (ESG) ideas. This entails modifying internal procedures to reduce emissions and allocating funds to sustainable companies, including clean technologies, green building, and renewable energy (Utomo, 2024; Özbek, 2024).

Empirical research implies that sustainable banking practices can boost institutional resilience, enhance long-term financial performance, and draw in ecologically minded investors. Companies using sustainability models typically exhibit better stakeholder confidence and risk management abilities. Moreover, research demonstrates that banks following environmental, social, and governance (ESG) criteria demonstrate higher performance during financial crises by avoiding investments bad for the environment and society (Akdemir Ömür, 2012).

The emergence of green financial instruments such as green bonds, sustainability-linked loans, and carbon-neutral investment portfolios has strengthened banks' influence in shaping the sustainability agenda. These solutions satisfy investors' demand for proper decisions and enable banks to provide help to achieve climate-modifying targets (Otomo, 2024).

Developing country banks still face difficulties. Restricted access to reliable ESG data, unequal regulatory enforcement, and inadequate digital infrastructure could make it challenging to generally implement sustainable plans (Rahman, 2025). Nonetheless, several businesses in these areas have begun adding sustainability policies into their strategic planning and reporting under increasing global demand and market expectations.

Renowned Turkish firm QNB Finansbank is positioned especially to profit from this trend. The 2017 Eric and Eichel study underlines the tremendous relevance of Turkish banks in national development, therefore supporting the view that financial institutions are basic in influencing social and economic results. The engagement of QNB Finansbank in green financing and digital transformation projects offers a strong base for improving operational sustainability. Particularly with features tracking and displaying carbon impacts, the digital platforms are essential tools for motivating consumer participation in environmental preservation.

2.4 ARTIFICIAL INTELLIGENCE IN CARBON FOOTPRINT TRACKING

As the financial sector develops its sustainability initiatives, artificial intelligence gains ever more relevance in environmental management. Artificial intelligence helps banks to compile, evaluate, and analyze enormous environmental data, therefore enabling more accurate client and institutional level carbon footprint monitoring (Marty, 2023). These technologies are especially important since banks have an increasing need for public disclosures regarding social, environmental, and governance (ESG) issues as well as for matching their portfolios with climate targets.

Monitoring the carbon footprint entails assessing financial operations as well as greenhouse gas emissions linked to consumer behavior patterns and bank branch energy consumption. Often manual, fragmented, and labor-intensive, standard approaches to emissions computation are applied. By closely analyzing transaction data and behavioral cues to deduce carbon emissions, artificial intelligence models, especially those using machine learning and neural networks, can automate this process (Marty, 2023; Zhao, 2024).

Certain banks and fintech startups have begun to add carbon tracking capabilities into their web platforms. These initiatives attribute carbon ratings to retail, utilities, transportation, and other expenditure areas, therefore providing consumers with instantaneous feedback on their environmental impact. Research indicates that this type of user involvement might raise overall firm ESG ratings and inspire more environmentally friendly consumer behavior (Suherdjo, 2024; Iseal & Luz, 2025).

In carbon tracking, artificial intelligence drives scalability and customization. Algorithms can adapt to meet various user profiles and regional carbon trading, thereby boosting the accuracy over large-scale populations. Moreover, predictive analytics can show emission routes, thereby offering vital information for environmental planning (Martini, 2023; Zhao, 2024).

Nonetheless, adding artificial intelligence to carbon control strategies presents certain challenges. Data privacy, algorithmic bias, and lack of consistent emissions data remain the main concerns. Strong government institutions and the creation of open models are necessary to guarantee the moral use of artificial intelligence, particularly regarding the study of private financial operations. (Chaudhry, 2020).

Including a carbon tracking tool driven by artificial intelligence into its mobile banking app would help QNB Finansbank significantly raise its environmental commitment. Using its

present digital infrastructure, QNB Finansbank can improve its ESG reporting capabilities at the same time give customers tailored carbon insights. This action will promote innovative concepts in sustainable banking solutions targeted at consumers and follow the worldwide best standards.

2.5 MOBILE BANKING AND CUSTOMER ENGAGEMENT IN GREEN FINANCE

As digitization transforms the financial sector, mobile banking systems have developed into effective means of embedding sustainability into consumer interactions. Although these sites provide ease and accessibility, they also obviously can affect customer behavior toward greener solutions. Banks are progressively adding green finance elements into mobile apps to boost openness, encourage responsible purchasing, and integrate clients in the sustainability goals of their businesses (Othman, 2023).

Among the most innovative ideas in this field is mobile phone tracking of the carbon footprint. Using transaction data, these initiatives assess the carbon footprint of consumer spending in utilities, food, and transportation among other industries. Customized visualizations and feedback systems integrating carbon dashboards and emission comparisons support clients to grasp and lower their capability of environmental impact (Iseal & Luz, 2025).

This strategy is beyond mere customer service in banks. Using mobile phones for carbon tracking includes consumers and improves ESG reporting by tying personal activities to company sustainability programs. Particularly for younger groups that give digital convenience and climate responsibility top importance in their financial decisions, this also reflects more general trends in consumer values (Oloyede, Idowu & Ok, 2025).

Application of these elements demands strong digital infrastructure and rigorous ethical guarantees. Financial institutions must make sure new technologies honor privacy, are simple and transparent to operate. Artificial intelligence-driven mobile services must be precisely calibrated to avoid distorting carbon statistics and guarantee accessibility among multiple user types (Rahman, 2025).

The strategic orientation of QNB Finance Bank enables it to embrace this innovation. Working on digital banking projects already, QNB Finansbank can enhance its mobile offerings with a carbon footprint calculator. This would enable the bank to stand out in the Turkish market and assume a teaching and supporting role in national sustainability projects.

2.6 INSTITUTIONAL CHALLENGES AND ETHICAL CONSIDERATIONS IN AI INTEGRATION

Although artificial intelligence presents the banking sector with changing opportunities for sustainability, its use raises various institutional and ethical issues. Applying AI-driven carbon tracking and ESG analytics forces financial institutions to tackle difficulties with data governance, algorithmic transparency, and stakeholder confidence (Choudhury, 2021).

The lack of cogent models for artificial intelligence ethics and carbon accounting presents a primary institutional obstacle. Many banks run across borders with varying regulatory rules for sustainability reporting, therefore hindering the integration of uniform artificial intelligence systems. Especially in loan decisions or ESG assessments, erroneous or inconsistent emissions data could compromise the integrity of carbon monitoring instruments (Chao, 2024).

Ethical problems are crucial. When used to sensitive financial and behavioral data, artificial intelligence systems pose the risk of producing erroneous findings regarding sustainability or spreading already existing prejudices. These tools could unintentionally harm specific user groups or wrongly identify consumption habits without proper oversight (Chaudhry, 2021). Therefore, banks must emphasize transparency and interpretability in artificial intelligence design, especially when dealing with individual consumers through mobile platforms.

Two further problems are data privacy and user permission. Applications for carbon monitoring are driven by transaction data, which can provide complete knowledge of customer environmental actions and way of life. Following privacy rules and preserving ethical standards depend on obtaining informed authorization and allowing consumers control over their data (Rahman, 2025).

From an institutional standpoint, the use of these technologies asks for internal management framework changes and workforce up-skilling modification. Financial institutions must set aside money for staff training so they may implement the sustainability insights offered by artificial intelligence into their complete risk management and compliance systems (Alwi, 2025).

Using AI-driven sustainability technologies, QNB Finansbank must overcome these obstacles as much as other technologically forward businesses. Establishing strong ethical standards, collaborating with regulatory authorities, and including stakeholder comments in the evolution

of tools helps the bank to guarantee that technological innovation benefits rather than compromises its purpose in green financing.

2.7 BENCHMARKING IN GREEN DIGITAL FINANCE

Daily benchmarking is used in academic research, corporate planning, and the comparison of results to ideal criteria or similar companies. Evaluating the degree to which financial institutions are including ESG, societal, and consumer-oriented activities into their online platforms in line with the green finance paradigm is best accomplished by benchmarking. Scholars use benchmarking to find laggards, innovators in digital sustainability, and discipline leaders (Bayri, 2023; Kashi & Shah, 2023). Institutions against standardized criteria like mobile sustainability features, carbon footprint tracking, and artificial intelligence help to do this.

In addition to their availability of environmentally friendly products, including bonds or loans, digital green finance assesses financial institutions on their potential to digitally engage consumers in environmental stewardship, which is becoming more and more important. Financial organizations like ING, Garanti BBVA, and HSBC are known for their capacity to include sustainability ideas into consumer-oriented mobile apps, thereby allowing users to track carbon dioxide emissions in real time, as per (Zhao, 2024; Martiny, 2023). By use of data-driven technology and artificial intelligence, these solutions show the degree to which environmental, social, and governance (ESG) influence is extended outside institutional portfolios into consumer behavior within the financial sector.

Banking sustainability conformance is assessed in benchmarking studies using feature matrices and score systems. Numerical scores (Cansler & Johnson, 2024) help to simplify comparisons and statistical data display by qualitative evaluation. Digital weaknesses in the competitive sustainable finance market must be found; examples of these include the lack of creative bank-oriented ideas and mobile carbon calculators.

The digital sustainability of QNB Finansbank is assessed in this study using benchmarking against that of its rivals. The study creates a grading matrix to compare QNB Finansbank against industry heavyweights such as Garanti BBVA. The matrix assesses digital banking based on six main criteria that give environmental sustainability priority. According to this study, including an artificial intelligence-driven carbon monitoring feature into QNB's mobile banking app will help the bank satisfy the world's digital sustainability criteria.

2.8 CONCLUSION AND RECOMMENDATIONS

Investigating green banking, artificial intelligence, mobile banking innovation, and client participation in carbon footprint tracking was the aim of this literature review. Recent studies indicate that sustainability is today a strategic need driven by regulatory pressure, stakeholder demand, and the global need to act on climate change. The banks would not give this any thought. Financial institutions usually help to increase resilience, openness, and consumer trust by including environmental, social, and governance (ESG) elements (Akdemir Ömür, 2012; Bayri, 2023).

In the realm of sustainable finance, artificial intelligence has shown promise. This results in better predictive environmental modeling, ESG analysis, and emissions monitoring powers of banks. Artificial intelligence-powered mobile banking apps could help to translate nebulous sustainability goals into direct, customized experiences with consumers (Martiny, 2023; Zhao, 2024). These systems generate real-time information on the carbon footprint of financial activity.

While many financial institutions are funding sustainable finance solutions and environmentally friendly internal operations, the poll reveals that just a small percentage of these institutions have included these ideas in their online customer interactions. For example, Garanti BBVA uses carbon calculators included in their mobile apps to inspire consumers to adopt unique habits. Benchmarking helps companies like QNB Finansbank to deliberately grow their operations by highlighting the quantitative variations across peers. Looking at these results, QNB Finansbank should:

- Make sure their smartphone app has artificial intelligence technologies driving a carbon tracking capacity.
- Use reputable and open emission estimations by using well-known ESG data sources.
- Use ethics and data governance in artificial intelligence helps one to find answers to problems of transparency, justice, and privacy.
- Industry-wide benchmarking helps you to monitor the expansion of digital sustainability as well as best practices.
- By means of digital innovation, QNB Finansbank helps programs aiming at improving global environmental and climate resilience, as well as strengthens its market position in Turkey.

3. METHODOLOGY

3.1 RESEARCH DESIGN

This paper aims to ascertain the degree to which green digital banking tools are efficiently integrated across a small number of financial institutions through a benchmarking-based grading system combined with quantitative analysis and qualitative evaluation. The benchmarking model developed sought to compare QNB Finansbank with Garanti BBVA, ING Bank, and HSBC. The main emphasis of the approach was on digital technology and methods fostering environmental sustainability.
The study was carried out combining several approaches:
Weighted grading considering the strategic relevance of every green digital element; descriptive benchmarking to identify which ones are used.
Using statistical analysis and visualization in Microsoft Excel helps one to compare scores with the development of knowledge.

3.2 FEATURE SELECTION

Six benchmarking matrix properties were selected using the following guidelines:
1. Their frequency of appearing in research on digital and sustainable banking (Martiny, 2023; Kashi & Shah, 2023)
2. Systems of global sustainability reporting covering CDP, GRI, UNEP FI, and TCFD
3. Useful applications in other institutions, most importantly, the Garanti BBVA created a carbon footprint measuring tool.

Two primary categories characterize these capacities: institutional ESG activities, which include sustainability reporting, green loans, and partnerships.
Consumer digital sustainability technologies (carbon tracking and mobile CO2 analytics driven by artificial intelligence)

3.3 SCORING AND WEIGHTING METHOD

Each feature was scored on a binary scale, where:

- 1 indicates that the feature is present or implemented, and
- 0 indicates that the feature is absent.

To reflect the strategic impact of each feature, a weighting system was applied:

Appendix A. Benchmarking Matrix of Green Digital Banking Features

The total weighted score for each bank was calculated by multiplying feature scores by their respective weights, then summing the results. Averages were also calculated per feature to assess sector-wide trends.

3.4 DATA COLLECTION

All the data was gathered from annual reports, bank sustainability studies (2022–2023), and other public sources.
Descriptions for Google Play and App Store Mobile Apps
Corporate and official website disclosures, confirmed CDP, GRI, UNEP FI references
There was no consultation of any private or internal bank data.

3.5 TOOLS AND ANALYSIS

Microsoft Excel entered and analyzed data for the following purposes: weighted calculations and grading.
Creating descriptive statistics (averages, totals); developing visuals comprising layered columns, bar charts, and radar charts.
The Findings section of the report was supported by these visuals, which similarly clearly demonstrated how different digital sustainability is between QNB Finansbank and the other banks it faces.

3.6 LIMITATIONS

This study is limited by:

- A small sample size (4 banks) for focused comparison
- The absence of real-time emissions or behavioral data from QNB Finansbank customers
- Reliance on publicly available documents, which may not reflect internal strategies not disclosed
- Nonetheless, the benchmarking framework is scalable and can be applied to broader samples or adapted to future datasets.

4. FINDINGS

4.1 OVERVIEW OF BENCHMARKING RESULTS

Digital green banking projects of QNB Finansbank were benchmarked against Garanti BBVA, ING Bank, and HSBC. The study includes six key components from scientific publications, ESG models, and useful applications. Depending on their strategic relevance, these attributes were weighed one to three.

Every financial institution got a weighted score based on whether these characteristics were present (1) or absent (0). The findings showed rather different variances in institutional performance.

Garanti BBVA topped all with a 13 out of 13 weighted score. All six elements, including artificial intelligence in environmental, social, and governance applications and real-time carbon footprint tracking via its mobile app, have been fully applied. With just four out of thirteen, however, QNB Finansbank exposed a strategic weakness in highly weighted client engagement and AI-driven sustainability solutions. Both ING and HSBC score 7, hence both exhibit modest institutional adoption but inadequate customer-oriented digital innovation.

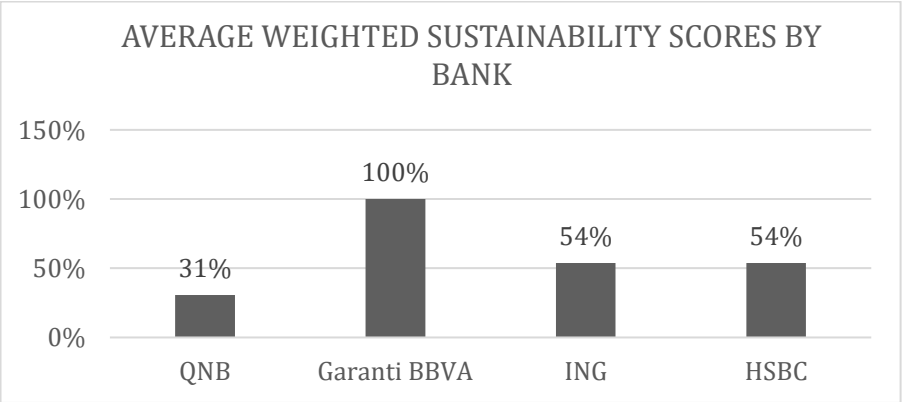

Figure 4.1: Total Weighted Sustainability Scores by Bank

In Figure 4.1, the bar chart shows QNB's competitive disadvantage. These figures will form the basis for feature-by-feature and strategic effect assessment. This chart compares the cumulative weighted performance across six strategic green banking features.

4.2 FEATURE-BY-FEATURE COMPARISON

Radar maps helped one to visualize the four banks' performance across the six green digital criteria. Figure 4.2 shows that Garanti BBVA continuously outperforms the rivals, having one on all six criteria. This implies that both customer-facing and institutional sustainability solutions are being fairly and extensively used.

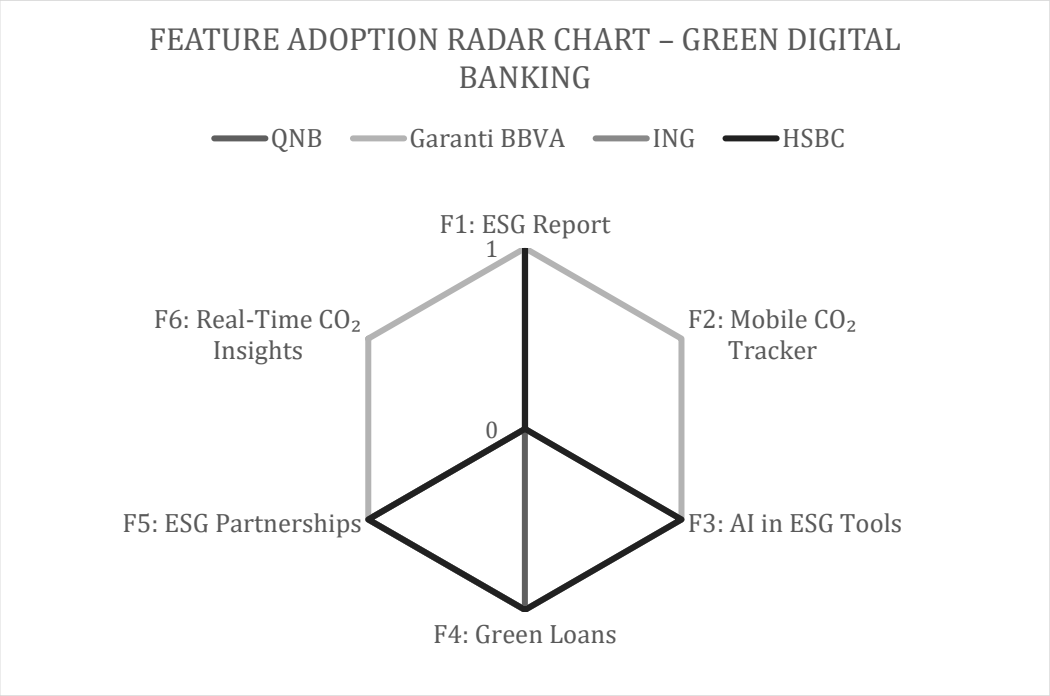

Figure 4.2: Radar Chart of Green Banking Feature Adoption by Bank

In Figure 4.2, Garanti BBVA scores one across all features, while QNB lacks high-impact digital features.

However, QNB Finansbank gets points only for ESG reporting, green loans, and ESG collaborations. Not among them are mobile CO2 tracking, real-time carbon insights, and AI-driven technology. ING and HSBC have institutional traits, even if they lack contemporary digital sustainability elements.
This data shows the digital innovation gap, especially in customer engagement and artificial intelligence, which are essential for modern green banking operations.

4.3 STRATEGIC FEATURE ADOPTION

Figure 4.3 shows, in a bar chart, the average weighted score for every attribute over all four banks. Said the report, "AI in ESG Tools" and "Green Loans" are evidently being adopted by a

bigger audience and strategically linked with sectors' advances based on their highest average scores. These traits either reflect standards or new best practices.

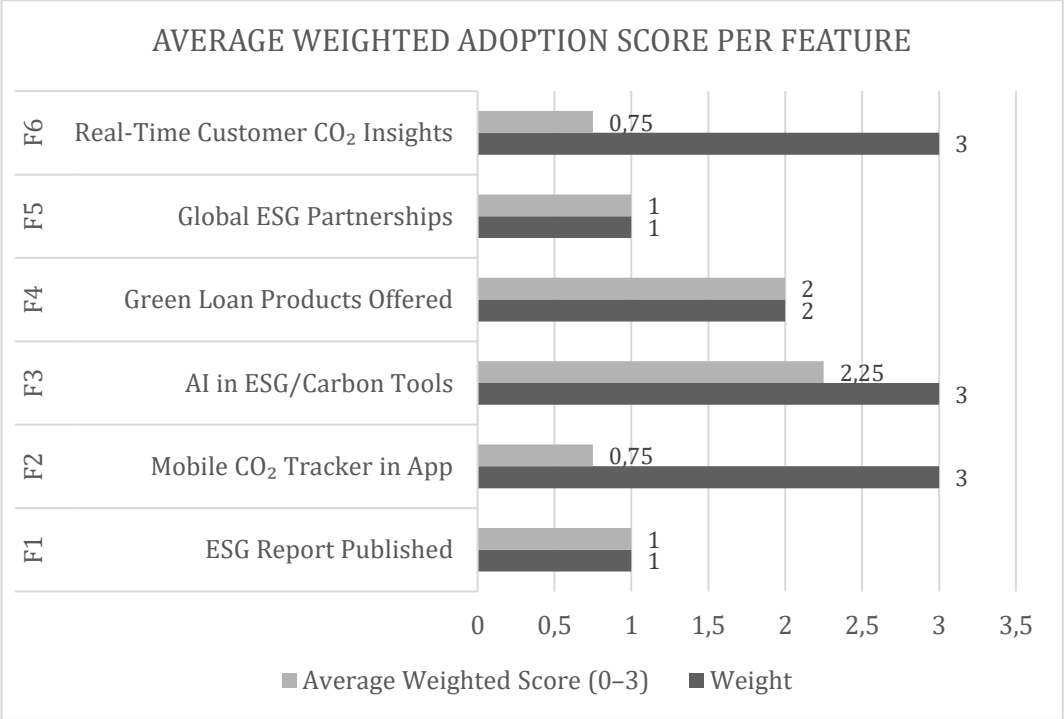

Figure 4.3: Average Weighted Adoption of Green Features Across Banks
Figure 4.3 illustrates that AI in ESG and Green Loans is widely adopted, while carbon tracking tools remain rare.

Comparatively, "Mobile CO2 Tracker" and "Real-Time Customer CO2 Insights" ranked lowest (0.75), implying most of the sector underuses customer-specific carbon tracking. Given these highly weighted but little-used instruments, QNB Finansbank has great innovative potential. This comparison implies that, even if some financial institutions have adopted institutional environmentally friendly policies, consumer interaction and targeted sustainability services available via digital platforms seem to be the next frontier.

4.4 RAW VS. WEIGHTED IMPACT

Figure 4.4 illustrates a stacked column chart contrasting the weighted score, which denotes strategic relevance, with the raw score, that is, the number of acceptable features. Garanti BBVA stresses the most crucial of all six criteria and uses them to get the best score. QNB Finansbank only scores three out of six criteria, most of which have minimal strategic weight, nevertheless. The bank's score is just 3/6. Though they are more strategic, ING and

HSBC exhibit the same traits as QNB Finansbank. This paper demonstrates that increasing features does not ensure a strategic advantage. Particularly those that use artificial intelligence and offer real-time data, sustainability elements are quite appreciated.

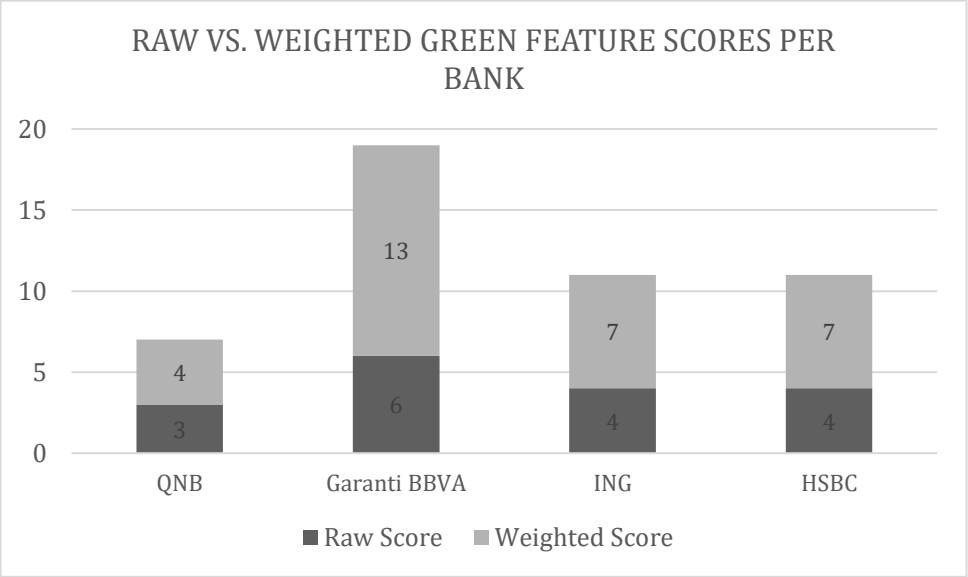

Figure 4.4: Stacked Column Chart – Green Feature Coverage vs. Strategic Impact by Bank
Garanti BBVA shows both quantity and quality; QNB implements fewer, lower-weighted features.

5. DISCUSSION

5.1 INTERPRETATION OF MAIN FINDINGS

According to the benchmarking research carried out for this study, it was determined that QNB Finansbank, Garanti BBVA, ING, and HSBC all had significantly more substantial variations in digital sustainability than was previously believed. The maximum weighted score that Garanti BBVA received was 13, which indicates that they unquestionably support efforts related to digital sustainability in each of the six different sectors. The institution's strategic alignment with innovative digital projects that are aimed at the client is indicated by this good score, which also reflects the institution's dedication to developing these projects. The QNB Finansbank is experiencing considerable difficulties, as indicated by a score of four out of thirteen. A weighted score of zero shows that QNB Finansbank did not successfully integrate key elements such as real-time CO2 analytics, artificial intelligence-enhanced environmental, social, and governance (ESG) technologies, and mobile carbon footprint tracking. These examples are all examples of elements that are essential. The strategic value of the environmental efforts that QNB Finansbank has been making is being lost due to these concerns, which in turn affect the competitiveness of the enterprise for which it is responsible. The fact that both ING and HSBC received seven points implies that the digital advancements they have made are not particularly striking but rather acceptable. These two banks each received seven points, which is the justification for this.

According to the findings of in-depth research, the poor performance of QNB Finansbank may be a sign of skepticism over digital transformation. This is the conclusion found in the analysis. When it comes to the acceptance that took happened with Garanti BBVA, this opposition illustrates the necessity of having a business culture, executive leadership, and strategic vision. It appears that financial institutions are beginning to recognize the significance of the digital environmental, social, and governance (ESG) aspects of their operations, as seen by the contradictory results of ING and HSBC. On the other hand, these banks have not yet made any regulatory allocations or adjustments to their processes to accommodate the incorporation of Garanti Financial Group.

5.2 COMPARISON WITH EXISTING LITERATURE

These findings make sense in line with the previous evaluation of scholarly literature. Garanti BBVA has a digital sustainability score of one hundred percent, hence, Martiny's (2023) suggestion to make use of new digital tools to increase customer knowledge of sustainability is backed. Garanti BBVA shows Martiny that solutions with mobile and artificial intelligence help to raise consumer interaction levels as well as organizational reputation. Furthermore, these facts support Zhao's (2024) assertions that digital sustainability strategies enhance the financial and reputational results of the banking company. Given a score of 31% of the possible weighted score, QNB Finansbank's poor performance fits the concerns voiced by Kashi and Shah (2023). Institutional reluctance, typically resulting from conservative management practices, limited innovation cultures, and operational inertia, obstructed the acceptance of environmental, social, and governance (ESG) solutions. The events surrounding QNB Finansbank support these findings by proving internal opposition and poor strategic prioritizing. The results of Cansler and Johnson (2024) confirmed the rather average performance of ING and HSBC, which was 54% of prospective scores, supported by global industry assessments. The results of their study show that although many financial institutions know the need to include environmental, social, and governance (ESG) elements within customer-facing digital products only use these notions in a limited capacity. Like the results of the benchmarking of the present research, the World Economic Forum (WEF, 2023) found notable variation in the way important financial institutions applied digital environmental, social, and governance (ESG) technologies. The World Economic Forum (WEF) notes that industry leaders are emphasizing digital customer contact and innovation to improve their competitive posture and sustainable branding. Conversely, wary adopters like QNB Finansbank run the risk of not staying competitive. Garanti BBVA's strategic focus gives validity to the proposition put forward by Zhao (2024) and Martiny (2023), which holds that strong digital environmental, social, and governance policies increase customer satisfaction and institutional reputation, thus generating constant competitive advantages. Within the parameters of this research, theoretical models proving a link between strategic priority and fast digital deployment, and improved organizational results are validated. These models show how institutions that commit to digital and customer-oriented sustainability activities can reach these objectives to negotiate market uncertainties, draw consumers who are worried about sustainability, and build themselves as market leaders.

5.3 REASONS FOR GAPS AND STRATEGIC DIFFERENCES

Several factors can be discovered that cause the differences between QNB Finansbank and its rivals. Lack of customer-centric digital sustainability solutions addressed in QNB Finansbank surely shows internal constraints: mobile CO2 tracking (0/3), artificial intelligence-driven ESG apps (0/3), and real-time CO2 analytics (0/3). These difficulties could be a lack of technology knowledge, inadequate strategic prioritizing of digital environmental, social, and governance projects, or uncertainty about consumer acceptance and return on investment. Dependency on well-known sustainability practices, such as green loans (2/2) and institutional inertia, as well as environmental, social, and governance (ESG) reporting (1/1), can feasibly impede innovation. Perfect grade Garanti BBVA obtained in the scope of leveraging digital technology to increase customer participation in sustainability shows the company's proactive attitude, leadership commitment, and clear plan.

Organizational theories (Kashi & Shah, 2023) assert that sometimes the acceptance of innovations is slowed down by institutional inertia, internal opposition, and obsolete ideas. The agile and flexible methodology of Garanti BBVA differs from the digital transformation projects of QNB Finansbank. These concepts are still not fully understood. Given QNB Finansbank's cautious stance parallels more common trends in the financial sector, especially among institutions unwilling to welcome digital and technical innovation as they depend on legacy systems.

Moreover, influencing the reception of digital ESG are the institutional resource allocation priorities. The Garanti BBVA business makes significant investments in digital transformation in areas of sustainability and innovation. Adoption may suffer should QNB Finansbank highlight less investment in digital sustainability and innovation. When compared to banks handling consumers who are more conservative or less technologically minded, those who serve consumers who are technologically advanced and ecologically sensitive may feel a greater need to grow fast.

Under the pressures of outer standards and competitiveness, these inner traits are even more difficult to regulate. Early digital adopters or those in fields with high sustainability criteria force institutions under considerable competitive pressure to speed up the implementation of digital sustainability. Legislative and financial issues enable Garanti BBVA to be in a stronger position than QNB Finansbank in grabbing the economic opportunities presented by sustainable development and digital market conditions.

5.4 PRACTICAL IMPLICATIONS

This report lists the main areas of development that QNB Finansbank must give top priority. It is advised that QNB Finansbank provide the provision of customer-oriented digital solutions, especially those provided by artificial intelligence (AI), including mobile CO2 tracking and real-time data, and of great relevance. This will let the business close the information technology sustainability gap. Two banks that show how even a partial adoption would help QNB's customer engagement, competitive positioning, and global sustainability goals are ING and HSBC (7/13). By developing strategic alliances with top ESG data sources and technology companies, QNB Finansbank could be able to hasten the acceptance of digital innovation. This will help the enterprise to be ready for significant transformation and help to lower the implementation challenges.

To guarantee sustainable integration and eradicate talent shortages in developing technologies, QNB Finansbank should also apply top-down initiatives aiming at promoting internal innovation and skill-building. One can help to strengthen corporate alignment and the acceptability of environmental, social, and governance issues by employing executive-level lobbying, systematic training, internal awareness campaigns, and lowering of internal opposition.

Practically, QNB Finansbank should compare itself with other corporate leaders to keep an eye on consumer preferences, market trends, and competitive surroundings. An internal innovation team or expert task force can help support strategic goals in environmental, social, and governance (ESG) digital transformation be supported. Another approach that might help to speed up strategy changes is using outside consultants knowledgeable in ESG integration and digital transformation. Utilizing environmental, social, and governance (ESG) initiatives that enhance stakeholder communication, one can generate increasing investor confidence, draw customers worried about sustainability, and strengthen the company's reputation.

Using environmental, social, and governance (ESG) performance measures as well as digital innovation projects, the management and staff members at all levels of the organization should be further inspired to help contribute to the strategic sustainability goals. Linking the goals of departments and people to the goals of the institution about sustainability will help to enable the possibilities of incentive systems to overcome organizational stagnation.

5.5 THEORETICAL AND ACADEMIC CONTRIBUTIONS

This paper aims to propose a weighted benchmarking method for implementing digital sustainability in banking, therefore augmenting the corpus of knowledge already in use on green finance and digital transformation. Since it shows the consequences of digital sustainability policies in the real world, this paper largely stresses strategic considerations. This is not the case with previous models that overlooked the feature effects. The unambiguous numerical rating of the six criteria spans zero to three, therefore helping to partially explain the better objectivity and repeatability of the procedure. Future studies could copy or alter this methodological technique to apply it to bigger samples or more general ranges of conditions. This will produce a more credible and realistic study of green banking.
Furthermore, supporting theoretical ideas considering technology and digital investments as primary drivers of banking organization competitiveness are the results of this study. Including digital sustainability into benchmarking plans not only generates fresh ideas and strict approaches for the implementation of the next research but also extends theoretical perspectives. To correctly present the sustainability performance of financial institutions, it is necessary to evaluate the capacity and features targeted at the client demand. This all-encompassing strategy fills in the gaps in the theoretical literature, stressing either the behaviors of the external clients or the capabilities of the internal operations of the organization.
This paper emphasizes the relevance of innovation management theories in understanding the challenges and facilitators related to the acceptance of organizational strategies by financial institutions. Utilizing literature on organizational change and innovation diffusion, the results provide knowledge on how banks either promote or reject current sustainability projects. The article looks at strategic prioritizing, institutional inertia, financial allocation, and leadership commitment. This permits theoretical models stressing the intricate interaction of organizational variables driving digital transformation to get support.
Finally, this research offers academic and professionally effective tools and insights to increase financial sector sustainability using digital innovation. Stressing systematic rigor and pragmatic application helps one to reach this and hence extend the scholarly debate on sustainable banking.

5.6 LIMITATIONS OF THE STUDY

The study shows specific shortcomings, although it is strong. The sample is meant to include just four banks taken separately. Institutions should help to increase knowledge and generalizability in the corporate sector. Therefore, the choice of Turkish banks could restrict the pertinence of the results to other nations with different market dynamics and regulatory systems. Moreover, the general public's access to the data may cause internal strategic decisions and challenges to be neglected, so restricting the scope of the research as well as its general quality. Correctly weighed, the binary scoring system applied in the benchmarking process may oversimplify the degrees of adoption and the maturity of digital sustainability elements. Since this study was only concerned with the capability and operations of institutions, it primarily overlooked the acceptability and involvement of end users.

5.7 FUTURE RESEARCH DIRECTIONS

Future studies with more banks from different countries are advised to validate and extend these outcomes. Globally, research indicates that acceptance of digital environmental, social, and governance practices could be influenced by regional regulatory systems, market dynamics, and cultural variances. The data from the studies confirm this possibility. Organized interviews or case studies help qualitative research reveal organizational challenges and enable digital environmental, social, and governance acceptability. These methods permit qualitative research to be practical. Tracking the development of digital sustainability in financial institutions over several years should ideally reveal trends and the degree of success of strategic projects. Future research on consumer attitudes and behaviors concerning the aspects of digital sustainability is probably inevitable. This will provide consumer uptake and use trends as well as the degree of customer loyalty and satisfaction. Those in charge of making decisions who look at the financial results and return on investment of advanced digital environmental, social, and governance (ESG) projects will be more qualified to merge the aims of sustainability with financial management. Finally, cooperation between many sectors and strategic alliances helps to increase the capability of social governance, digital governance, and environmental governance. In the banking industry, these partnerships could help find innovative collaboration models and best practices that might accelerate the evolution of sustainable digital technology.

5.8 SUMMARY AND FINAL DISCUSSION

This study reveals how strategically important digital sustainability is developing into a distinction for banks. Benchmarking exposed considerable differences between QNB Finansbank and its rivals HSBC, ING, and Garanti BBVA. There are observed several digital integrations of sustainable strategies. Leading in digital sustainability, Garanti BBVA demonstrates how successful creative culture, good leadership, and technological integration can provide a business with a competitive edge and raise its brand. But QNB Finansbank performed poorly, especially in digital ESG targeted at customers. This implies either purposeful priority or systematic transformation.

The research presents a repeatable benchmarking approach, including suitable evaluation criteria, therefore improving scholarly debate. Emphasized also includes leadership commitment, institutional flexibility, market reaction, and theoretical frameworks tying together digital innovation, sustainable integration, and organizational success.

If financial institutions such as QNB Finansbank want to remain competitive in the fast-changing financial scene, they must embrace customer-centric digital environmental, social, and governance innovations, invest in internal capacity, and create strategic alliances. This will enable financial institutions to position themselves to lead in a future when environmental, social, and governance rules are core to commercial success and match themselves with global sustainability goals.

6. CONCLUSION

According to the findings of this study, QNB Finansbank is not as far ahead as its rivals when it comes to incorporating digital sustainability aspects that are driven by artificial intelligence. According to the findings of benchmarking, QNB Finansbank has not yet completely embraced strategic green banking technology like mobile CO2 tracking and real-time ESG information. This contrasts with Garanti BBVA, which has already done so. The resolution of this gap is of the utmost importance, particularly considering the increasing significance of digital involvement in banking and environmental sustainability.

The findings of the study indicate that this gap can be explained by both strategic supervision concerns and an underestimation of the influence that client-facing sustainable technologies have on brand reputation, customer loyalty, and regulatory alignment. Both assumptions are supported by the findings of the study. Using this study, QNB's digital ESG flaws will be identified, and solutions that are research-based, pragmatic, and targeted will be developed because of those flaws. According to the findings of the study, which were driven by data, QNB Finansbank underperformed on all high-weight criteria, except for traits that differentiated the industry. The results of the study indicate that the implementation of artificial intelligence (AI) dashboards and interactive mobile solutions that are driven by environmental, social, and governance (ESG) dashboards has the potential to significantly enhance the performance of QNB, as well as its market positioning and alignment with national and international sustainability outcomes.

During the researcher's internship at QNB Finansbank, the researcher became aware of a problem that the study assisted in addressing in the workplace. Insufficient digital tools that can monitor clients in terms of the impact they have on their surroundings were one of the most serious issues that they faced. A reasonable and evidence-based strategy to improve environmentally friendly digital services is provided by the project. This approach is intended to meet the expectations of both customers and legal authorities. The use of scholarly insights and case studies helps to anchor the recommendations in the theory and trends of the business, which in turn increases the flexibility of the plans.

This analysis does provide answers to the "what" and "why" of the challenges that QNB Finansbank is experiencing, although institutional reform is a challenging endeavor. The acquisition of organizational buy-in, the investment in technology, the management of change, and the performance of continuing assessments are all necessary for the successful

implementation of the solutions offered. It is also emphasized in the study that institutions need to adapt their mentalities to pressure sustainability at all levels of operation, and not just concerning new tools. This is because digital transformation needs institutions to change their mentalities.

Within the context of the QNB Finansbank sustainability plan, the findings of this study provide insightful analysis that is suitable. Through the implementation of the benchmarking method described in this paper, Turkish and other banks may be able to improve their environmental, social, and governance (ESG) capabilities. This demonstrates how strategically vital financial institutions should place a high priority on the degree of digital maturity they possess in terms of sustainability. It is therefore necessary for QNB Finansbank to act and implement the digital tools and practices that are the norm in responsible finance if the company wants to be an innovator in the field of sustainable banking. QNB Finansbank will be able to gain a competitive advantage because of this.

According to the findings of the research, QNB Finansbank ought to immediately establish agreements with ESG data suppliers, initiate projects to develop capabilities in artificial intelligence and sustainability, and test customer-facing products on its mobile banking platform. When it comes to developing a comprehensive digital ESG strategy, QNB Finansbank can start with measures that are relatively minor yet extremely impactful. The effective implementation of these policies may not only improve the brand identity and climate goals of QNB Finansbank, but it may also improve the company's long-term competitiveness.

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APPENDIX A: Benchmarking Matrix of Green Digital Banking Features

APPENDIX A. Benchmarking Matrix of Green Digital Banking Features. This matrix summarizes the application and weighting of six digital sustainability features across four banks.

Feature	Weight	QNB	Garanti BBVA	ING	HSBC
F1: ESG Report	1	1	1	1	1
F2: Mobile CO_2 Tracker	3	0	3	0	0
F3: AI in ESG Tools	3	0	3	3	3
F4: Green Loans	2	2	2	2	2
F5: ESG Partnerships	1	1	1	1	1
F6: Real-Time CO_2 Insights	3	0	3	0	0
TOTAL		4	13	7	7