

# Monetary Modernization and Sustainable Currency Innovation: The Future of Banknotes in the Era of Digital Transformation under Oman's Vision 2040

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## **Abstract:**

The traditional role of central banks is changing because of the significant transformation of global monetary systems brought about by digital innovation and sustainability imperatives. To position currency material innovation as a strategic tool of sustainable and digitally enabled monetary policy, this study looks at monetary modernization through the shift from cotton-based to polymer banknotes. This study examines how the Central Bank of Oman incorporates currency redesign with the innovation, green economy, and digital transformation pillars of Oman Vision 2040, using Oman's recent polymer banknote initiative as a case study. This study creates a conceptual framework that connects polymer currency with operational effectiveness, environmental sustainability, and future-ready monetary infrastructure by utilizing policy analysis and global best practices. The results demonstrate how polymer banknotes support resilient financial systems, sustainable finance, and technological readiness. By redefining physical currency as a catalyst for sustainable economic and environmental transformation, the study offers novel insights.

**Keywords:** Monetary modernization; Sustainable currency; Polymer banknotes; Central bank innovation; Digital transformation; Green economy; financial innovation and Oman Vision 2040.

## **1. Introduction**

Rapid technological advancement, changing financial architectures, and growing sustainability imperatives have all contributed to the significant transformation of the global monetary landscape over the last 20 years. Central banks are becoming strategic agents of innovation, financial inclusion, and environmental responsibility rather than being limited to their conventional mandates of price stability and currency issuance. Today, monetary modernization includes redesigning physical currency systems to meet sustainability, security, and resilience goals in addition to digital payments and financial technologies.

The gradual transition from conventional cotton-based banknotes to polymer currencies is one of the most obvious but little-studied aspects of this change. Since they were first widely used, polymer banknotes have been known to be more durable, more resistant to counterfeiting, and to have a longer circulation life than paper-based notes. Their potential environmental benefits, such as less frequent replacement, lower lifecycle costs, and recyclability, have also drawn attention in more recent times. The material makeup of money has become a strategic policy

consideration as currency systems are expected to support low-carbon transitions and circular economy objectives.

Concurrently, currency design is changing globally due to the growing significance of sustainability, durability, and digital compatibility. Advanced security features, machine-readable components, and digital interfaces that enable integration with automated banking systems, fintech platforms, and cash-handling technologies are now incorporated into modern banknotes. These advancements present physical currency as an evolving part of digitally enabled and ecologically conscious monetary ecosystems rather than as a dwindling legacy instrument.

Oman Vision 2040 offers a thorough national framework that emphasizes economic diversification, growth driven by innovation, environmental sustainability, and digital transformation in this global context. The Vision emphasizes the strategic role that institutional innovation and financial modernization play in fostering a competitive, inclusive, and environmentally friendly economy. In keeping with these goals, the Sultanate's monetary development has reached a major turning point with the Central Bank of Oman's introduction of a new RO 1 polymer banknote. By integrating durability, security, and sustainability considerations into the foundation of monetary infrastructure, this initiative represents a move away from commemorative issuance and toward structural modernization of the national currency system.

Even though polymer banknotes are becoming more widely used worldwide, most of the scholarly material that is currently available focuses on technological security characteristics, resistance to counterfeiting, or public acceptance. In national development objectives, polymer currency has rarely been considered as a tool of sustainable monetary policy or as a strategic facilitator of digital change. Empirical and conceptual research that place monetary material innovation within the Oman Vision 2040 policy framework are conspicuously lacking.

Considering this, the goal of this study is to investigate how Oman's monetary modernization the switch from cotton-based to polymer banknotes can serve as a catalyst for long-term economic and environmental change. The study creates a strategic analytical framework that connects the goals of central bank policy, digital financial ecosystems, and green economy outcomes with polymer currency innovation. This study attempts to provide fresh perspectives on how currency innovation might assist long-term national development plans by placing Oman's polymer banknote endeavour within the framework of global best practices and sustainability discourse.

## **2. Literature Review**

This study uses visual inspection and Video Spectral Comparator (VSC 8000/HS) analysis to compare the security aspects of the UK £10 polymer note versus the Egyptian polymer 10-pound notes. The UK banknote has more sophisticated and varied security mechanisms, making it superior in counterfeit protection, even if the two notes have certain design similarities. The study underlines the need for more concentrated research on safeguarding polymer substrates and shows that design similarities may present security problems. By offering an organized, side-by-side mapping of overt and covert elements, it supports enhanced counterfeit detection techniques and examiner training, contributing new forensic insight. (El Nasr, A. W., Hagar, M., Abu Saied, M. A., & Shaker, A. M. 2025).

Polymer banknotes are increasingly replacing traditional paper currency, with over 45 countries currently adopting polymer substrates and projections indicating wider global diffusion by 2030. Recent studies emphasize that polymer banknotes offer superior durability, advanced optical security features, and improved environmental performance compared to cotton-based notes, including longer circulation life and recyclability. The literature positions polymer currency as an emerging innovation in sustainable banknote design, though largely examined from a technical rather than monetary policy perspective. (Rafiei, A., Karimi, A., Bodaghi, M. 2023)

Banknotes are still in high demand despite the rise of digital payments, and the materials used to make money have changed from metal and shells to cotton paper and, more recently, polymer. Polymer banknotes, which were first used in Australia in 1988, have extended circulation lives, improved security, and environmental benefits. This study looks at the operational and technical needs of Egypt's move to polymer currency, including changes to counting machines, ATMs, printing procedures, and inks. The results, which were obtained using a descriptive-analytical method, indicate that intaglio printing underwent very slight modifications and that holographic application and protective varnishing were the key printing stage changes. The findings also show popular acceptance and highlight the significance of durability evaluations and awareness initiatives. (Simonian, G. N., Khalil, M. M. M., & Youssef, S. R. H. 2022)

The UK's switch from paper to polymer banknotes under its Series G issuance is detailed in the Bank of England's Quarterly Bulletin (2021), which covers the entire process from design and production to circulation and public involvement. According to the study, polymer banknotes were used to make money stronger, safer, and cleaner while highlighting improved durability, cutting-edge security features, and environmental advantages. In addition to benefits in lifecycle efficiency, waste reduction, and carbon footprint, the paper shows notable decreases in counterfeiting after polymer adoption. It also describes how advanced optical security features, tactile accessibility components, and recyclability are made possible by polymer substrates. Crucially, the paper presents polymer banknotes as a component of a long-term plan to update physical currency while preserving public confidence in cash in an increasingly digital payment landscape.

This study compares the environmental performance of Mexican banknotes made of thermoplastic polymer and high-durability cotton paper using a life cycle assessment. The analysis, which uses a functional unit based on lifespan, denomination, household cash consumption, and a five-year period, reveals that polymer banknotes have lower overall environmental impacts, mostly because of their much longer circulation life. However, the stages of raw material extraction and distribution based on crude oil have significant negative effects on the environment. The environmental effects of cotton paper notes are mostly caused by the extraction and transportation of raw materials. Additionally, the study shows that ATM electricity usage is the biggest environmental contributor and that the longevity of banknotes is a crucial factor in determining the overall environmental impact. (Luján-Ornelas, C., Mancebo del C. Sternenfels, U., Güereca, L. P. 2018)

This study investigates whether the maintenance of relatively low-density coin and banknote denomination structures by central banks may be explained by production costs. The authors replicate the efficiency implications of increasing denomination series by adding a per-

denomination fixed cost to Lee et al. (2005)'s matching model and calibrating it using U.S. banknote production data. According to the findings, central banks could greatly increase transaction efficiency and add more denominations without the costs of production outweighing the advantages. This implies that rather than being caused by central bank production limitations, low denomination density is more likely to be the result of costs absorbed by merchants and consumers. (Bouhdaoui, Y., & Van Hove, L. 2017)

The mechanical, chemical, security, and environmental aspects of natural polymer (paper) and synthetic polymer substrates used in banknotes are compared in this study. In addition to inbuilt security features, it looks at mechanical strength, thermal effects, chemical composition, infrared spectroscopy, and thermogravimetric qualities. Performance and color stability were assessed using standard durability and hazard tests, such as abrasion, crumpling, chemical resistance, humidity exposure, and washability. The study offers a thorough comparison of the durability, usefulness, and sustainability of polymer versus paper banknotes by evaluating printability, counterfeit detection, cost-effectiveness, hygiene, and environmental effects. (Goher, A. 2012)

In New Zealand, the need for physical currency has been gradually increasing despite the quick development of electronic payment methods. The value of all banknotes in circulation has gone up, with \$50 notes seeing the biggest gain. To maintain currency quality and protect public trust, the Reserve Bank of New Zealand's note-processing operations are still crucial. The Bank effectively removed older cupronickel coins in 2006 and replaced them with smaller 10, 20, and 50 cent pieces. Revenues from recycled coins paid for all related expenses, and the transfer was finished swiftly and without significant disturbance. Since then, the demand for low-value coins has increased, indicating a growth in household hoarding as opposed to active recirculation. (Boaden, A. 2008)

The mechanical characteristics of natural and synthetic banknotes are compared, including breaking length, tear factors, burst factors, and folding endurance. The mechanical characteristics of natural and synthetic banknotes are examined in relation to aging at various temperatures (100–200°C) for varying durations (1/4–16 hours). Heating has a minor impact on the mechanical characteristics of natural banknotes, particularly at low temperatures and for brief periods of time. After being heated to 80°C, the mechanical qualities of synthetic banknotes weaken and produce unpredictable outcomes. Additionally, the thermal behavior of both synthetic and natural banknotes is examined. It is discovered that compared to synthetic banknote sheets, natural banknote sheets are less impacted by thermal treatment. The activation energy of natural banknotes is higher, at roughly 188.567 KJ. Compared to synthetic banknote sheets, natural banknote sheets have a greater decomposition temperature. (Nada, A & El-Kady, M & Simonian, G & Basalah, R & Goher, Ahmed. 2007)

This essay examines a significant but little-studied aspect of money and banking: the Central Bank's issuance of currency. The supply of liquidity to the economy is one of central banking's most crucial roles. However, in carrying out this role, central banks must be ready for unforeseen shocks to the money supply as well as limitations on production, transportation, and capital costs. The study creates a dynamic cost-minimizing note inventory model that determines the ideal note order size and frequency for the Central Bank. An inventory "cushion" is found using a value at risk model as part of the modelling activity. (Massoud, N. 2005)

In addition to 18 other nations that have released at least one polymer note, Australia, New Zealand, and Romania have all completely embraced polymer (plastic) banknotes. Concern over counterfeiting was the main driving force behind Australia's creation of polymer banknotes. This paper, however, demonstrates that the shift was profitable. After polymer notes were introduced, the net gain was around \$A 90 million (\$U.S. 65 million) within ten years. (Menzies, G. 2004)

The worldwide shift to polymer banknotes is indicative of a structural change in currency systems brought about by need for sustainability, durability, and increased security. Polymer substrates currently make up over 15% of banknote denominations worldwide, according to recent market and policy evaluations. By 2030, over 70 countries are expected to have adopted polymer notes, and their dispersion is expected to accelerate. Regional adoption trends differ: Asia-Pacific is becoming a centre for sustainable and circular polymer solutions, Australia is at the forefront of polymer innovation, and Europe has institutionalized polymer currency within sophisticated security frameworks. The literature emphasizes how certified circular polymers, smart materials, and hybrid substrates are becoming increasingly important in the manufacturing of contemporary banknotes. Nevertheless, the majority of current research is still focused on the market or technology, with little incorporation into frameworks for central banking strategy, sustainability policy, and monetary modernization.

The Planet Banknote guide traces the development and technological foundations of polymer banknotes back to Australia's reaction to growing dangers of counterfeiting in the late 20th century. Biaxially oriented polypropylene (BOPP) polymer, which greatly outperforms paper money in terms of lifespan and resistance to physical and biological degradation, is presented as a strategic upgrade that improves durability, hygiene, and security in place of conventional cotton-based substrates. Now widely used throughout the world, polymer notes have sophisticated security measures that are hard to imitate, which helps central banks save money over time and prevent counterfeiting. Future advancements in "smart banknotes," which might incorporate digital features, are also suggested by the report. All things considered, polymer banknotes are positioned as a significant advancement for physical money in the future.

The increasing significance of sustainability in the currency cycle is demonstrated by recent advancements in banknote end-of-life management. The need for safe and ecologically friendly banknote disposal is growing as worldwide cash circulation rises despite the growth of digital payments. By damaging cotton fibers, traditional shredding techniques reduce the amount of recycling that can be done. In response, Giesecke+Devrient (G+D) has developed a novel technique called banknote fiber extraction, which breaks down cotton-based and hybrid banknotes without destroying the underlying cellulose fibers. Closed-loop recycling is made possible by this technique, which yields totally recyclable raw materials appropriate for paper goods and packaging. The technology supports the sustainability agendas of central banks while improving efficiency and security. This innovation establishes end-of-life banknote management as a key element of more circular and environmentally friendly financial systems by including fiber recovery into destruction systems.

### **3. Research Gap**

The literature lays solid foundation for digital transformation, green finance, polymer currency, and monetary modernization. But three crucial gaps still exist:

- There exists little connectivity between frameworks for monetary modernization and sustainable currency innovation.
- Polymer banknotes are not given enough attention as strategic sustainability tools rather than as technological advancements.
- Oman-specific research is lacking, especially when it comes to connecting central bank innovation with Vision 2040.

By creating a strategic framework that links digital innovation, polymer currency adoption, and monetary modernization to Oman's sustainable development strategy, this report fills in these gaps.

#### **4. Research Questions**

The study answers the following research questions to fulfil the goals:

- How is the conventional role of central banks in the creation and operation of national currencies being altered by monetary modernization?
- What strategic reasons support the worldwide switch to polymer currency from banknotes made of cotton?
- How does Oman Vision 2040's focus on innovation, sustainability, and digital transformation relate to the Central Bank of Oman's polymer banknote initiative?
- How might polymer banknotes support resilient financial systems, operational effectiveness, and environmental sustainability?
- How do digital financial ecosystems and future-ready monetary infrastructure benefit from sustainable currency innovation?
- What policy framework may successfully combine Oman's long-term objectives for environmental and economic development with monetary modernization?

#### **5. Objectives of Study**

This study's primary goal is to investigate, within the context of Oman Vision 2040, the use of polymer banknotes as a strategic tool for monetary modernization, sustainability, and digital transformation.

- Examine the transition from cotton-based to polymer banknotes as a component of contemporary monetary innovation and central banking.
- Consider durability, environmental effect, lifecycle efficiency, and waste reduction when evaluating polymer currency as a sustainable monetary instrument.
- Examine how polymer banknotes promote digital transformation, taking into account their integration with new digital financial ecosystems, compatibility with smart features, and anti-counterfeiting technologies.
- Evaluate the polymer banknote effort of the Central Bank of Oman as an example of Vision 2040-aligned policy-driven monetary modernization.
- Create a conceptual framework for sustainable currency innovation that incorporates digital preparedness, green economic goals, and monetary policy.
- Make policy-relevant suggestions to direct future monetary policies, currency design, and sustainability-focused central banking reforms.

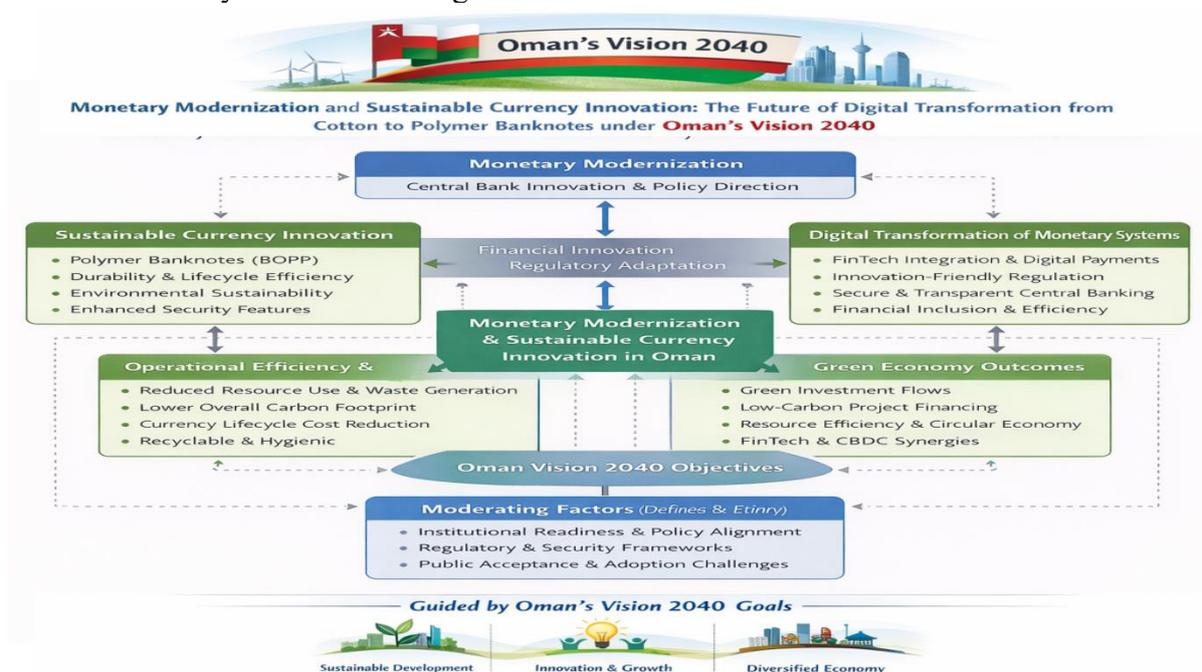
#### **6. Scope of the Study**

The monetary, sustainable, and digital transformation aspects of Oman's switch from cotton-based to polymer banknotes are the main topics of this study.

- An examination of the Central Bank of Oman's currency modernization approach from an institutional and policy perspective
- An analysis of polymer banknotes as a sustainable currency innovation, considering technological, operational, and environmental aspects
- Evaluation of how well Oman Vision 2040 goals, especially those related to innovation, the green economy, and digital transformation, correspond with currency modernization
- Examining global best practices and contrasting central bank experiences to put Oman's proposal in context
- The creation of a conceptual framework that connects digital preparedness, sustainable currency design, and monetary modernization

## 7. Conceptual Framework

The visual model illustrates how monetary modernization, driven by central bank innovation, serves as the strategic foundation linking sustainable currency innovation (polymer banknotes) with the digital transformation of monetary systems. Polymer banknotes act as the operational instrument connecting environmental sustainability, operational efficiency, and digital readiness. These interactions generate green economy outcomes and enhance financial system resilience, which are directly aligned with Oman Vision 2040 objectives. The model also highlights moderating factors - institutional readiness, regulatory capacity, and public acceptance - that shape the effectiveness of sustainable currency implementation within Oman's monetary modernization agenda.



## 8. Significance of the Study

- Contributes to the literature on central banking, sustainable finance, and monetary economics by understanding currency material innovation as a part of monetary modernization that goes beyond traditional instruments like interest rates and payment methods.
- Offers a fresh viewpoint that presents polymer banknotes as a strategic tool for policy within the agendas of central banks for innovation and sustainability.
- Creates an interdisciplinary connection between digital transformation, green economy transition, sustainable finance, and polymer currency.

- Addresses a significant empirical and regional research vacuum by offering the first systematic academic analysis of Oman's polymer banknote program within the framework of Oman Vision 2040.
- Creates a framework for sustainable currency that is governed by a central bank and incorporates technological, environmental, and monetary aspects.
- Provides direct policy relevance by giving central banks evidence-based advice on how to match currency innovation with strategies for digital transformation and national sustainability.

### 9. Expected Outcomes of the Study

The following results are expected from this study:

- A thorough analytical grasp of polymer banknotes as a tool for monetary modernization that goes beyond improving security to include sustainability, operational effectiveness, and digital preparedness.
- An organized conceptual framework that places innovation in currency materials at the nexus of digital change, sustainable finance, and monetary policy.
- Policy-based and empirical analysis of Oman's polymer banknote program, emphasizing how it aligns with Vision 2040 aims, especially innovation, environmental sustainability, and financial sector modernization.
- Determining the keyways that polymer currency promotes sustainability, such as lower lifecycle costs, fewer replacements, waste reduction, and enhanced environmental performance.
- An assessment of polymer banknotes as facilitators of digital compatibility, including fintech-focused payment infrastructures, smart security features, and integration with machine-readable systems.
- A transferable sustainable currency model for central banks in resource-based and emerging economies looking to update monetary systems while advancing green economy goals.

### 10. Policy Implications

The following significant policy consequences are expected from the study

- **Monetary Policy Innovation:** Central banks may see currency redesign as a strategic monetary tool that supports agendas for modernization, sustainability, and resilience rather than just an operational function.
- **Green Central Banking:** The study encourages central banks to consider lifecycle impact, recyclability, and carbon concerns in monetary operations by supporting the integration of environmental criteria into frameworks for currency issuance.
- **Digital Transformation Strategy:** Polymer banknotes can be positioned as an infrastructure that supports smart financial services, cash-digital integration, and anti-counterfeiting measures.
- **Vision 2040 Alignment:** According to the research, currency innovation can help Oman implement the innovation, economic diversification, and environmental stewardship pillars of Vision 2040.
- **Institutional collaboration:** The results emphasize the necessity of improved collaboration between national sustainability organizations, fintech regulators, environmental agencies, and central banks.

- **Regional and Global Relevance:** Other central banks looking to match physical currency management with sustainable development and technology advancement, especially in the GCC and emerging economies, can find guidance in the suggested framework.

## 11. Limitations and Future Research Directions

- The study's qualitative, policy-analytical, Oman-focused design promotes in-depth contextual understanding but restricts statistical generalizability. Indicators including lifecycle cost, carbon footprint, circulation duration, and public acceptance parameters could be used in quantitative or mixed-methods research in the future.
- Documentary and secondary sources are the primary sources used in the analysis. Empirical robustness might be strengthened by incorporating primary data (interviews, surveys, Delphi studies) from central banks, financial institutions, fintech entities, and environmental agencies.
- Macroeconomic and monetary transmission effects are not quantitatively modeled in the study. Future research should look at connections to digital substitution, financial inclusion, payment patterns, and inflation dynamics.
- No environmental assessment of the entire lifecycle is carried out. Methods from industrial ecology and environmental economics could be used in future research.
- To create global best-practice standards and typologies for sustainable currency innovation, cross-national comparative studies are encouraged.

## 12. Conclusion

The study advances our knowledge of monetary modernization by viewing polymer banknotes as a strategic innovation rather than just a technological improvement. It demonstrates how the shift from cotton-based to polymer currency represents a more comprehensive change in central banking, one that incorporates ecological goals, technological readiness, and policy reform. The paper illustrates how currency design may support digital transformation initiatives, increase financial system resilience, and advance green economy goals by placing Oman's polymer banknote program within the framework of Vision 2040. It comes to the conclusion that sustainable currency innovation is an important but little-studied aspect of contemporary monetary policy, establishing central banks as important institutional forces behind technologically advanced and sustainable economic futures in addition to their customary functions of maintaining price and financial stability.

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