

CBE
CENTRAL BANK OF ESWATINI
UMNTSHOLI WEMALIMATI

Giesecke+Devrient

Digital Lilangeni Design Paper

2024

Table of Contents

Executive Summary 2

Key CBDC Definitions 6

List of Abbreviations 7

1. Vision 9

2. Motivation and purpose of the Digital Lilangeni initiative by the Central Bank of Eswatini 9

3. Current payment landscape in Eswatini 10

4. Payment Scenarios with a potential Digital Lilangeni (use cases) 14

5. Design principles of the Digital Lilangeni 22

5.1 Key Design Criteria 22

a) Accessibility 22

b) Legal tender 23

c) Non-interest bearing Digital Lilangeni 23

d) Interoperability 23

e) Privacy aspects 23

f) AML/KYC 24

g) Limits 25

h) **Transaction fees** 25

a) Foundational technology 27

b) Token-based (UTxO) protocol 28

c) Two-tier hybrid model 29

d) Governance in a two-tier hybrid model 29

e) Information security 32

6. Learnings from the pilot projects 35

7. Conclusion 38

Glossary 39

Executive Summary

The exploration of Central Bank Digital Currencies (CBDCs) has sped up dramatically in recent years across the globe. The exploration ranges from research to technical testing, including proof-of-concepts and pilots, and even to live CBDC systems. The Central Bank of Eswatini (CBE) is among the first African countries to take the steps towards a retail CBDC within the framework of providing a secure digital version of its fiat currency and the overall digitalisation agenda of The Kingdom of Eswatini.

The Digital Lilangeni could potentially serve as a retail or general purpose CBDC for domestic payment transactions. It could be used by individuals for peer-to-peer payments and transactions with merchants or businesses, thus representing a digital version of the publicly accessible Lilangeni. However, it should be noted that the CBE has not yet made a decision regarding the issuance of CBDC.

The CBE has laid down its vision and motivations for the Digital Lilangeni:

- Providing secure access to central bank-issued money available by the public
- Fostering the digitalisation of the domestic economy and the financial sector
- Catalysing innovation and new business opportunities within the Kingdom of Eswatini
- Deepening financial inclusion
- Anticipating the future role of the CBE as an active regulator and facilitator of digitalisation within the Common Monetary Area (CMA) and the African continent

Although cash is the most preferred retail payment method in Eswatini, the CBE has achieved remarkable milestones in its payment infrastructure modernisation along with the large uptake of digital financial services (e.g., mobile money, bank cards) by the public., The CBE envisages opportunities in Digital Lilangeni to address the remaining challenges and make the payment system more resilient and effective.

In line with the vision and motivations of the CBE, the Digital Lilangeni enables a wide array of both online and offline use cases. The offline functionality ensures continued usage even in the absence of Internet connection, during power outages, or simply in certain rural areas. Some payments with - and wallets that store - Digital Lilangeni can be equipped with programmability features for value-added and innovative use case scenarios. The Digital Lilangeni has to be designed such that it is able to support cross-border functionality.

The functional design of the Digital Lilangeni should ensure appropriate user experience and inclusiveness to foster broad acceptance. From a consumer perspective, the usage of Digital Lilangeni needs to be as easy and intuitive as possible. Consumers should be able to make a payment in fewer and simple steps familiar to them and with no need for advanced digital literacy.

To make those payment options work, the CBE could implement two types of wallets for the Digital Lilangeni. The first type is called hosted wallet that is managed by financial institutions, whilst the second type is a hardware wallet that is a secure and portable storage device held by individuals. Hosted wallets require access to the Internet while hardware wallets work in offline environment consecutively.

The core design principles of the Digital Lilangeni stress the importance of Accessibility, Interoperability, Infrastructure, Governance, and Security.

Among the key design principles, the CBE envisages the followings for a potential Digital Lilangeni:

- It provides universal accessibility, so that it is accessible to everyone, anywhere and anytime regardless of economic and social status. This ensures inclusivity and mimics the feature of cash.
- It has a full legal tender status, so payments in Digital Lilangeni have to be accepted up to any amount as a medium of exchange and to settle financial obligations. This raises confidence in the digital version of the currency and hence might raise adoption.
- It balances transparency of transactions with the privacy of consumer data while being fully compliant with the KYC and AML/CFT regulations and requirements. Taking these into consideration, the CBE proceeds with partial pseudo-anonymity within the privacy design for a potential Digital Lilangeni.
- It is unremunerated since the Digital Lilangeni is primarily aimed to be a means of payment and is designed to limit its appeal as a savings vehicle even if some amount can be stored in CBDC.
- It enables true and full interoperability with the existing payment methods and wholesale and retail infrastructures, and potentially with future payment applications. The Digital Lilangeni should be available 24/7/365 in (near) real-time manner.
- In a globalising world, cross-border considerations are essential to incorporate into the CBDC design. CBDCs could contribute to accelerate the integration of African countries with other economies, which can be particularly true for the Common Monetary Area. The Digital Lilangeni considers CBDC standards which allow it to participate in intraregional and international cross-border CBDC projects and make it interoperable with potential foreign CBDCs. Attention is paid as to how the Digital Lilangeni maintains the status quo with regards to substitution and its convertibility to the South African Rand.
- Limits on Digital Lilangeni wallets (e.g., holdings, transactions) in the context of domestic retail payments can be considered for financial stability reasons in the future.
- Similar to cash, a Digital Lilangeni transaction could be free of charge to consumers. With it, the Digital Lilangeni would be a strong contender of cash, promote competition in the payment market. However, to facilitate the provision

of innovative value-added services to individuals and businesses by FSPs, affordable fees and charges could be considered. The exact compensation model for a potential Digital Lilangeni is still a topic that needs to be thoroughly discussed and decided upon.

The CBE puts particular emphasis on the system architecture and infrastructure of the potential Digital Lilangeni. The following aspects of a potential Digital Lilangeni architecture were confirmed after successfully testing the technology in a Proof-of-Concept (POC) and two pilot projects:

- The foundational technology is built upon a distributed database, which is operated and permissioned by the CBE, so it is centralised from a management perspective.
- The potential Digital Lilangeni is a token-based CBDC. In this value-based approach the Digital Lilangeni represents a digital token. The payment is carried out by transferring the digital token from one individual to another entity and vice versa, even in offline environment and/or without the need of formal financial account(s). This concept enables that the Digital Lilangeni fully resembles cash transactions, where banknotes and/or coins are transferred from one person to another.
- The CBE follows a two-tier approach to the potential Digital Lilangeni, where the CBE operates the core infrastructure and intermediaries are in charge of distributing CBDC to end users, once obtained from the CBE, and handle all customer-facing activities.
- Regarding the governance, the Digital Lilangeni is under full control of the CBE, which is the only entity to mint and to redeem CBDC. The Digital Lilangeni ecosystem includes key stakeholders such as commercial banks, mobile money service providers, credit institutions, fintech firms, who provide access to Digital Lilangeni for consumers. The CBE defines policies for participants in the ecosystem, including - but not limited to - transaction caps, monitoring, and regulatory compliance. FSPs deliver basic and innovative services upon the core infrastructure, process AML/KYC checks and onboard customers. Financial institutions are responsible for monitoring the Digital Lilangeni payment transactions and shall report to the Eswatini Financial Intelligence Unit (EFIU) all suspicious transactions. The CBE can access only aggregated payment data. The potential Digital Lilangeni is introduced to the payment infrastructure of merchants.

As a fiat currency, trust is critical to the adoption and usage of the Digital Lilangeni. Therefore, it must meet the highest security requirements. As a result, currency issuance and distribution modules of the core Digital Lilangeni infrastructure are separated to address cyber risk. The system should have high availability with no single point of failure. Both hardware and software security are ensured by multiple layers.

The design criteria and system architecture principles outlined above were based on research and expert discussions. However, the CBE aimed to evaluate these assumptions from the conceptual phase of the Digital Lilangeni project also on a technical level. Thus, the CBE tested G+D's "Filia" CBDC technology in a POC and two pilot projects. In an internal Canteen Pilot Project, the CBE was able to test primarily the offline functionalities of a potential Digital Lilangeni in a closed and secure environment within the Central Bank. Together with Swaziland Building Society (SBS), the CBE was also able to test the online functionalities of a CBDC in a FSP Pilot Project. The main focus was on Person-to-Business (P2B) and Person-to-Person (P2P) use cases. The learnings that the CBE gained from these pilot projects are outlined in section 6 of this paper.

Key CBDC Definitions

Central Bank Digital Currency (CBDC) is defined as a digital version of fiat money, denominated in the national unit of currency, and is a direct liability of the Central Bank. CBDC can also be a country's legal tender.

There are two different types of CBDC based on the use cases. It can be distinguished between retail and wholesale CBDCs. Retail CBDC, often called general purpose CBDC, is used by individuals to pay each other and/or businesses and merchants. Simply put, retail CBDC can be understood as the digitised form of banknotes and coins. On the other hand, a wholesale CBDC is used by regulated financial institutions and intended for settlement of interbank payments and/or security transfers. Both retail and wholesale CBDC can be deployed either domestically in the local jurisdiction or abroad for cross-border payments.

Further explanations and definitions can be found in the Glossary.

This design paper presents the design characteristics of the domestic retail CBDC in Eswatini, that is called the Digital Lilangeni, with a slight reference to cross-border aspects.

List of Abbreviations

AML	Anti-Money-Laundering
ATM	Automated teller machines
BIS CPMI	Bank for International Settlements Committee on Payments and Market Infrastructure
BIS	Bank for International Settlements
CBDC	Central Bank Digital Currency
CBE	Central Bank of Eswatini
CFT	Countering the Financing of Terrorism
CMA	Common Monetary Area
DLT	Distributed Ledger Technology
EBA	Eswatini Bankers' Association
ECH	Electronic Clearing House
EFIU	Eswatini Financial Intelligence Unit
EFT	Electronic Funds Transfer
FSB	Financial Stability Board
FSP	Financial Service Provider
G2P	Government-to-Person
GDP	Gross Domestic Product
KYC	Know-Your-Customer
MMA	Mobile money agent
NFIS	National Financial Inclusion Strategy
P2B	Person-to-Business
P2P	Person-to-Person
PKI	Public Key Infrastructure
POC	Proof-of-Concept
POS	Point of Sale
RTGS	Real-Time Gross Settlement
SDK	Software Development Kit
SWIPPS	Swaziland Interbank and Settlement System

SZL	Swaziland Lilangeni
TPS	Transaction per second
USSD	Unstructured Supplementary Service Data
ZAR	South African Rand

1. Vision

The Bank envisions the Digital Lilangeni as a secure digital version of the Lilangeni trusted by the Eswatini Nation and complementary to notes and coins. It should offer safer, faster, accessible, and more affordable ways to transact in Eswatini using both offline and online capabilities.

- The potential Digital Lilangeni catalyses participation and interoperability of new and existing financial service providers as well as third-party providers in the Eswatini financial ecosystem.
- As legal tender, the potential Digital Lilangeni acts as an enabling platform to assist in accelerating the digitisation of services and enhance payment efficiency in Eswatini.
- It supports the Eswatini Government by honing the distribution and collection of public sector revenue.
- It enhances the transmission and integrity of data to assist in the formulation of monetary policy and promotes financial stability and integrity of the financial sector in the Kingdom of Eswatini.

2. Motivation and purpose of the Digital Lilangeni initiative by the Central Bank of Eswatini

The Central Bank of Eswatini (CBE) envisions a potential Digital Lilangeni as a secure digital version of the Lilangeni, trusted by the Eswatini Nation and complementary to banknotes and coins. The citizens of Eswatini are thus given access to central bank-issued money in the digital age with digital payments. This gives them the possibility to transact digitally in a more affordable way.

The approval of a Digital Lilangeni as legal tender enables the citizens of Eswatini to pay with it anywhere and at any time. Crucial to this is the ability of the Digital Lilangeni to be operated in online and offline modes as well, i.e., the latter means digital transactions can be carried out without connection to the Internet. This helps to make the payment system in Eswatini more efficient, faster, and more resilient, whilst financial inclusion could be further deepened. In addition, the Digital Lilangeni offers the potential to accelerate the digitisation of services as well as innovations. Strong collaboration between the public and private sectors in Eswatini is particularly important for a successful implementation of the Digital Lilangeni, as it is the payment service providers e.g. banks, mobile money service providers, Fintechs, (see Glossary in the Appendix) that can make a significant contribution to innovation. The Digital Lilangeni provides a platform for them to create innovative financial products and services. The core infrastructure is backed by the Central Bank of Eswatini, such that investment risk for private companies is reduced.

The Digital Lilangeni can also provide interoperability of new and existing financial service providers, payment aggregators, third party providers and fintech companies in Eswatini. As a central platform, both physical (i.e., cash) and electronic (i.e., mobile money) payments can be channelled and linked by the Digital Lilangeni.

The ability to utilise the analytics on aggregate retail payment data opens up new opportunities for the CBE in financial stability and monetary policy. The availability of holistic data, keeping end users' privacy in utmost respect, allows the Central Bank to respond to market events more quickly and provide better-informed analysis for policy decisions.

3. Current payment landscape in Eswatini

The design of an effective CBDC ecosystem is based on a deep understanding of the current payment system in a country. It is important to understand the initiatives, strategies, as well as challenges and opportunities to create the appropriate CBDC design, which is outlined in this section.

3.1 Overview of the payment landscape in Eswatini

The payment system consists of the Swaziland Interbank and Settlement System (SWIPSS), which provides real-time gross settlement (RTGS) for high-value critical payments, and the Eswatini Clearing House (ECH), which processes interbank retail payments. SWIPSS is owned, managed, and located within the CBE and directly serves the Treasury Department through the Ministry of Finance and the four commercial banks in Eswatini. ECH serves the four major commercial banks that operate in the country.

Commercial banks and building societies play a crucial role in Eswatini's economy and payment system. They provide credit and deposit-taking services, allow customers to make transactions and open/maintain accounts, make investments and savings available to individuals and companies, some even have insurance business in place as well. First National Bank (FNB), Standard Bank and Nedbank are domiciled in South Africa and operate extensive branch network in Eswatini, whilst Eswatini Bank with its determinate operation in the country is owned by the Government of Eswatini. The building societies (e.g., Swaziland Building Society) are the leading providers of long-term mortgage finance for real estates.

The domestic payment system has undergone an outstanding transformation. The number of financial access points[1] in Eswatini has increased substantially between 2015 and 2019. For instance, the number of registered mobile money agents has increased from 2019 to 2023 from 4,816 up to 14,822 which is one of the indicators that the

[1] Access refers to when a "consumer has sufficient physical proximity to access points—including branches, agents, automated teller machines (ATMs), and other outlets or devices — to enable him or her to easily select and use a range of financial products and services" (World Bank Group and People's Bank of China, 2018).

accessibility of financial services is steadily improved within the country[2]. This improves the ability and convenience for customers to access financial services.

Financial services had already experienced a dynamic uptake by 2018 which can be attributed to the high uptake of mobile money. In the cited period, there was a surge in card adoption as well. According to interviews with the commercial banks in Eswatini, the number of cards has almost tripled, and banks expect cards to be an important driver of further business opportunities in the future.

Mobile money

Mobile money has been a financial inclusion success story for Eswatini. The usage of mobile money grew threefold in terms of transaction value as well as transaction volume since 2016. Mobile money agents (MMA) are the most accessible access points. The number of MMAs has grown by 1,038% over the period of 2014 and 2018. As of 2019, there were approximately 19 times more MMAs than bank branches and ATMs. Mobile money accounted for approximately 15% of retail payments in Eswatini in 2019 in terms of value and 76% in terms of volume[3]. Between 2015 and 2019, the number of mobile money subscription went through a 124% increase. Data by 2017 already shows that mobile cellular subscriptions in Eswatini has climbed to 94% of the adult population from 84% in 2014. Online/app banking and mobile/cell phone banking (Unstructured Supplementary Service Data, abbreviated by USSD) were adopted by more than one third of the population in 2018. However, the proportion of inactive customers could be further decreased.

Person-to-business (P2B) payments are the most important use case by volume of transactions (E62 million) conducted through mobile money, even though Eswatini citizens still conduct most of their P2B payments in cash. The volume of P2B in general increased sharply by 338% and the values have tripled between 2016 and 2019. Person-to-person (P2P) payment is accounting for 51% of the total value of all the mobile money use cases in 2019, and thus is the largest use case by value for mobile money. From 2016 to 2019, P2P transactions increased by 228% in volume and by 187% in value.

For the unbanked population, accessibility is key to facilitating higher volumes of mobile money. One of the main ways that unbanked people are introduced to transacting with mobile money is through USSD. However, aggregate transaction values on bank-based apps were 35 times greater than for mobile money in 2019. This points to the trend that consumers prefer bank apps for conducting high-value transactions and a difference in target customers between mobile banking apps and mobile money.

2 Central Bank of Eswatini (2023): Financial Stability Report. Issue 7. June 2023. (Availability: https://www.centralbank.org.sz/financial-stability-report/).

3 Central Bank of Eswatini (2023). Eswatini FinTech Landscape Report. (Availability: https://www.centralbank.org.sz/wp-content/uploads/2021/04/Eswatini-Fintech-Landscape-Report-1.pdf)

SWIPSS

SWIPSS demonstrates the growing wholesale payments system in Eswatini. There was a significant increase in the volumes (79%) and values (71%) of SWIPSS transactions between 2014 and 2018. The utilisation of RTGS, measured in transaction value/GDP, could further improve compared to some regional countries.

ECH

On the retail side, the utilisation of ECH remained constantly high whilst experiencing a mild increase in volume (8.5%) and value (7%) of transactions from 2014 to 2018. The utilisation is driven up by credit EFT. This ECH facility[4] clears EFT debits and credits and sends a batch file to SWIPSS for final settlement. The increase in volumes and values, particularly in EFT credit transactions, is indicative of a growing retail payment system in Eswatini. As a proportion of GDP, the values currently processed through ECH remains between 30% and 35%, so that the utilisation rate might further improve also in comparison to regional countries.

EFT debits are still at low levels but indicate some signs of an upward trend. EFT debits have increased over the past five years, particularly by volume (+28%), even if debit ceiling limit is E500 thousand.

EFT credits are a systemically important payment stream for the ECH and continue to grow in use. They represented 63% of ECH transactions in 2018, accounting for 81% of the values processed. The volume of EFT credits increased by 46% whereas values increased by 78% from 2014 to 2018.

3.2 Key developments and strategic initiatives by the CBE

Important role of cash in Eswatini's society

Although the payment system is largely dominated by the banking sector and mobile money operators, the society in Eswatini is currently mainly cash based. The majority of payments are made in cash (see CENFRI Report: Eswatini National Payment System Vision 2025[5]) and people's trust in cash therefore appears to be very high.

The increasing amount of banknotes in circulation in Eswatini contradicts the strategy of a cash-lite society in Eswatini and also comes with high cash management and cash handling costs. These costs arise not only for the Central Bank (in terms of printing and issuing) but also for all other players in Eswatini's economy (in terms of distributing, accessing, and storing).

[4] Cheques were also cleared by the ECH facility but were phased out in 2022. The decreasing demand for cheques were observable in cheque volumes and values which declined steadily by 45% and 63%, respectively, during the 2014 to 2018 period.
[5] CENFRI (2021): Eswatini's National Payment System Vision 2025. (Availability: https://cenfri.org/publications/eswatinis-journey-towards-revolutionising-its-payments-system/).

Phasing-out of cheques[6]

In 2022, the CBE together with the Eswatini Bankers' Association (EBA), decided to discontinue cheques as an official means of payment. Payments by cheque were not very efficient and involved high management costs. People were urged to seek alternative means of making payments. This transition to alternative payment methods has been smooth following the phasing-out of cheque payments. People very quickly got used to and accepted alternative methods such as mobile money.

Less affordable digital financial services to end users

Payments with digital payment instruments (i.e., mobile money and transactional bank account) come with fees charged to end users for each action they take (i.e., transactions and/or withdrawals). The citizens of Eswatini take these costs into account in their choice of the appropriate means of payment. Due to high fees per transaction, many people in Eswatini therefore opt to cash out of digital payment methods in order to use cash to make payments without incurring fees.

Lack of interoperability

There is a limited level of interoperability among digital financial services. Individuals might face challenges when they send electronic funds to each other, to businesses or to public services from a mobile money service provider to another one and/or to a transactional bank account. The limited level of interoperability might add to the costs, make transaction times longer and deduct from seamless consumer experience. The CBE has realised these challenges and embarked on a national switch project prior to exploring CBDC in the country.

Cash-lite society

In the wake of the Eswatini National Payment System Vision 2025, the CBE is driving the strategic initiative of a cash-lite society. Increasing the use of digital payment streams and promoting innovation in Eswatini's payment system is expected to expand and to modernise the entire payment ecosystem.

Financial Inclusion Strategy

In the form of the National Financial Inclusion Strategy (NFIS), the government is dedicated to transforming the local financial system to meet the needs of the Eswatini population and to simplify access to the financial system. This is intended to enable a broader proportion of Eswatini's society to participate in the financial system and utilise digital payment channels more actively.

The dominant role of cash, less affordable digital financial services, and the lack of interoperability between retail digital financial services are considered high and

[6] Central Bank of Eswatini (2021): Public Statement: Elimination of Cheques in Eswatini. July 2021. (Availability: https://www.centralbank.org.sz/elimination-of-cheques-in-eswatini/).

important challenges by the CBE. The CBE believes that CBDC could address them and provide a more sustainable path forward.

National payment switch project

The CBE has a primary objective to ensure that local card transactions amongst the local commercial banks are switched and settled in-country. To achieve this, the Bank has launched its own national switch project. This project is designed to further enhance the national payment system. By providing direct access to non-bank financial service providers, it opens up new opportunities for these institutions. This in turn, benefits the citizens of Eswatini as it offers them more options and can improve the efficiency and reliability of financial services within the country.

On top of the many achievements and policy initiatives, the CBE is committed to undertake further improvements in some fields, including the underutilisation of SWIPSS and ECH, limited instant payments, and lacking interoperability between FSPs and networks. It is in this regard that the CBE is looking at implementing a domestic switch to address the issue of instant payments and interoperability.

4. Payment Scenarios with a potential Digital Lilangeni (use cases)

4.1 Online Use case:

The Digital Lilangeni allows payments to be executed using a “hosted wallet” on digital devices such as smartphones or feature phones. Constantly being connected to the Internet network, payments can be made from one person to another (P2P), as well as between individuals and merchants/businesses (P2B). The latter includes both purchases in a physical store and payments with Digital Lilangeni in online shops (see Figure 1), or even public services (e.g., paying utility, tax) are taken into account here. The main user interface on smartphones is an installed app, by means of which transactions can be carried out (see Figure 2 for an example)

Within the digital wallet on the mobile application, payments can be sent as well as requested/received. Using QR codes, the payment can also be triggered and authorised. The ability to use a smartphone as a digital wallet allows the use of NFC technology to create an interface between a physical CBDC smart card and the digital wallet. This enables the end user to top-up the smart card with Digital Lilangeni, so that it can be used for both online and offline purposes (a detailed process can be seen in Figure 3).

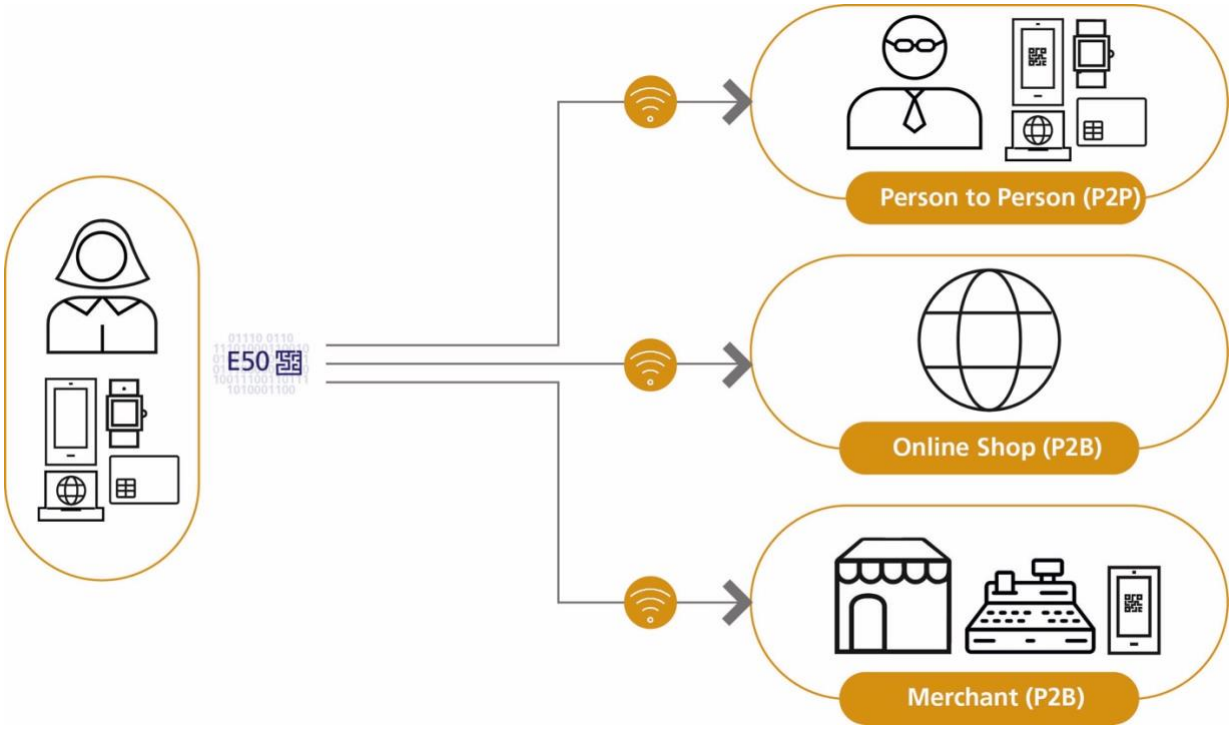

FIGURE 1: ONLINE USE CASES WITH DIGITAL LILANGENI

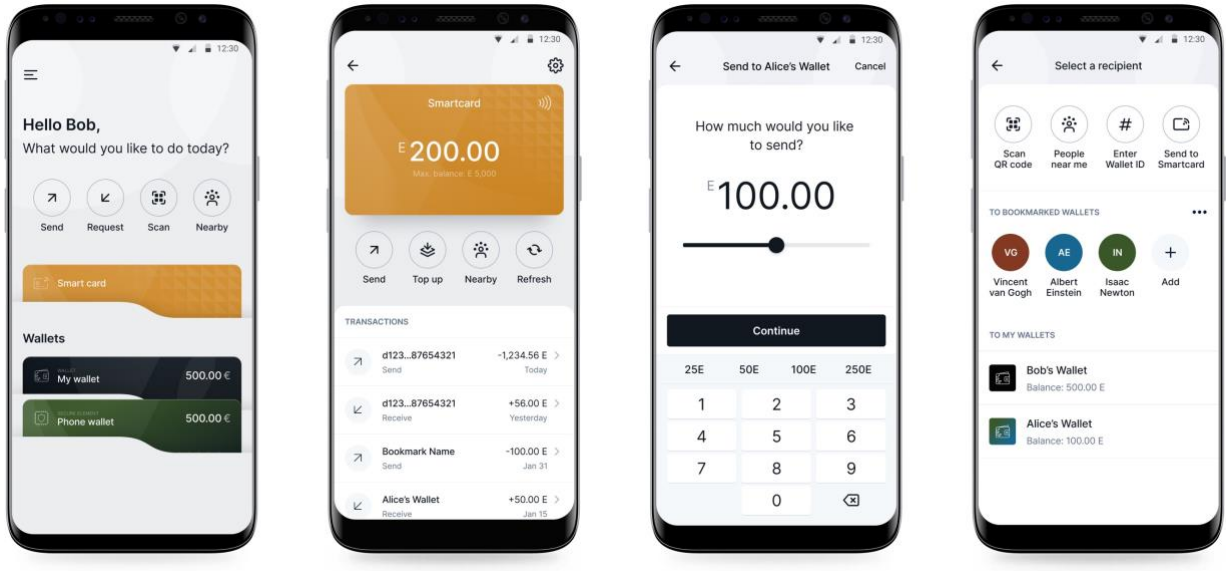

FIGURE 2: EXEMPLARY MOBILE APPLICATION FOR A DIGITAL LILANGENI

For the end user, onboarding to the Digital Lilangeni should be made as easy as possible (see Figure 3). Both banked and unbanked citizens of Eswatini are supposed to go through a straightforward onboarding and KYC process at authorised institutions (e.g., financial service providers). Subsequently, CBDC can be used in online mode on various

digital devices (e.g., by downloading the mobile application on a smartphone, *see Figure 2 for an example*).

Offline gadgets such as smart cards can also be distributed to the end user during the onboarding process by the FSP, which also enable online payments (e.g., at the POS or via NFC technology on the smartphone). Access to Digital Lilangeni via any device now has to be topped up with physical Lilangeni or bank deposits and converted to Digital Lilangeni ("top up"). Top-up from bank deposits suggests that bank account can be linked to the Digital Lilangeni wallet. In the end, digital payments with Digital Lilangeni are possible in the P2P as well as in the P2B environment. Citizens of Eswatini are granted convertibility to physical cash at any time, allowing them to switch from digital to physical Lilangeni (see "Convertibility of Digital Lilangeni to physical Lilangeni" in Figure3). To illustrate which entity the citizen of Eswatini interacts with during the onboarding and transaction process, the respective institution/citizen is indicated in the dark blue boxes in the graph.

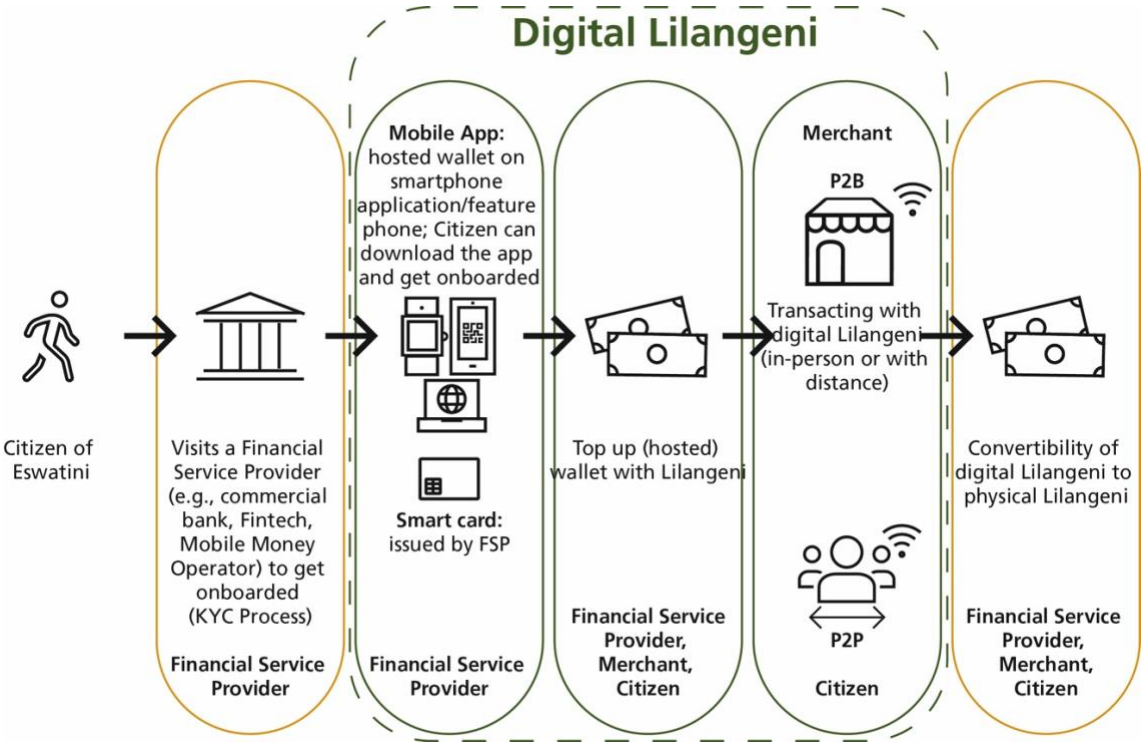

FIGURE 3: EXEMPLARY USER EXPERIENCE TOWARDS THE ONLINE USE OF DIGITAL LILANGENI

4.2 Offline use case:

Since the Digital Lilangeni is provided as a public good by the CBE, a steady availability of the CBDC must also be guaranteed. Supplementing the online version of the Digital Lilangeni with an offline component can alleviate this requirement. This means that payers and payees can still make payments consecutively using Digital Lilangeni even though they are both not connected to the network. It increases the resilience of the

payment system and ensures smooth use of CBDC even without a stable network connection.

Offline payments with CBDC are generally carried out using a smart card, which end users obtain through authorised institutions such as commercial banks or other financial service providers during the onboarding process. This smart card can be topped up with Digital Lilangeni which can be used for different payment scenarios (*P2P, P2B, see Figure 4*). In P2B payments, the offline payment is made by using special point of sales terminals that support offline payments and are only developed to execute such transaction types. In order to keep the barriers to entry for merchants as low as possible, the integration of the Digital Lilangeni payment infrastructure into the existing POS system must be as simple and cost-effective as possible. Conversion to the CBDC infrastructure should at best be possible on the basis of the existing terminals, eliminating the need for merchants to purchase new expensive equipment.

The possibility of consecutive offline payments allows making several offline payments in a row without connecting to the network. This ensures that in the event of a lack of access to the network, payments with Digital Lilangeni are still possible for a certain period of time. Verification of the transaction data occurs upon reconnection to the network. It is up to the CBE to determine when data reconciliation is to be carried out.

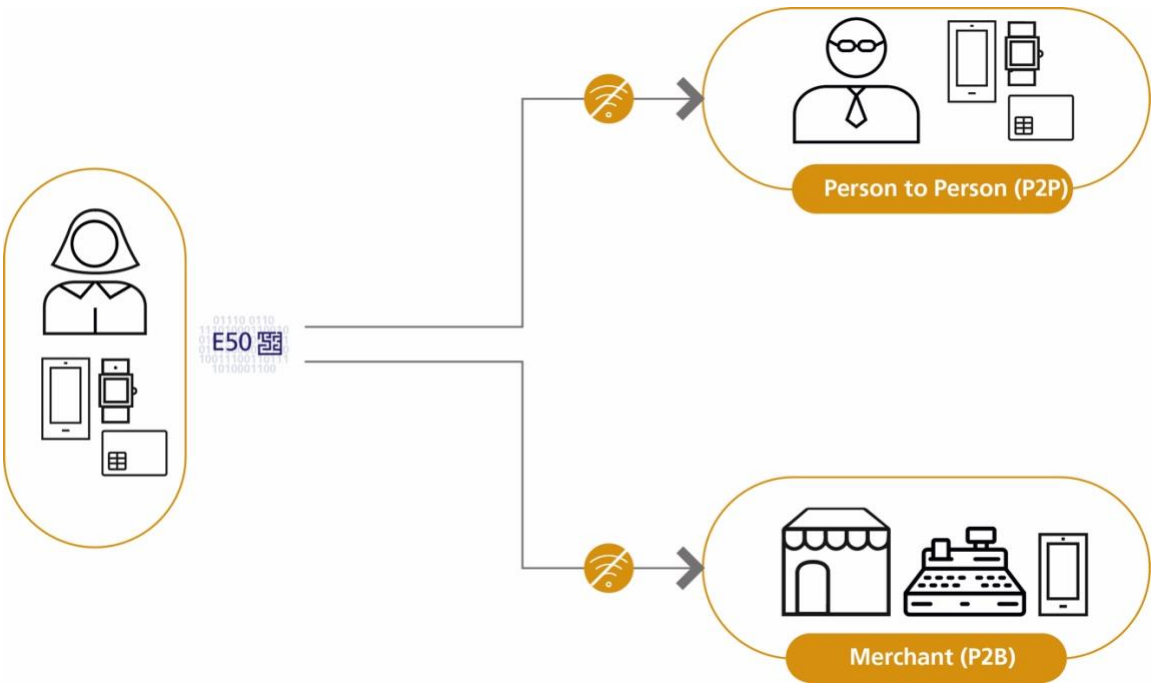

FIGURE 4: OFFLINE USE CASES WITH DIGITAL LILANGENI

Eswatini citizens' path to using Digital Lilangeni in offline mode looks similar to that in online mode (see Figure 5). After an onboarding and KYC process with an authorised

institution (e.g., financial service provider) that is as simple as possible, end users receive a smart card that supports offline payments. Smart cards can be distributed by FSPs and Merchants. This card, as well as digital devices that support the execution of offline payments, can be topped up with physical Lilangeni or bank deposits. The interface for this can be either the user's own smartphone with NFC features or the POS terminal of a merchant, who can perform the top-up process with Digital Lilangeni in exchange for physical Lilangeni.

The devices (Smart card or any other device with offline function/NFC) can now be used in face-to-face transactions in offline mode at the merchant via the POS terminal or between persons via an NFC-enabled offline device.

As with the online use case, people are granted convertibility to physical Lilangeni at any time (see "Convertibility of Digital Lilangeni," Figure 5). To illustrate which entity the citizen of Eswatini interacts with during the onboarding and transaction process, the respective institution/citizen is indicated in the dark blue boxes in the graph.

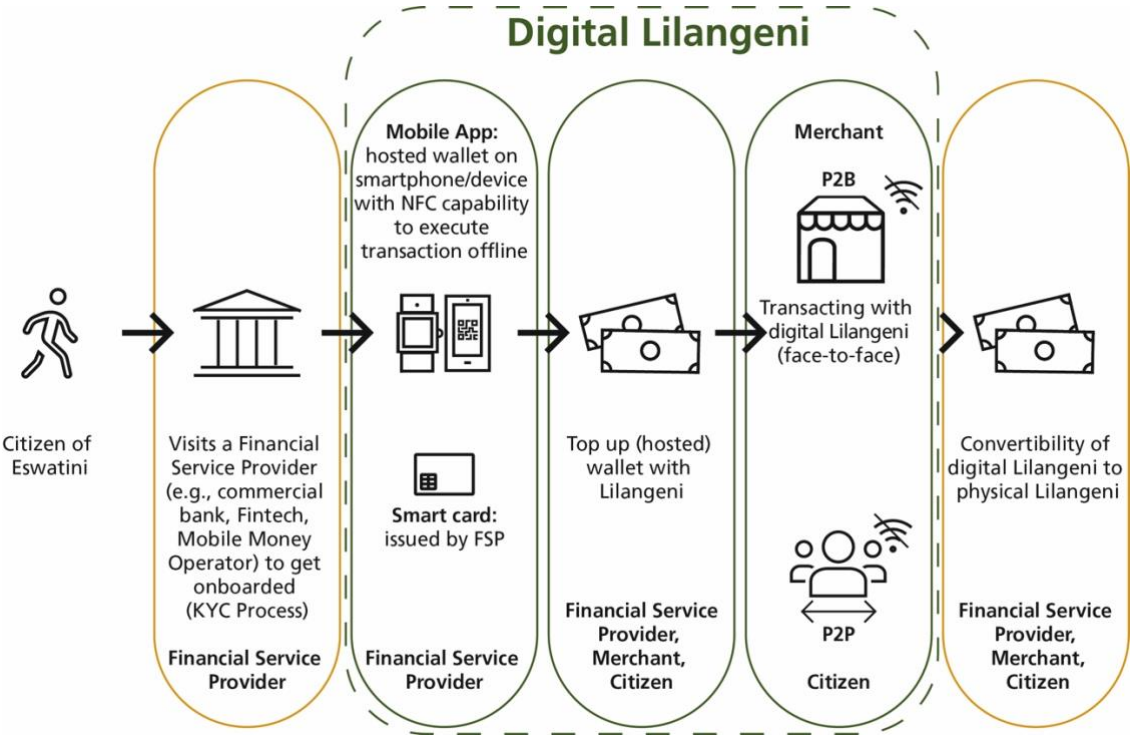

FIGURE 5: EXEMPLARY USER EXPERIENCE TOWARDS THE OFFLINE USE OF DIGITAL LILANGENI

The CBE has carried out a technical test for this specific use case within the Canteen Pilot Project. It took place within the premises of the Central Bank itself, more precisely in the Bank's Canteen. The test involved the usage of smart cards and POS terminals that support payment transactions in offline mode.

The Canteen, acting as merchant in this pilot ecosystem, inserted its smart card into the POS terminal and the customer had to attach their smart card to the device's NFC reader.

The transaction process involved the transfer of a digital token from the customer's smart card to the merchant's card.

Due to the offline nature of the transaction and the transfer of the digital token, the processing time was longer than for the online use case. Despite this longer processing time, however, all transactions were successfully completed.

An important insight that the CBE gained from this test process was an understanding of the requirements as well as limitations of consecutive offline payments. While multiple offline transactions can be completed with a smart card, it was realised that at some point the smart card needs to go online to reconcile the transaction history and "clean up" the card. This purging process can also significantly improve the transaction processing time of the smart card during the payment process, thus improving overall efficiency. This limitation is mainly based on the storage capacity of the form factors (e.g. smart card and POS terminal) used to process offline payments.

4.3 Unstructured Supplementary Service Data (USSD) use case:

The incorporation of USSD technology can broaden the accessibility of CBDC to a larger population, ensuring that individuals, irrespective of their technological knowledge or resources, can participate in the digital economy. The ability to execute digital transactions through basic feature phones eliminates the barrier of needing high-end smartphones or constant internet connectivity.

This approach forms an integral part of the strategy to promote financial inclusion through the introduction of CBDC. By lowering the technological threshold for digital payments, it is possible to include more people in the financial system, particularly those in underprivileged or remote areas. The successful integration of CBDC into the USSD application would be a significant step towards achieving widespread financial inclusion in the era of digital currency.

As highlighted in section 3 discussing the current payment landscape in the Kingdom of Eswatini, mobile money plays a crucial role in extending the reach of financial services across the country. Given the high penetration of feature phones in Eswatini, it is essential that any potential Digital Lilangeni is adaptable to this form factor to perform Digital Lilangeni payments.

One FSP, Instacash, was attempting to complete the necessary integration to operate a potential CBDC on a USSD-based system. This presented its own set of technical challenges, most notably the need to translate the code to support Digital Lilangeni payments. As a result, Instacash had to develop an entirely new product with a new back-end system, a process that naturally takes time.

Given the timeframe of the pilot project, Instacash was not able to finalise the integration with the USSD system, which meant that this particular use case could not be tested during the pilot phase. Nevertheless, Instacash invested significant effort into the

integration and also developed a sandbox solution to demonstrate the process of a USSD-based Digital Lilangeni.

Even though this use case could not be tested in the live pilot, it was successfully tested in the sandbox environment. The CBE considers this a unique use case for the region for any potential CBDC engagements. With regard to a potential Digital Lilangeni roll out, this use case could still prove crucial. It would not require a change in end-users' payment behaviour and would allow them to use their existing payment infrastructure (i.e., feature phone). The main difference would be the use of central bank money instead of private money."

4.4 G2P/P2G Payments:

The Digital Lilangeni infrastructure can be leveraged as a payment system between the citizens of Eswatini and the government. By having the CBDC system provided by the CBE as a publicly trusted institution opens up the possibilities of such Government-to-Person (G2P) and Person-to-Government (P2G) payments to no longer fully depend on private payment infrastructures (see Figure 6) and make those payments more effective. Examples of G2P payments can be social welfare payments and stimulus money from the government to the general public. P2G payments, for example tax payments, can be processed digitally with CBDC in real time.

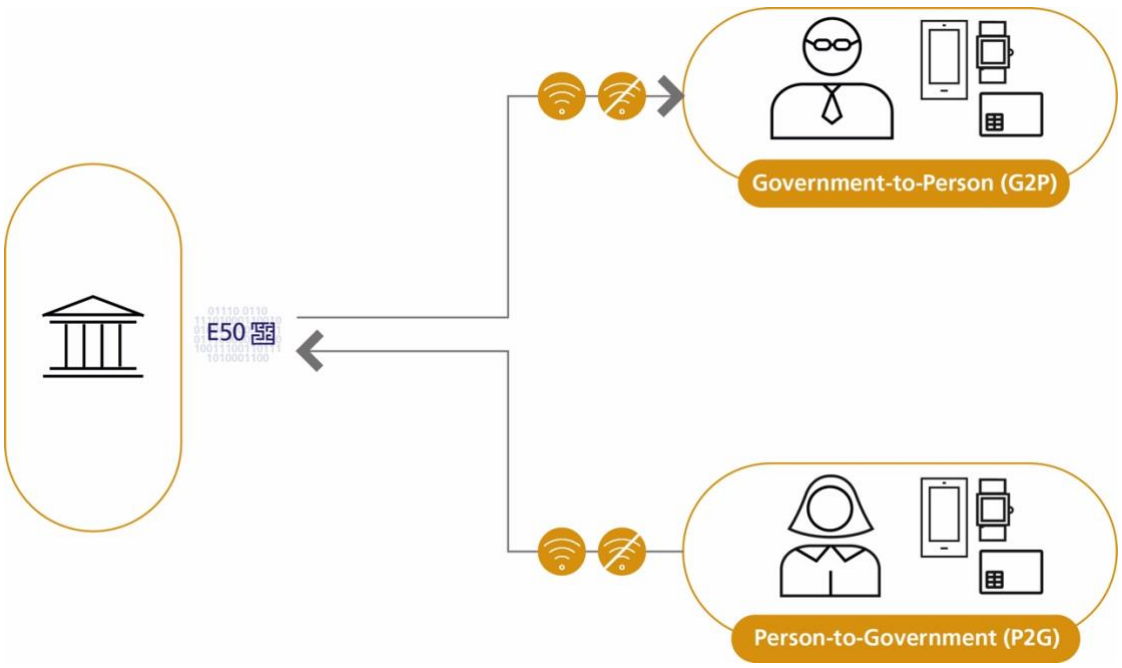

FIGURE 6: GOVERNMENT-TO-PERSON (G2P) AND PERSON-TO-GOVERNMENT (P2G) USE CASE WITH DIGITAL LILANGENI

While the Government-to-Person (G2P) use case was not tested in the Digital Lilangeni pilot project, its potential value to Eswatini's society cannot be underestimated. A strong

collaborative effort between various institutions could significantly streamline and enhance the efficiency of governmental payments. This would not only simplify the payment process but also provide wider access to governmental services, particularly for those in remote areas or with limited banking access. By reducing transaction complexities and increasing accessibility, the G2P use case could play a pivotal role in promoting financial inclusivity and equality in Eswatini, thereby contributing to the overall socio-economic development of the country.

4.5 Programmability

By virtue of its digital nature, the Digital Lilangeni enables programming of payments and thus a wide range of innovative business models (such as machine-to-machine payments on the Internet of Things, restricted wallets for children). Programming payments on a wallet level means conditions can be defined in advance that must be met in order to be able to make an (automated) payment with Digital Lilangeni. The design of the Digital Lilangeni should support the programming of payments and provide an open way so as not to limit private sector innovation.

The programming itself, however, is not intended to happen at the public money level, but rather at the payment or wallet level. This use case was not tested as part of the pilot project for the Digital Lilangeni.

4.6 Cross-border Payments

The Digital Lilangeni can contribute substantially to making cross-border payments more effective. With its own CBDC solution, the CBE could be able to participate in international cross-border projects where there are cross-border arrangements especially within the SADC and CMA region. The Digital Lilangeni should therefore be designed in line with international standards to enable cross-border interoperability with other jurisdictions.

The Financial Stability Board (FSB) along with the Committee on Payments and Market Infrastructure (CPMI) and other relevant international organisations and standard-setting bodies set and published quantitative targets[7] for cross-border payments that should be fulfilled by 2027. This roadmap has been endorsed by the G20.

For further pursuit of the Digital Lilangeni cross-border project, however, developments in other countries, especially within the Common Monetary Area (CMA) and South Africa, need to be considered and discussed jointly with the respective Central Banks. The CMA has started working on such a project. Further elaboration on the interplay between Eswatini and the CMA countries on CBDC transactions is available under Section 5.1.5 Interoperability: Cross-border perspectives.

[7]Financial Stability Board (FSB): G20 Roadmap for Enhancing Cross-border Payments; Consolidated progress report. 9 October 2023 (Availability: https://www.fsb.org/2023/10/g20-roadmap-for-enhancing-cross-border-payments-consolidated-progress-report-for-2023/)

Cross-border payments were not in scope for the pilot project for a potential Digital Lilangeni, but the CBE is however considering this topic for potential CBDC engagements in the future.

5. Design principles of the Digital Lilangeni

5.1 Key Design Criteria

The design of the ecosystem of a potential Digital Lilangeni must meet the needs of the user groups (Eswatini citizens: end users, merchants). Ultimately, it is through their adoption of the Digital Lilangeni that determines the success of the CBE's CBDC initiative. Keeping this in mind, the CBE has examined a variety of possible design elements and weighed their advantages and disadvantages in line with its vision and motivations. The following key design criteria were thereby derived for the context of Eswatini:

a) Accessibility

The CBE envisions CBDC as an additional payment method to those already in place in the market. The Digital Lilangeni is intended to naturally coexist with other payment mechanisms to make the system more robust and resilient. To enable true coexistence, it is critical that CBDC, like cash, is always available to all citizens of Eswatini and in all areas of the country. Only if universal access to digital central bank money is ensured would it be seen as a true complement to cash and be accepted as such.

Accessible to everyone, anywhere, anytime.

The all-inclusive accessibility to CBDC is threefold:

Everyone should be able to use it. This includes both people who are already integrated into the financial system (i.e., people with bank accounts, mobile money accounts), but also those who have not yet had access to it (i.e., unbanked people). The Digital Lilangeni should also be able to be used by all demographics (i.e., old and young, male and female, urban and rural, etc.) – just like cash today.

Anywhere: Since CBDC is intended to transfer the same characteristics of cash into the digital space, it must also enable availability of CBDC anywhere. Regardless of whether one is in rural or urban regions of the country, the Digital Lilangeni should be able to be used as a means of payment in all those areas. An offline solution as a back-up for the possible loss of Internet connection in remote places of the country can support this (see use cases part). The integration of Digital Lilangeni into the USSD system can also serve as a significant driver for financial inclusion.

Anytime: CBDC, like cash, should be usable as a means of payment in any situation. This means that, regardless of external circumstances, even during natural disasters or power outages, it should be possible to make payments with a Digital Lilangeni at any time. This ensures the greatest possible resilience of the system and creates trust among the population. No single point of failure and an offline version of CBDC as a back-up solution can help here.

b) Legal tender

The CBE considers the potential Digital Lilangeni to be complementary to the physical Lilangeni (banknotes and coins). The Digital Lilangeni therefore has the same legal tender properties as cash has today in the country, and convertible to Eswatini Lilangeni in the form of cash or deposit money in the 1:1 ratio. The potential Digital Lilangeni has a full legal tender status, meaning that it should be accepted as a medium of payment up to any amount when it comes to settling debt or financial obligation. Legal tender status could increase inclusiveness since the Digital Lilangeni can be trusted by everyone and can be accepted or used for all payment scenarios in Eswatini.

c) Non-interest bearing Digital Lilangeni

The Digital Lilangeni is seen by the CBE as a complementary digital means of payment to existing Central Bank money (banknotes and coins) that is available to the public. CBDC should therefore mimic the characteristics of cash as closely as possible. Like cash, the CBE does not envisage any interest payments on the potential Digital Lilangeni. This means that CBDC should be conceived primarily as a means of payment and not as an investment medium. Due to the efficient domestic monetary policy framework of the CBE and that the Lilangeni is pegged 1:1 to the South African Rand, any remuneration on the Digital Lilangeni is not intended to be introduced.

d) Interoperability

Eswatini already has an established payment network, where different payment methods like cash, mobile money, and bank accounts co-exist. A Digital Lilangeni can support interoperability amongst existing payment methods especially, in the absence of a domestic payments switch. This also includes interoperability between physical banknotes, coins, and Digital Lilangeni.

e) Privacy aspects

In the context of payments, privacy is crucial to foster a trustworthy relationship between end users and the entities responsible for handling their transactions. Financial and payment service providers take measures to safeguard this confidential information of end users based on local privacy regulations. Privacy can range in a broad scale of two extremes with flexible configurability between complete anonymity and full transparency. Complete anonymity in a payment implies that neither the payer nor the payee would disclose or retain any information about the user anywhere, similar to a cash transaction. While this could offer users the highest level of privacy, it would make it very difficult for financial service providers to comply with regulatory requirements such as Anti-Money Laundering/Countering Financing of Terrorism (AML/CFT) regulations or to conduct the "know your customer" (KYC) process to identify potential risk factors. On the contrary, full transparency in a payment may imply that the Central Bank or one authorised party can access or store all levels of transaction data including payer/payee identities, transfer amount, transaction date, etc. Although this transparency can reduce illicit activities in the ecosystem, this option would highly risk user adoption on CBDC, and the large amounts of data would increase cybersecurity threats.

Taking these into consideration, the CBE envisions a level of privacy in between. It prefers some configurable information to be shared by customers that could be collected and/or analysed by FSPs following the local data policy guidelines and the policy of the CBE about data that is collected (e.g., based on transaction amount, online and offline modes, KYC tiers). Therefore, partial pseudo-anonymity is a preferred design choice which enables a level of privacy between cash and e-money. FSPs can run AML/CFT checks locally which protects privacy better than if the Central Bank ran analyses. This privacy design can be configured over the lifetime of CBDC but should be communicated transparently to end users.

Data Protection Act, 2022 (Act No. 5 of 2022) should be kept at full respect when it comes to data protection and privacy regarding the potential Digital Lilangeni.

As the Central Bank can validate the payments with Digital Lilangeni and trace the flow of tokens through the system without any personal information, the excerpted aggregated digital cash-like data could further assist the CBE in the formulation of monetary policy, the enhancement of financial stability, and the integrity of the financial sector.

To conclude, it is utmost important to establish balance between privacy and transparency and implement it accordingly into the potential Digital Lilangeni design.

f) AML/KYC

Given that the Digital Lilangeni is intended to be a digital token[8] that needs to be stored in a digital wallet, it should meet the AML/KYC requirements to onboard customers for digital financial transactions. Considering that FSPs are responsible for distributing CBDC

[8] Detailed description under Section 5.2.2 Token-based (UTxO) protocol

to end users, they are also committed to AML/CFT compliance in the Digital Lilangeni ecosystem. Adherence to AML/CFT can ensure that the CBDC is protected from being used for illicit financial activities, thus preserving its integrity. The private sector can further offer innovative KYC solutions (e.g., biometric authentication). FSPs are responsible for reporting fraud to the CBE and suspicious transactions to the Eswatini Financial Intelligence Unit.

The Data Protection Act, 2022 (Act No. 5 of 2022) provides a legal framework to implement an optimal level of AML/CFT.

The purpose of the KYC monitoring and reporting is to maintain financial stability in parallel to increasing financial inclusion and consumer privacy.

g) Limits

Even though the Digital Lilangeni is intended to ensure universal access, thereby enabling the best possible end user experience, the CBE could still set holding limits in order to ensure the stability of the financial system. The design of the Digital Lilangeni is therefore envisaged to flexibly allow the CBE to set caps in order to be able to implement appropriate measures in line with financial stability.

CBDC allows to set constraints through digital interventions (compare “Programmability” in chapter 4). For example, restrictions can be placed on time, amount, and condition. These can be introduced by the CBE in the future.

h) Transaction fees

In principle, the Digital Lilangeni should be able to be used as a means of payment without any fees. This is the only way to ensure that the Digital Lilangeni is accepted as a digital alternative to the physical Lilangeni. This can also increase acceptance by the general public, since it gives the citizens of Eswatini a clear benefit if no fees are charged on the digital transactions with the Digital Lilangeni.

Nevertheless, the CBE may consider imposing fees that would apply only above a certain transaction amount or volume. In addition, services beyond the basic payments can also be subject to a fee, which gives private stakeholders an incentive to offer further innovative solutions based on the core CBDC infrastructure.

A multi-tier structure towards pricing can be considered by the CBE in line with its vision and motivations. The base tier could be for supporting financial inclusion and low-income people where no fees are applied, and basic products or services can be free of charge. The next tier, with fees included, could be applicable for higher transaction amounts and value-added financial services.

5.2 Domestic considerations

The CBE is working on a national payment switch which is under development at the moment. Should a CBDC be rolled out in Eswatini, it should be able to integrate with existing payment infrastructures, including the national switch as envisioned by the CBE.

The CBDC in Eswatini should also take into consideration futuristic payment use cases. As a consequence, the Digital Lilangeni can be interoperable with smart contracts to enable programmable use cases, such as delivery versus payment. This ability could further increase the innovative capacity.

Since a Digital Lilangeni is intended to be token-based (see chapter 5.2.2), it entails a real-time settlement that is adapted to the current definitions of financial messaging standards (e.g., ISO 20022). Regarding availability, the Digital Lilangeni should be available on a 24/7/365 basis with no scheduled downtime.

The technology behind the Digital Lilangeni enables increased volumes, within set parameters, if demand for Digital Lilangeni payments increases remarkably. Scalability is effectively ensured. The CBDC in Eswatini would also supports instant payments. Payment initiation with CBDC is executed swiftly with certainty of completion. Offline payments are settled instantly, without the need to access the backend system.

The South African Rand (ZAR) is a legal tender in Eswatini, and the Lilangeni is pegged to the ZAR. This peg enhances the trust in the Eswatini currency. Attention should be paid as to how the Digital Lilangeni maintains the status quo with regards to substitution and its convertibility to ZAR, in its currently existing form or any potential digital form.

5.3 Cross-border considerations

In an interconnected world where supply chains are getting even more interrelated and transnational payments increase in volumes and values, it is vital that domestic CBDC designs incorporate cross-border considerations. The door should be left open for making the potential Digital Lilangeni interoperable with the CBDCs of other jurisdictions. CBDCs could contribute to accelerate the integration of African countries with other economies, which can be particularly true for the Common Monetary Area (CMA), of which Eswatini is one of the members alongside Namibia and Lesotho under the leading role of the Republic of South Africa. The potential Digital Lilangeni considers CBDC standards which allow it to participate in intraregional and international cross-border CBDC projects. There might be several cross-border CBDC models to achieve digital integration once the business case(s) is/are found, to which the Bank for International Settlements (BIS) provided some applicable models. As a result, the Digital Lilangeni

should be designed in line with the global CBDC standards. Participation in international projects around cross-border CBDCs can also be considered. The potential cross-border CBDC could support international trade, make remittance payments more effective, as well as provide improved efficiency to the existing CMA payments system.

The CMA stresses particular importance to investigating whether and how cross-border CBDC could be deployed between its member countries. The developments in the CMA arrangement can to some extent influence the domestic CBDC systems in each CMA country. Once the motivation and the use case(s) for cross-border payments have been identified, the CMA can embark on a cross-border CBDC project both on the retail and wholesale angles. This cross-border CBDC project could serve as a lighthouse for many other similar projects between economically integrated African regions or countries, which may be considering having a joint settlement currency.

5.4 System Architecture

As the CBE plays the key role in overseeing and operating the core payment system, it should ensure that the system architecture effectively supports the desirable payment features of the Digital Lilangeni to the end users in addition to maintaining the CBE's mandate in monetary policy and financial stability. This sub-section presents technical design features of a potential Digital Lilangeni.

a) Foundational technology

The foundational technology is the core upon which the CBDC ecosystem is rolled-out in Eswatini. The CBE envisages to build the Digital Lilangeni on a distributed database[9]. This is a collection of multiple autonomous processing elements which can have different capabilities and are all part of an operating system. This setup gives sufficient resilience for such a critical infrastructure. Each processing element is logically integrated in its access and management. This is operated and permissioned by a single entity, the CBE, so it is centralised from a management perspective. The performance of distributed database in real scenarios, measured by transaction throughput (transaction per second, abbreviated by TPS), is found to be superior to distributed ledger technology (DLT)[10]

[9] A distributed database replicates data across different physical servers and/or locations. This increases resilience in case of network outages. See also Özsu, M. T., & Valduriez, P. (1999). Principles of distributed database systems (Vol. 2). Englewood Cliffs: Prentice Hall.

[10] DLT is a system that records and shares data across multiple data stores (or ledgers), which then later are synchronized. DLT addresses ownership and double spending concerns. This technology does not require a single owner; thus, it may be permissionless. – *based on* Natarajan, H., Krause, S., & Gradstein, H. (2017). Distributed ledger technology and blockchain.

alternatives[11], especially in retail CBDC applications. In addition, it has less complexity in managing additional participants in the network compared to DLT.

In the retail CBDC system of Eswatini, the CBE is the only entity which is authorised to issue and to redeem CBDC without any consensus mechanism, just like in the case of cash. This also means that the CBE ensures that proper governance controls are implemented for the operation of this system.

b) Token-based (UTxO) protocol

In order to be recognised by the population as an equal alternative to coins and banknotes, the design of the potential Digital Lilangeni follows a token-based protocol to guarantee an adequate level of system security. The minting and distribution process of CBDC are similar to the one of cash, and has specific denominations in this scenario. CBDC verification ensures authenticity of tokens, which include cryptographical functions and formal mathematical models.

In the token-based approach, money is represented as a cryptographic private key, coupled with a particular denomination (the "token"). Knowledge of that private key equals ownership of the token and enables payments. Therefore, a token-based CBDC is a digital bearer instrument. Just like with cash, payments can be executed by handing over the token from the payer to the payee.

The token's denomination represents an equal amount in cash that can be redeemed at the Central Bank as its own liability, which also means that the settlement risk does not depend on financial intermediaries or FSPs.

In technical terms, tokens have a short lifetime, because they would be replaced frequently. Specifically, every time a payment happens, both payer and payee may replace the cryptographic keys and make this replacement known to the Central Bank for verification. If anyone were to use a token that has been replaced, verification would fail, since it would now be recognised as "spent".[12]

As opposed to an account-based model, this approach bears closest resemblance to cash in certain transactional aspects.

The token-based design of a Digital Lilangeni extends the attributes of cash to the digital world by enabling universal access, configurable anonymity, and security for CBDC holders. Since this approach highly supports offline payments and no formal financial accounts are needed, the adoption of the Digital Lilangeni can be increased, thus even higher and deeper financial inclusion can be achieved.

11 Bank of England. (2023). The Digital Pound: Technology working paper. Bank of England. https://www.bankofengland.co.uk/-/media/boe/files/paper/2023/the-digital-pound-technology-working-paper.pdf

12 In cryptocurrency parlance, this is also referred to as "UTxO" or "unspent transaction output".

c) Two-tier hybrid model

The ideal architecture for a Digital Lilangeni is a two-tier hybrid model in which the CBE is the sole issuer of the Digital Lilangeni, as well as the owner and operator of the CBDC infrastructure. The Digital Lilangeni is, like banknotes and coins today, a direct claim on the CBE.

Intermediaries (commercial banks, financial service providers, non-bank financial institutions) take over the distribution of the Digital Lilangeni to the end users in this model. Likewise, all customer-facing activities (e.g., KYC, onboarding processes and customer support) fall to the intermediaries in this two-tier model. This approach corresponds to the current cash cycle, in which the intermediaries also assume this role. The intermediaries' expertise in dealing with end customers can thus be used efficiently in a two-tier CBDC ecosystem and the intervention in the existing system is only minimally invasive.

This two-tier hybrid approach was also tested during the FSP Pilot Project, where Swaziland Building Society (SBS) was the intermediary to take over the integration of a Digital Lilangeni into their system and to offer the CBDC payment option as a service to its employees including selected CBE staff members with accounts at SBS. The CBE took on the role of minting, while SBS handled the distribution to and onboarding of end users in the pilot ecosystem.

d) Governance in a two-tier hybrid model

The roles and responsibilities of the entities involved must be clarified in advance for a successful CBDC ecosystem. The following paragraphs describe and discuss the roles of the participants in a two-tier hybrid model (see Figure 7).

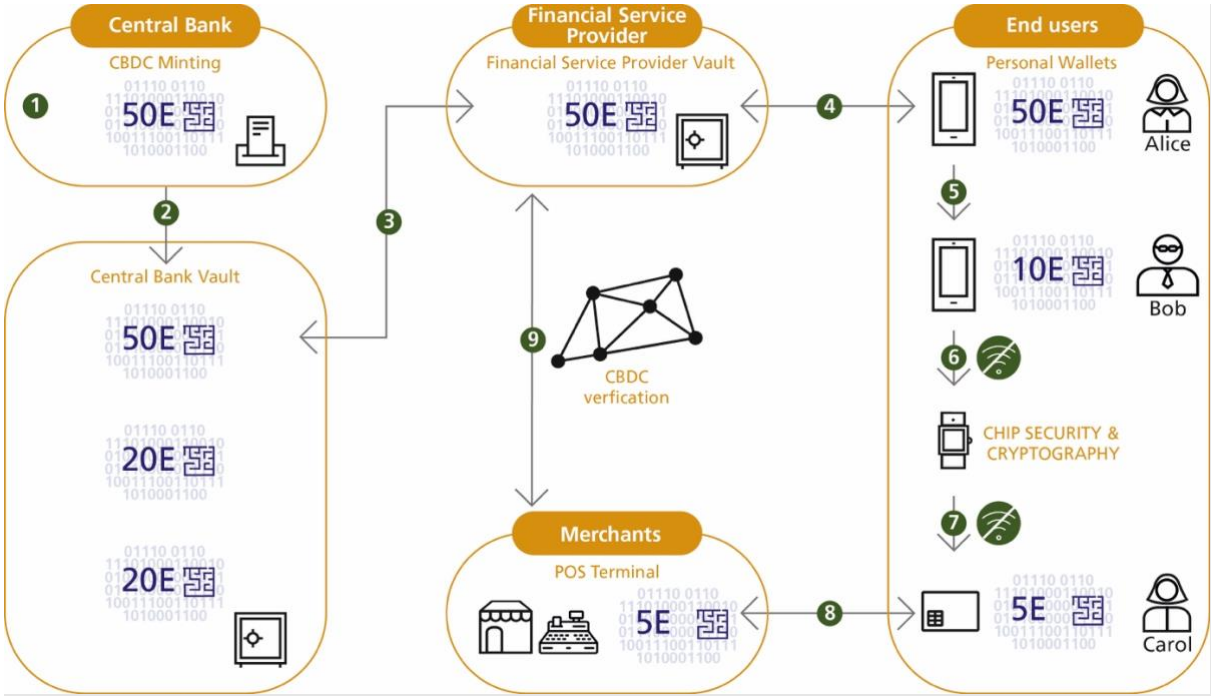

FIGURE 7: GOVERNANCE IN A TWO-TIER HYBRID CBDC MODEL

Central Bank

The CBE as the key entity in the CBDC ecosystem provides the core infrastructure and manages the core system of a Digital Lilangeni. The Central Bank sets the rules in the system and ensures that the governance framework is maintained. The CBE also defines concrete policies for all participants in the ecosystem (e.g., maximal transaction limits, minimum KYC requirements).

As with the physical cash cycle, the power to create Central Bank money lies solely with the CBE. It thus mints the Digital Lilangeni and is also the only entity in the system that can destroy it again. The Digital Lilangeni is distributed to the FSPs from the Central Bank vault, which is separate from the CBDC minting suite. This process follows today's cash cycle, in which commercial banks are supplied with cash by the Central Bank in exchange for reserves.

Once the Digital Lilangeni is introduced, the CBE monitors and ensures the integrity of CBDC in circulation.

The CBE stores analytical data that is configurable in accordance with local data governance policies. Deciding which data streams can be viewed by which entity in the CBDC ecosystem falls equally within the CBE's decision-making authority. The Central Bank can use aggregated data to improve the information base for important monetary policy decisions. Thus, better-informed decisions can be made with real-time market data. However, privacy of end users in line with the local data protection law must be kept in respect.

Financial Service Providers

FSPs are responsible for all customer-facing activities in a two-tier hybrid model. Their experience in dealing with existing customers ensures that onboarding and KYC processes can be carried out efficiently. With the liquidity of Digital Lilangeni provided by the Central Bank, the intermediaries can distribute CBDC to the end users.

In interacting with the end users of the Digital Lilangeni, the FSPs offer and manage CBDC-wallets in different user interfaces (e.g., online through mobile application, offline through smart card). Based on the core CBDC infrastructure provided by the Central Bank, FSPs can develop innovative business models that allow them to collect fees from end users for value-added services.

FSPs play a pivotal role in the entire CBDC ecosystem. They act as the bridge between the digital currency and the end users, ensuring seamless transactions. Therefore, it is crucial for these providers to integrate the CBDC solution into their existing systems or establish new ones to accommodate this digital transformation. This integration not only ensures the smooth running of transactions but also helps in the widespread adoption of CBDC. By doing so, FSPs contribute significantly to the promotion of financial inclusion and the progress of the digital economy.

Merchants

The Merchants' role is primarily to accept and transact with CBDC as an official means of payment. This allows a high level of usage by the citizens of Eswatini, which would be otherwise diminished if it is not adopted by merchants. By integrating CBDC into their existing payment processing system (e.g., POS terminal), shoppers can be offered an additional payment option, thus improving the versatile acceptance of in-store payments. Merchants, as direct points of contact for end users, can likewise take on part of the onboarding process by distributing smart cards, for example. These smart cards can then be topped up in the store by exchange with cash to use Digital Lilangeni on the smart card for digital payments (online or offline).

Beyond customer-directed payments, payments can also be made between merchants using Digital Lilangeni (B2B). Merchants have the choice whether they keep their liquidity in CBDC or convert it to bank deposits or cash out. Additionally, payments with the Digital Lilangeni provide immediate liquidity for the merchants, which helps them to rotate their earnings faster, for example, grocery stores that are able to replenish more products when they have money available for it.

End users

A retail CBDC is designed to provide the citizens of Eswatini with an additional means of payment. As such, it offers them the possibility of making digital payments between one another (P2P), paying at the merchant checkout with Digital Lilangeni (P2B) as well as making transactions with governmental institutions (e.g., receive or pay funds, tax bills, G2P, P2G).

The design of a Digital Lilangeni allows the citizens of Eswatini to use different form factors available in both online (e.g., via smartphone application, feature phone, smartwatch) and offline mode (e.g., smart card, smartphone with NFC). To use the smart card in offline mode, end users can top up the card with Digital Lilangeni. This can be done either at a merchant in exchange for cash or via another end device that can interface with the smart card (e.g., NFC technology in smartphone). The Digital Lilangeni on the smart card can then be used for payment in offline mode or can be withdrawn at any time. This also means that the Digital Lilangeni can be stored on the end devices (e.g., smart card) and kept secure due to the authentication process with a PIN code.

In addition, end users benefit from the innovative power of the FSPs in the ecosystem of the potential Digital Lilangeni through new, value-added service offerings, which are particularly supported by programmable features.

e) Information security

Any CBDC system attracts attackers with a multitude of skills, capabilities, incentives, and budgets. Therefore, and as it is part of a country's critical infrastructure, a CBDC solution such as the Digital Lilangeni must fulfil the highest security standards. This entails a holistic view of security: any infrastructure is as weak as its weakest component. The potential Digital Lilangeni fulfils these requirements both from a broad architectural view, as well as in the detailed design specifications.

This means securing any data-in-transit by encrypting all confidential data with state-of-the-art standardised algorithms. Furthermore, authentication of systems and servers within the ecosystem are ensured with signatures by using certificates from a self-hosted public key infrastructure (PKI) or other trusted Certificate Authorities.

But confidential data is not only in-transit but also at-rest, both at the Central Bank side but also on the customer side in the form of hardware wallets. By deploying well-established smart cards and secure elements on the customer side, and encryption systems on the Central Bank side, fraud is prevented in the whole supply chain from issuer to user.

Security in depth, by deploying multiple layers of nested encryption/authentication, is another method employed to prevent attacks.

The system is designed redundantly. That is, there is no single-point-of-failure. The CBDC minting process is deployed at the Central Bank at an air-gapped system and further secured by organisational security, such as rights and role models and least-privilege principles.

FSPs are provided with their own ecosystem and are locally responsible for operating it securely. The combination of technical security and organisational security makes the

infrastructure resilient and secure as a whole, where potential risk of internal attackers is also minimised by separation of duties and dual controls.

Figure 8 presents visually the key security aspects and explains them in more detail.

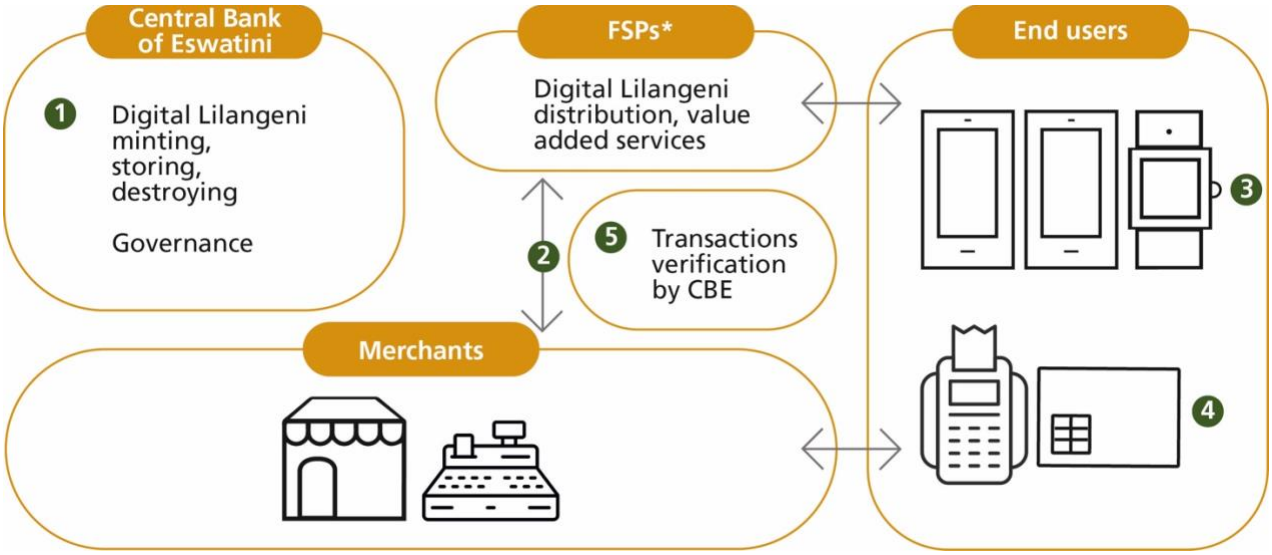

FIGURE 8: KEY SECURITY ASPECTS IN A DIGITAL LILANGENI ECOSYSTEM

*FSPs include commercial banks, mobile money operators, fintech firms, credit institutions, etc.

1. The CBDC minting and redemption infrastructure is under full control of the CBE. This is the most sensitive part, so it is separated into a highly secure air-gapped offline environment at the CBE with strict organisational controls.
2. Authenticated and encrypted communication channels between FSPs and merchants are deployed.
3. FSPs, which provide smartphone apps to consumers, will be provided with secure software development kits (SDKs).
4. The security of smart cards as well as POS terminals is ensured by five layers:

- Secure storage and processing of data are allowed on smart cards, which can serve as end points in an end-to-end system.
- Symmetric and asymmetric cryptography can be handled.
- Key material is stored in secure elements.
- Both hard- and software are resilient against security attacks with a set of established countermeasures.
- Security certification criteria investigates the resistance against potential attack scenarios.

5. Cryptographic algorithms such as hash functions, signature algorithms, key-agreement mechanisms and symmetric encryption algorithms are all deployed and chosen according to international security standards and secure all relevant data by means of authentication and encryption.

Further elaborating on resilience, a potential Digital Lilangeni is designed to be able to recover from operational disruption, including software and hardware-related challenges. This design also minimises the credit and liquidity risks in the broader ecosystem.

Learnings from the pilot projects

The Digital Lilangeni pilot projects (Canteen Pilot Project & FSP Pilot Project) aimed to technically test and validate the propositions and assumptions that were made in the Initial Digital Lilangeni Design Paper. From the use cases that were outlined in section 4, the CBE tested both online and offline use cases in this pilot project. G2P, Programmability, and Cross-border use cases were not part of the testing in this pilot project.

For online and offline test cases, the CBE together with FSPs successfully tested Peer-to-Peer (P2P) as well as Peer-to-Business (P2B) payment scenarios with a potential Digital Lilangeni. Those transactions were executed within a closed user environment among the employees of the Central Bank as well as the employees of FSP. This approach enabled the CBE to gain immediate and honest feedback on the technology which was tested in the project.

These pilot projects were a relevant exercise for all entities involved – the CBE, G+D as well as the FSPs. The main learnings about the assumptions that were made before the pilot as well as their impact on the overall Digital Lilangeni ecosystem design are the following:

- Use Cases and Accessibility: As outlined in the Initial Digital Lilangeni Design Paper, the CBE aimed to test both major use cases, online and offline CBDC payments. For a digital currency to be truly inclusive and offer a form factor for all demographics of the Eswatini society, it turned out that the offline use case was very viable for Eswatini. Swaziland Building Society as the Financial Service Provider within the pilot ecosystem even worked on a solution to print out a static QR-Code to provide it as a wallet with CBDC “stored” on it. The CBE keeps in mind the importance of a resilient CBDC solution, thereby focussing on both online and offline solutions. This should enable every Eswatini citizen to access the potential Digital Lilangeni, thus making it a fully financial inclusive means of payment. Furthermore, although it was not tested during the pilot projects, the CBE still considers the value of the CBDC integration into a USSD based system for any further potential CBDC engagement.

- Non-interest bearing and legal tender: The pilot project tested a non-interest bearing Digital Lilangeni which should act as a legal tender in the country. The outcome of the pilot projects has not changed the position of the CBE in this regard, meaning that the CBE still aims to design a potential Digital Lilangeni as a non-interest bearing CBDC with legal tender status.

- Interoperability: The CBE still envisages a potential CBDC to be an interoperable means of payment in the country (domestic). Interoperability on a cross-border level still needs some further investigation also with regard to the role of a potential Digital Lilangeni within the Common Monetary Area (CMA).

- Limits: To maintain the stability of the financial system in the country, the CBE keeps its position to be able to set limits on Digital Lilangeni holdings.

- Transaction Fees: FSPs provided feedback after the pilot projects that they need clarity on the fees that can be incurred with a CBDC. This is an important aspect for them to build their business model around a CBDC solution in Eswatini. The CBE is aware of this and will discuss this topic with the FSPs with regard to a potential Digital Lilangeni in the future.

- Foundational Technology: During the pilot projects, the CBE has extensively tested G+D's CBDC solution Filia for online and offline transactions. This solution was based on a distributed database as outlined in chapter 5.2.1.

- Token-based protocol: Furthermore, the token-based approach that was tested during the pilot projects has proven to be beneficial. Since with this token-based CBDC approach, especially offline payments are supported, the CBE keeps the position to further investigate the potential of this tokenised CBDC solution.

- Two-tier infrastructure: During the FSP Pilot Project, this two-tier infrastructure with the FSPs as the intermediating entity between the Central Bank and the end users was tested. The process that was tested as well as the different roles and responsibilities of each entity in the pilot ecosystem can be seen in Chapter 5.2.4 (Figure 7). Even if there were some hurdles to overcome during the integration phase, the CBE is still committed to a two-tier infrastructure with the Financial Service Providers as the intermediary entity. It has proven that the FSPs can make a viable impact on the overall system.

- Governance: The roles in the FSP Pilot Project were set up as outlined in section 5.2.4. The role of the Central Bank as the sole "Minter" of a CBDC token which is then issued further to the FSPs has proven to be beneficial. Especially the fact that FSPs know their existing customers and that they are familiar with the standard onboarding process of new customers makes the whole CBDC ecosystem efficient.

- Information Security: Security of such a digital currency remains priority of the CBE also for a potential Digital Lilangeni. The need to secure all processes along the CBDC token lifecycle derives from the responsibility that the Central Bank has towards the citizens of Eswatini to provide a secure fiat currency. With regard to a potential roll-out of CBDC in the Kingdom of Eswatini, the CBE will treat the topic of information security with the highest priority.

Besides those learnings for the potential Digital Lilangeni ecosystem and architecture, the CBE also gained some more learnings with regard to such CBDC initiatives:

- Timeline: A key learning from the FSP Pilot Project was the importance of time management. It turned out that the integration effort, which is required in such a two-tier hybrid CBDC infrastructure, cannot be estimated precisely in advance. It is important to note that the actual time that is needed for executing the integration can also vary from stakeholder to stakeholder. For the CBE this was a valuable learning from the pilot project in order to better understand the effort that is needed for a potential roll-out of a Digital Lilangeni in Eswatini.
- Staff requirements: Staff constraints can lead to significant delays. To build a CBDC-compatible application, FSPs must have a deep understanding of CBDCs and involve all team members, including those who work remotely, from the project's onset. Key roles include mobile and back-end developers, DevOps/Infrastructure architects, QA, technical lead, and project manager. Also for the CBE, it is important to be involved in those technical discussions together with the FSPs and CBDC Solution/Technology Provider from the beginning. This should happen very early in the project to establish a common understanding among all participating stakeholders.
- Collaboration: Collaboration between the public and private sectors is essential for the success of such a CBDC project. With multiple stakeholders such as the CBE, FSPs and technology provider, efficient co-operation is a necessity. The FSP Pilot Project with SBS has shown that a close co-operation can contribute to the success of such an initiative. This is also of particular importance in view of possible roll out of Digital Lilangeni in Eswatini.
- Stakeholder engagement: Engaging stakeholders early in the initiative is pivotal for the success of a potential Digital Lilangeni project. FSPs, being the key players in such a CBDC ecosystem, need to have a clear understanding of their role within the system to effectively contribute to the project's success.

6. Conclusion

A potential Digital Lilangeni can only be viable if it meets the needs and requirements of the citizens of Eswatini. This is the premise that the CBE has taken as a guiding principle in the design of a Digital Lilangeni ecosystem. Based on a deep understanding of challenges and the needs of the population regarding payments in the digital age, various design criteria were weighed and the advantages and disadvantages of each were analysed.

The design of the CBDC ecosystem in Eswatini is an important first step on the journey. It is based on findings (from trainings, workshops, industry analysis, stakeholder consultation and surveys) and the experience of the Central Bank together with Giesecke+Devrient with regard to the existing payment systems in Eswatini. The evaluation of the particular design of the Digital Lilangeni also included considerations of the extent to which CBDC can bring added value to the country. However, the design decisions made here only provide a theoretical framework.

To gain even more insights into how the CBDC ecosystem can work in Eswatini, involving multiple stakeholders, the next step was to experiment with the technology. In a sandbox environment, this allowed different scenarios (e.g., issuance, distribution of Digital Lilangeni to FSPs, transactions with CBDC) to be tested and evaluated in a controlled setting by a defined group of users. The technology was also further examined in the form of a Proof-of-Concept (PoC), which ultimately led to the roll-out of two pilot projects. The insights gained from this series of testing confirmed the assumptions that were made in the initial design paper and can be used to further develop the system design of Digital Lilangeni and prepare for possible scenarios (which might have been less considered previously).

Such a testing environment (Sandbox, PoC, Pilot Project) is important to provide stakeholders in the CBDC ecosystem with an understanding of the potential Digital Lilangeni and to further reduce their uncertainties and concerns. Key stakeholders should be involved in the process towards a Digital Lilangeni from the beginning.

Glossary

Token-Based Approach	The object of verification is the digital token that represents each CBDC unit. This is similar to cash, in which verification amounts simply to determining whether relevant banknotes or coins are genuine (not counterfeit). The minting and distribution process of CBDC in this scenario is similar to cash. CBDC can have specific denominations in this token-based scenario. The verification is based on the authenticity of tokens which include cryptographical functions. The value note represents an equal amount in cash that can be redeemed at the Central Bank (Central Bank liability). The settlement risk does not depend on financial intermediaries.
Programmable payments	Transfers of money for which the time, amount and/or type are determined by conditions specified.
Distributed Ledger Technology (DLT)	DLT provides a consensus of replicated, shared, and synchronised digital data spread across multiple sites, countries, or institutions. There is no central administrator or centralised data storage, thus it may be permissionless.
UTxO	This is a cryptographic parlance, referring to unspent transaction output. Tokens have a short lifetime because they would be replaced frequently. Specifically, every time a payment happens, both payer and payee may replace the cryptographic keys and make this replacement known to the central bank for verification. If anyone were to use a token that has been replaced, verification would fail, since it would now be recognised as “spent”.
Distributed database	This is a collection of multiple autonomous processing elements (PE) which may have different capabilities and are all part of a global system. Each PE may be physically different; however, it will be logically integrated in its access and management. This is achieved by having a close cooperation between PEs to have a consistent view for the users. These are traditionally operated by a single entity, thus being permissioned. Simply put, it could be centralised from a management perspective.

FSP	Financial Service Providers: Intermediary in a CBDC ecosystem including commercial banks, mobile money operators, fintech firms, credit institutions, etc.
PSP	Payment Service Provider: it refers to payment service providers, including banks, mobile money service providers, fintech companies and any FSP that can provide payment services as well.



Physical Address
Mahlokohla Street,
Mbabane, Eswatini

Postal Address
P.O Box, 546
Mbabane (H100)
Eswatini

Telephone
Tel: (+268) 2408 2000
Fax: (+268) 2404 7865

Email
info@centralbank.org.sz