Zambia Honey Supply Chain and Minimum Viable Ecosystem Report

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By: Sam Lambert (Co-Founder of zenGate Global) and Kyle Curry (Co-Founder of Nature's Nectar)

1. Executive Summary

Nature's Nectar Zambia (NN) in partnership with **Palmyra Pro** is advancing a transformative model for honey production by combining a vertically integrated outgrower approach with cutting-edge digital systems to bring unprecedented **transparency**, **traceability**, and **integrity** to the supply chain. Centered around small-scale beekeepers and community-based structures, this model enables decentralized honey production while maintaining high standards for quality and sustainability. The purpose of developing the **Minimum Viable Ecosystem (MVE)** is rooted in leveraging existing community engagement with more advanced organic certification, and digital tools that provide real-time data validation across the supply chain.

The **Nature's Nectar** model begins with community organization through Zone Lead Farmers, each overseeing local beekeepers who manage around **10 beehives each**. These hives are assembled, distributed, and suspended in nearby forests, allowing for natural bee occupation, honey production, countering deforestation, **in balance with the nature and traditional beekeeping systems of Zambia.**

Key challenges such as adulteration and lack of traceability in global honey markets are directly addressed through Palmyra Pro, an integrated digital platform enabling secure data capture, credentialing, and auditability. **Biometric Authentication** technologies, alongside blockchain-anchored **verifiable credentials** will allow stakeholders to validate data integrity from hive to consumer. This level of transparency not only increases trust but also creates new market opportunities for **traceable and ethical honey brands.**

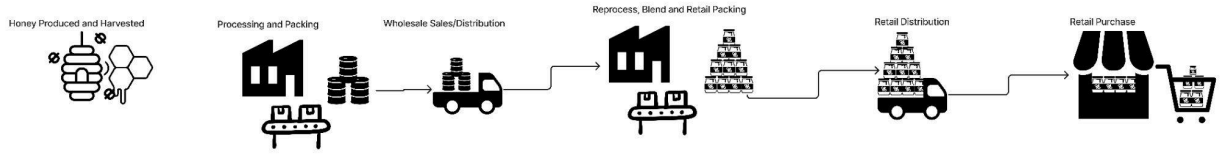
To establish the **MVE**, key stakeholders have been identified and prioritized based on their readiness for digital integration. For this project; the MVE is made up of **Nature's Nectar, its Field Supervisors, and organic certification auditors** due to their existing systems, networks, and capacity to support real-time data collection and compliance verification. Other actors—including farmers, government entities, conservation partners, and local buyers—are envisioned for integration in later stages, once barriers such as digital literacy, infrastructure, and market readiness are addressed.

The **MVE pilot will use Palmyra Pro (as the core foundation)** to capture detailed production data including hive locations, occupation status, and harvest logs, as well as transactional data around honey purchases such as pricing, water content, and farmer identity. Processing metrics, including input/output ratios, waste, and packing information, will also be recorded, along with live audit data flows that can be accessed by certified auditors through credentialed dashboards. With a network of over **3,000 beekeepers and 30,000 hives, Nature's Nectar is uniquely positioned** to pilot this ecosystem, **providing a blueprint for digitizing trust** in

agricultural value chains while **delivering measurable impact** for producers and consumers alike. Using **Palmyra Pro** as a foundation; the MVE and Pilot as part of Catalyst milestone requirements, we will leverage the **Credentials** and **Oracle** solutions to extend **current capabilities.**

2. Understanding the Honey Supply Chain

The honey supply chain consists of several steps that apply generally to most agricultural supply chains, ensuring products move from production through to consumers while maintaining required standards. The honey supply chain can be divided into the following key stages:



a. Beekeeping & Honey Production

- **Key actors**: Beekeepers

- **Description:**
    - Beekeepers maintain bee colonies, ensuring their health and productivity.
    - Bees collect nectar and other resources, which are transformed into honey and other products within the hive.
    - Beekeepers harvest honey by removing honeycombs from the beehive and this is where processing begins.

- **Output of stage:** Honeycomb

b. Processing & Packing

- **Key actors:** Processing stakeholders such as cooperatives or factories.
- **Description:**
    - Raw honey is extracted from the combs and filtered to remove wax, pollen, and other impurities.
    - Some producers may heat or strain honey for further purification, depending on the type of honey produced, the seasonality or the intended use of the product.
    - Honey is stored in bulk containers before transportation.

- **Output of stage:** Processed honey

c. Auditing, Quality Control & Testing

- **Key Actors:** Labs and Quality Assurance Experts

- **Description:**
    - Audits are conducted by 3rd parties to ensure best practices (e.g organic certification standards) - this will be a **focal point of the credentials MVE solution.**

    - Samples are tested for purity, moisture content, and contaminants (e.g., pesticides, antibiotics, or adulteration with syrups).

    - Compliance with regulatory standards is ensured through 3rd party analysis.

- **Output of stage:** Reports of certifications attesting the quality of the processed honey.

d. Bulk Distribution & Transportation

- **Key Stakeholders:** Logistics and distribution agents.

- **Description:**
    - Large-scale honey producers or cooperatives sell honey in bulk to processors, packagers, or wholesalers.

    - Honey is transported via trucks, ships, or air freight, depending on market destinations.

- **Output of stage:** transporting honey from origin to destination locations.

e. Re-Processing, Packaging, Wholesale and Retails Distribution

- **Key Stakeholders:** Importers, Wholesalers and Retailers

- **Description:**
    - Honey (once purchased) may undergo further aggregation, filtration, pasteurization, or blending for consistency.

    - It is packaged in bottles, jars, or bulk containers for retail, food service, or industrial use.

    - Honey reaches supermarkets, specialty stores, online retailers, or food manufacturers.

    - It may be marketed under different brands or as private-label products.

- **Output of stage:** Consumer-ready honey, ready for purchasing.

f. Consumer Purchase & Consumption

- Consumers buy honey for personal use, cooking, health benefits, or industrial applications (e.g., cosmetics, pharmaceuticals).

Each step in the supply chain impacts quality, price, and sustainability, with variations depending on market regulations, consumer demand, and regional practices.

3. Honey Supply Chain Structures and Existing Industry Challenges

Honey production occurs all over the world and different regions have different ways of coordinating their markets. Section 3 provides an overview of the various generalized production systems and supply-chains that exist for honey across the global industry.

Model Variation: Firstly, we have outlined below the differing supply-chain models for the production of honeycomb and honey processing.

Models	**Description**:	**Prevalence**:
Independent Beekeepers	Individual beekeepers manage their own hives, harvesting and selling honey directly to consumers or local markets.	Common in regions with rich beekeeping traditions, such as parts of Europe and Africa.
Cooperatives	Groups of beekeepers collaborate to process, market, and/or sell honey under a unified brand or structure, sharing resources and profits.	Notable in countries like Mexico and Ethiopia, where collective efforts enhance market access and bargaining power.
Vertically Integrated Honey Companies	Firms oversee the entire honey production process—from beekeeping to processing and distribution—ensuring consistent quality and supply.	Prominent in major honey-exporting nations such as China and Argentina.
Contract Farming	Companies contract independent beekeepers to supply honey, often providing resources and guidelines to meet specific standards.	Observed in countries like India, facilitating scalability and quality control.

Supply-Chain Preferences via Region: We have also noticed that various regions have developed preferences on the set up. Much of this is due to the trade-offs in the regions; from quality controls, the need for bargaining power via cooperative structures to scaleability. We have summarised the main honey producing markets and their common models that are used.

China	As the world's largest honey producer, China predominantly utilizes vertically integrated operations, enabling control over quality and large-scale production.
Europe	Features a mix of independent beekeepers and cooperatives. For instance, Greece and Spain have strong traditions of small-scale beekeeping, while countries like France have successful cooperatives.

United States	Combines large commercial beekeeping enterprises with numerous hobbyist beekeepers, catering to both domestic consumption and pollination services.
Africa	Relies heavily on traditional beekeeping methods, with cooperatives playing a crucial role in aggregating products for larger markets.

Key Challenges in the Honey Industry: Honey is one of the most adulterated products in the world and continues to face significant challenges around trust. The following table provides an overview of these issues and how solutions leveraging Cardano technology can help improve trust in the markets.

	Challenges in Transparency and Auditability	**Solutions to Address Transparency and Auditability Issues**
Adulteration	The blending of pure honey with cheaper sugar syrups undermines product integrity. Recent studies have highlighted widespread fraud, with a significant percentage of honey samples failing authenticity tests.	• **Lab Testing:** Prior to integrating directly with laboratories for on-chain test results, every effort must be made to ensure and secure honey purity while in processing and inventory stages. • **Tracking:** Ensuring all honey is tracked via the traceability solutions such as Palmyra Pro system and batched accordingly will ensure trust in honey purity post harvest through final purchase from NN. • **Leveraging Tamper-Proof IoTs:** Deploying IoT systems, such as RFID and/or NFC chips, to verify when containers of honey are open, closed, batched or going to processing will be vital in proving NN honey is not adulterated.
Traceability	Varying and complex supply chains make it difficult to trace the origin of honey, complicating quality control and fraud detection efforts.	• **Blockchain-Led Traceability:** Utilizing blockchain via verifiable credentials for producers, aggregators, wholesale buyers and retail brands creates opportunities to re-establish trust in the honey we purchase, while also creating new opportunities for fully traceable honey brands to become market leaders.

4. Deep Dive into the Nature's Nectar Supply Chain and Ecosystem

Nature's Nectar's supply chain is a **combination of a vertically integrated model** and **a cooperative model** that creates a unique opportunity to drive transparency in the honey sector as well as set a basis that is highly adaptable for other honey and general agricultural supply chains. The NN model starts with community organization and ends with a final product of liquid honey ready for consumers.

Step	Process Name	Details
1	Community Engagement, Organization & Initial Beehive Distribution	Nature's Nectar works only with small-scale beekeepers producing forest honey. Communities typically begin with 1,000 beehives, 100 members (10 beehives each). A Zone Lead Farmer (ZLF) is selected as the local manager for each group (the ZLF is the main point of contact and responsible for operations within that zone). NN only collaborates with trusted communities or producers using verified top bar comb honey.
2	Beehive Occupation & Honey Harvesting	Bees in Zambia naturally occupy hives due to environmental conditions and traditional systems. Beehives are placed strategically to support natural swarming and honey production. First harvest typically occurs 8–12 months after hive distribution. Harvesting is done twice annually by trained teams in each Zone.
3	Honey Purchasing	After harvest, NN organizes honey purchasing days in each Zone. Honey is collected and transported to Lusaka. Payments are made in cash or mobile money. Each honey bucket is traceable to the specific beekeeper and hive.
4	Processing, Filtration & Packaging	Honey is processed by Zone, heated to extract from comb, and filtered to remove impurities. It is then stored in labeled containers (tanks, drums, buckets) for inventory. From inventory, honey may be sold in bulk, reprocessed, or bottled for retail.
5	Auditing, Quality Control & Testing	**Organic Certifications** require Surveys for each farmer once a year. This is a necessary part to maintain market access and is a key requirement set by **exporters and importers.** Batch samples are retained for up to 2 years. Testing can be done per client request and includes chemical analysis,

		contamination identification, and pollen analysis. All results are documented and stored for future use.
6	Distribution, Transportation & Sales	NN aims to supply high-assurance honey globally. Exports use road and sea freight. Due to export challenges, NN currently sells white-label honey for 5+ Zambian brands. Using Cardano tech (traceability, credentials, oracles), NN is positioned to re-enter premium global markets with authentic, sustainable honey.

The Nature's Nectar Ecosystem (MVE Mapping)

Nature's Nectar has established its business model around building robust partnerships with communities, stakeholders, regulators, non-governmental organizations and other businesses. These partnerships make the Nature's Nectar model work and without these deep connections, work done by each party involved would not be as impactful as it currently is or could be in the future. Below is an overview of the existing NN network and ecosystem that allows for a robust selection process for the pilot MVE.

Stakeholder Map - Roles and Responsibilities

Stakeholders	**Roles**	**Responsibilities**
Nature's Nectar	Impact First Honey Company	● Establish beekeeping areas, purchase, process and sell honey to local and international markets. ● Provide alternative livelihood opportunities that create benefits for forests and forestry systems.
NN - Field Supervisor (FS)	Managing multiple Zones of beekeepers and ensuring a smooth process of hive distributions through to the final dispatch of purchased honey to processing.	● Field Supervisors are the leading change agent in the field that is employed by Nature's Nectar. These individuals have experience working in communities, are sourced from as close as possible to general beekeeping areas and are the responsible party for ZLF oversight, communication and motivation. ● Field Supervisors are the leading agent for Zones to verify they understand the organic honey production process and systems.
Conservation	Provide	● Conservation organizations in Zambia

Partner(s)	connections in communities for integrating NN beekeeping operations	have long focused on more heavy handed roles and systems for conserving ecosystems, mainly through law enforcement and shifts are occurring to integrate local communities into conservation roles through community engagement.
Beekeeper/Farmer	Produce top bar honey to sell at the premium NN price while experiencing the value of forest/ecosystem preservation.	● Beekeepers in Zambia have age-old traditional practices that inform the systems developed at NN. ● Over the course of receiving beehives, producing honey, and selling it to NN, Farmers are able to have a new/enhanced income source, have more security in meeting basic needs and understand the value forests have in securing honey money.
Zone Lead Farmer (ZLF)	ZLF are the responsible party at the community level and the point of contact for NN Field Supervisors.	● Zone Lead Farmers are leaders in their communities. They are often experienced beekeepers and/or dedicated community change agents. ● They are elected by their Zone of beekeepers and are responsible for ensuring smooth operations at the Zone level in regards to hive building, distributions, production and final honeycomb sale by farmers. ● Zone Lead farmers are incentivized through a commission based system that reduces threat of side-selling honey produced to other honey companies.
Traditional Leadership	Traditional governance systems are widely used in Zambia for local dispute resolution and land use agreements.	● Through different levels of traditional governance via Chiefdoms, Chiefs/Chieftainess(‘) , Headmen/Headwomen, and other community leaders, local decisions and disputes are resolved and communicated. ● Ensuring NN staff and ZLFs remain in good standing with these systems is vitally important to successful community engagement and long term

		commitment.
Government Entities	The Forestry and Veterinary Departments are the 2 most vital government structures for successfully and compliantly producing honey in Zambia.	• Because honey in Zambia is generally a non-timber forest product, there are regulations within the forestry act that dictate means of production, fees and other requirements that must be observed and reported with the Forestry Department. • Beyond a non-timber forest product, honey is also an animal product and thus is controlled by the Veterinary Department with regards to exporting of honey. The Veterinary Department is the designated authority for the export of honey from Zambia and for the declaration of imports abroad. • Currently, there are competing fees, regulations and industry discrepancies between the forestry department and the veterinary department. This overlap has brought issues to the honey sector through competing and varying fees and inconsistent enforcement of them.
Beehive Producer / Sawmill	NN has established a highly valuable relationship with a dedicated beehive production facility in Zambia that delivers beehives consistently, accurately and on time.	• Nature's Nectar has worked with multiple suppliers of beehives in Zambia with varying levels of success. • Since 2020, Nature's Nectar has worked with a single supplier of beehives. Together, NN worked with this sawmill to understand challenges and solutions that can be implemented to ensure accurate hive delivery. • Integrating sourcing of pine timber for the production of beehive kits to verify sustainability of timber inputs has potential to be developed.
Local- Honey Buyers	NN has developed sales agreements with many honey companies in Zambia that have	• With these companies being more advanced on the Zambian retail markets, Nature's Nectar works with them to provide a high quality honey ready for bottling and/or retail points

	direct to consumer brands on the shelves locally and in the region.	through whitelabelling services. ● Integrating traceability post sale to honey companies in Zambia has potential to increase the visibility of sustainable honey production locally and inform local consumers. ● The main challenge of integrating data with these brands is most don't care where the honey comes from, but solely care about price. This initially creates a challenge for extracting value at this time.
Export Honey BuyersBuyers	Purchase honey from markets worldwide that is organic and meets international standards.	● High uncertainty continues to exist for Zambian honey in many of the most valuable honey export markets. Many of these markets, such as Germany, have purchased Zambian honey in the past, but what was received was not what was advertised, meaning buyers and sellers generally lose out on future opportunities and current revenues. ● Export markets for NN honey has had its variability since inception and it has been difficult to overcome the bad reputation Zambian honey has with some of the biggest honey buyers worldwide.
Organic Certifier/Auditor	These organic certifiers and auditors engage with honey companies to ensure their process meet organic standards and issue certificates if systems are in compliance.	● Organic certification is mainly about following the standard systems and justifying internal processes and results. ● Organic bodies generally do annual audits as required by the standards being followed, with the cost of the certification being out of reach for most honey companies. ● Ensuring understanding of standards by producers is the most vital piece of information that must be verified and validated by the certifier.
Laboratory	Independent verification and	● Laboratory analysis and results are generally necessary for exporting

	analysis.	honey from Zambia, with the most trusted results coming from laboratories in Bremen, Germany. These labs conduct varieties of tests requested by the producer and/or buyer and result in the classification of honey at the batch level.

MVE Selection Process and Justification

Stakeholder	Selection in MVE	Roles, Actions, Reputation.
Nature's Nectar	**YES**	• Nature's Nectar is the only honey company in Zambia with a 1) robust network of registered producers, 2) is currently organic certified, 3) has existing data collection tools and procedures and 4) one of their co-founders is a Cardano Community Member.
NN - Field Supervisor (FS)	**YES**	• NN Field Supervisors are the most vital role in ensuring organic certification and production of honey in communities, already use similar data collection tools, have higher levels of education than the average beekeepers or ZLF and are employed by NN.
Conservation Partner(s)	**NO**	• Integrating with Conservation Partners is an integration that can occur in the future as more data flows and correlation occurs. Currently, the correlation of beehives to forest preservation/conservation rates are not available and are costly to access via existing tools.
Beekeeper/Farmer	**NO**	• Eventually, a system to incentivize reporting of more data points directly from beekeepers/farmers is envisioned (e.g earning tokens or rewards for confirming location of hives), but limitations of literacy, digital literacy,

		network access and resources limit such a large number of individuals being onboarded at this time.
Zone Lead Farmer (ZLF)	**NO**	• Zone Lead Farmers are the second most viable option for integration for individual positions. It is envisioned that over time, some responsibilities of FSs will be reassigned to ZLFs as resources, tools and incentives developed further.
Traditional Leadership	**NO**	• Integrating land use agreements between communities, traditional leadership and NN is envisioned, but with many chiefdoms having issues of network access, literacy and digital literacy, this integration will need to occur later in time.
Government Entities	**NO**	• Digital systems within the Zambian government are not yet fully available within all departments, with Forestry and Veterinary currently issuing and keeping most records via paper. Changing the entire internal processes for government departments is unachievable at the moment with the current state of the departments, but this is envisioned to be integrated as systems move forward within those departments.
Beehive Producer	**NO**	• Integrating the supply of beehives from the production facility to NN could occur, but again, current digitalization of records is not efficient in Zambian government entities. Most timber sourced by the production facility comes from ZAFFICO, a government para-statal forestry company. To understand the inefficiencies within ZAFFICO, here is one example. ○ In 2023, official pricing of timber was not released until March, making the purchase of any timber products unavailable for the first 3 months of the year.

Local- Honey Buyers	**NO**	• With many local honey companies with retail brands in Zambia purchasing white label honey from NN for their markets, integration of traceability would be great to have for the industry, but with cost of honey being THE limiting factory for these companies, integration is not possible until the market adjusts it value of traceability.
Export Honey BuyersBuyers	**NO**	• With some of the largest export buyers in many markets having low trust in Zambian honey because of past deals gone bad, the best way to redevelop trust is through validating that the NN production system consistently validates their standards, which is meant to be accomplish through the Palmyra Pro application.
Organic Certifier/Auditor	**YES**	• With the organic certification process being a standard issued by governments specifically for their jurisdictions and is the same for all producers, this is one of the easiest wins possible. • Because NN has already achieved organic status, bringing these processes on chain and integrating certifiers/auditors so that they may view data and verify as data streams from communities, higher levels of trust will be achieved.
Laboratory	**NO**	• Laboratory results being published and verified on chain at the batch level should be a very similar process to integrating with organic standards and a semi-easy win. • It won't be undertaken during this pilot as NN does not currently have purchase orders from buyers demanding these results. • Depending on markets that become available over the near term, this may become a priority post pilot validation.

Final MVE Selection Process and Justification

Stakeholder	Selected	Justification Roles in the MVE
Nature's Nectar	Impact First Honey Company	● Nature's Nectar is one of two organic certified honey companies in Zambia and by far, the most advanced regarding data collection and robust checks and balances. The only other organic certified honey company does not focus on sustainable beekeeping, does not have digital tools in the field and has been organic certified for many years, meaning change will be resisted. ● Working with the NN team, it is clear they are professional, systems focused, motivated and impact driven. Working with Nature's Nectar has been great thus far, as they have created impact systems and incentives throughout their journey that fit directly and applicably into web3 and blockchain solutions.
NN - Field Supervisor (FS)	Managing multiple Zones of beekeepers and ensuring a smooth process of hive distributions through to the final dispatch of purchased honey to processing.	● Field Supervisors are the lifeblood of operating effectively in the field and these individuals are the responsible party for multiple communities of beekeepers. These individuals will be the main point of contact for documenting the organic certification process through survey collections and checks with beekeepers. Data collection and recording is a large portion of this role at NN and by issuing verifiable credentials to this role only, a clear and easy audit trail will be able to be followed internally to rectify issues in a timely manner, as well as by the organic certifying body/auditor who will be enabled with live data flow of the organic survey collection responses.
Organic Certifier/Auditor	These organic certifiers and auditors engage with honey companies to	● Just over a year ago, Nature's Nectar completed their first organic audit with ECOCERT, an organic auditor/certifier for the United States and EU organic processes. Approval was issued a few

	ensure their process meet organic standards and issue certificates if systems are in compliance.	months later and the process has continued moving forward with the 2nd audit occurring this year. ECOCERT has the highest reputation in the certification industry in the region and are very well known. Integrating and showcasing the power of this technology with them will provide for potential growth and adaptation into new organic products and companies.

Summary of Targets/Goals for the pilot with Nature's Nectar

Overview: We have signed an MOU with Natures Nectar - a honey producer in Zambia that sources from over **3000 small scale honey producers with 30,000 top bar beehives.**

User Requirements; Palmyra Pro will be used as the base system for in field data collection regarding organic certification of honey production, purchase records of honey from beekeepers, validated and secure processing and packing data and live data flows for organic certifiers and auditors.

- **Production Data -** data regarding location of beehives, status of beehives, occupation of beehives and harvesting data.
- **Sale of Honey from Farmers to NN -** data regarding price per kilo gram, season, location, farmer, other actors, water content and potentially more.
- **Honey Processing and Secured Packing -** data regarding input of comb honey, processing factors, liquid honey output, beeswax output, waste, packing and securitization via RFD enabled security seals.
- **Live Organic Audit Flow Credentials** - data flow through verified field actors via credentials with read and write functions and external audit view with read only permissions.

5. Next Steps and Recommendations | Conclusion

With **core supply chain processes well-documented** and **stakeholder roles clearly defined**, the next stage of development with Nature's Nectar must focus on translating operational workflows into reliable, auditable digital systems. Immediate priorities include **finalizing the structure and logic for verifiable credentials**—starting with **organic certification**

surveys—and configuring Palmyra Pro to support secure, **role-based data capture from Field Supervisors**. Integration of **oracles for storing financial transaction data**.

Developers should also prioritize building lightweight, user-friendly interfaces that **accommodate limited connectivity and digital literacy** in the field, while also designing flexible modules that can evolve to **include Zone Lead Farmers, conservation data, and batch-level identity for import partners**. A phased, **modular approach** will ensure system integrity, scalability, and value delivery across NN's honey ecosystem. As Zambia's honey sector faces challenges in traceability, adulteration, and market perception, Nature's Nectar is positioned to **lead the industry's transformation.**

To move forward, **finalizing the credentialing system for field-based organic audits** and **integrating data oracles** for storing **financial records** are essential. These steps will **ensure end-to-end verification** and unlock premium export markets. Field Supervisors will remain key to maintaining data integrity, while **strategic efforts to engage Zone Lead Farmers** and local buyers will further **expand ecosystem participation**. By scaling these efforts carefully and continuing to build **trust across the value chain**, Nature's Nectar and zenGate can set a new benchmark for **transparent, ethical, and high-assurance agricultural exports from Africa.**