Introduction

Tourism stands as one of the most significant global economic drivers, generating an estimated USD 1.6 trillion in receipts in 2024 according to the United Nations World Tourism Organization (UNWTO). However, beneath this impressive figure lies a troubling reality: a substantial portion of tourism spending never reaches the local communities that host tourists.

Economic leakage, also known as "tourism leakage," occurs when revenue generated by tourism is lost to other countries' economies. Instead, that revenue "leaks" out to other economies. Tourism leakage happens when tourist dollars go toward businesses and companies that aren't local to the place being visited.

This paper introduces a blockchain-based solution that addresses this challenge by creating a more equitable tourism ecosystem—one that prioritizes the economic well-being of local communities while providing tourists with authentic, meaningful experiences.

Blockchain technology, at its core, is a distributed and immutable digital ledger that records transactions across multiple computers. Unlike traditional centralized systems, blockchain operates without a single controlling authority, making it inherently transparent, secure, and resistant to manipulation. This innovative approach has significantly impacted various industries worldwide, evolving from a niche technology associated primarily with cryptocurrencies to a versatile tool with numerous applications. The global blockchain market has grown substantially over the past few years and was valued at approximately $10.5 billion US dollars in 2023 (Sci-Tech Today, 2024).

By applying blockchain technology to tourism, we can create a system that ensures more tourism dollars remain in local economies, benefiting the very communities that make destinations worth visiting in the first place.

The Crisis of Economic Leakage in Tourism

Tourism is often celebrated as a pathway to economic development, particularly for developing nations. However, a closer examination reveals a concerning phenomenon known as economic leakage—where a significant portion of tourism revenue exits the destination country's economy rather than benefiting local communities.

Tourism has great potential for linkages with local enterprises, craft sellers, local guides, restaurants, local food producers and fishing communities but not all of a traveller's money spent will trickle down into local people's pockets due to what is known as 'tourism leakage' (Terra Sur Travels, 2024).

The scale of this problem is staggering:

- A 2014 UNWTO report puts leakage at "70% in Thailand and 80% in Caribbean countries due to factors such as foreign-owned operators, airlines, hotels and imported food and products" (Much Better Adventures, 2024).
- A 2022 report from the UNWTO found that "tourism leakage" amounts to an estimated 80% of all money spent by tourists in the Caribbean region (Pina Travels, 2024).
- A report by The Charles Darwin Foundation suggests that in 2007 the estimated value of Galapagos tourism was $418M of which only $63M enters the local economy. Therefore, only 15.5% of the full value of tourism reaches local residents (Terra Sur Travels, 2024).
- Another study found that tourism leakage in India may be around 40% (Pina Travels, 2024).

This leakage manifests in two main forms:

- **Export Leakage**: This occurs when there is international ownership and therefore profits from the tourism dollars you spend leave the country. For example, staying in the Mercure Alameda Quito, Ecuador means that the profits end up back in France as it's a French multinational hospitality company (Terra Sur Travels, 2024).
- **Import Leakage**: "Import leakages are caused when customers only want to eat or drink things they know - Heinz Ketchup or Carlsberg beer, for example" (Much Better Adventures, 2024). This occurs when destinations must import goods and services to satisfy tourist demands.

The consequences of this economic leakage extend beyond mere numbers.

The consequences of tourism economic leakage have negative impacts on the host community and its long-term development. Limited Local Economic Development occurs when a substantial portion of tourism revenue leaves the destination, causing the local economy to miss out on opportunities for economic growth and development.

The lack of reinvestment in local businesses and infrastructure hampers the creation of new jobs, limits entrepreneurship, and stifles the diversification of the economy beyond the tourism sector. This can result in a stagnant or underdeveloped local economy (Skal Europe, 2024).

Economic leakage leads to an unequal distribution of wealth within the destination. The benefits of tourism, such as profits, wages, and business opportunities, may be concentrated in the hands of a few major tourism companies or external investors, while local communities and small-scale businesses receive a disproportionately small share (Skal Europe, 2024).

Economic leakage hinders the empowerment of local communities. When tourism is dominated by external entities, local communities have limited decision-making power and control over their own resources and cultural assets. This restricts their ability to shape the development of tourism in a way that aligns with their priorities, values, and long-term sustainability (Skal Europe, 2024).

To create a fairer system, tourism's benefits must be more equitably distributed. Achieving this requires greater local control over resources, which is often undermined by commercial-scale businesses and global franchises. This is where our blockchain-based solution comes into play.

Community-First Tourism: A Blockchain-Based Approach

Our solution proposes a "Community-First" approach to tourism through a blockchain-powered ecosystem that prioritizes the economic well-being of local economies while enhancing the tourist experience. This innovative model leverages the unique capabilities of blockchain technology to create a transparent, low-friction system that redirects tourism spending back into local communities.

Core Components of the Solution

1. **Low-Friction Digital Tokens on Solana**

Solana stands out in the crowded blockchain space with its unique combination of speed, efficiency, and scalability. Built to facilitate decentralized applications (dApps) and cryptocurrencies, this Layer-1 blockchain employs a novel consensus mechanism known as Proof of History (PoH), which works alongside the established Proof of Stake (PoS) model. This innovative approach enables Solana to process thousands of transactions per second, significantly outpacing many of its competitors. Its scalability, low transaction costs, and high throughput capabilities address key challenges faced by blockchain technology, making it a preferred choice for developers and users alike (KuCoin Learn, 2024).

By utilizing Solana's blockchain infrastructure, our solution can offer transaction speeds reaching up to 65,000 transactions per second (TPS), with transaction fees averaging less than $0.01. This makes it practical for small, everyday tourism purchases.

2. **Gamified Tourism Experience**

At the heart of our solution is a gamified experience where tourists purchase a game priced at €25. This game allows tourists to earn digital tokens worth €20 that can be spent at participating local businesses. The remaining €5 contributes to the development and maintenance of the blockchain infrastructure and gamification.

The buyers of gamification services are the organisations with an interest in the tourism industry, like companies (hotel chains, restaurants, tour-operators), local institutions (mayor's office, tourism ministries, public employment offices) and NGOs (concerned with social, environmental and political issues). The providers and the buyers are the developers of the phenomenon.

The purpose behind this endeavour is to engage and persuade the players (tourists, employees, community) to change or reinforce their behaviour through enhancing specific organisational

activities (marketing, human resource management, public relations), a process carried on with the help of game mechanics (instant rewards, feedback, levels and missions, ranks and badges, etc.). The challenge is to do all this in a sustainable way, taking into account economic, social and environmental components (MDPI, 2015).

3. **Local Business Network**

Our platform partners with local businesses—restaurants, artisans, tour guides, and service providers—who agree to accept our digital tokens. This creates a network of authentic local experiences for tourists while ensuring that spending directly benefits the community.

4. **Charity Integration**

If tourists don't spend all their tokens during their stay, they can donate the remainder to local charities, further benefiting the community and creating an additional positive impact mechanism.

5. **Mobile-First Cloud Infrastructure**

The solution is built on AWS Fargate, a serverless compute engine that promises sub-200 ms response times, delivering a snappy and responsive user experience on mobile devices. This cloud infrastructure ensures high performance and quick interaction times, critical for ensuring a positive user experience that encourages frequent engagement with the platform.

How It Works in Practice

1. **Token Acquisition**: Tourists purchase the game for €25, receiving tokens worth €20 to spend at local businesses.

2. **Local Exploration**: Through the gamified application, tourists discover participating local businesses where they can spend their tokens.

3. **Direct Local Spending**: When tourists spend tokens at local businesses, those businesses can redeem them for real currency, keeping tourism dollars within the local economy.

4. **Charitable Giving**: Any unspent tokens can be donated to local charities before departure, extending the positive impact.

5. **Transparent Tracking**: All transactions are recorded on the blockchain, providing transparency and trust in the system.

This model effectively addresses economic leakage by creating a closed-loop system where tourist spending is directed primarily toward local businesses.

Providing economic benefits to local and other stakeholders as well as reaching tourists' satisfaction are among the important goals pursued by sustainable tourism development.

Blockchain technology can help achieve these goals through enabling disintermediation of tourism operations. Blockchain technology can effectively remove the intermediaries because of its potential to build trust, ensure more secure information exchange, reduce costs, and enable transparency (ResearchGate, 2021).

Technical Architecture: Building a Sustainable Tourism Ecosystem

The Solana Blockchain Advantage

Our solution leverages the Solana blockchain for several critical reasons:

Solana employs a combination of cryptographic techniques and economic incentives to secure the network. The architecture is designed to resist common attacks, ensuring the integrity of the blockchain (Rapid Innovation, 2024). This security is essential for building trust among users and businesses in the ecosystem.

As a proof-of-stake blockchain, Solana uses less energy than conventional proof-of-work networks. Less energy consumption means lower carbon emissions. Since December 2023, the Solana network has reduced its carbon footprint by **69% through on-chain purchase** of carbon credits and innovative biodiversity credits (Solana, 2024). This environmental efficiency aligns with sustainable tourism principles.

As of September 2024, the Solana network's energy consumption is projected to total 8,755 megawatt hours (MWh) for the year, about the same as the electricity used in 833 American homes. The average energy usage per transaction is 0.00412 watt hours (Wh) (Solana, 2024). To put this in perspective, a single transaction consumes less energy than turning on an LED light bulb for a few seconds.

Solana SPL Tokens

Our solution utilizes Solana Program Library (SPL) tokens, which function similarly to ERC-20 tokens on Ethereum but with far greater efficiency. These tokens serve as the medium of exchange within our ecosystem, allowing for:

1. **Fast Microtransactions**: SPL tokens enable near-instant transfers ideal for small purchases at local vendors.

2. **Programmable Money**: Smart contracts can be built into the tokens to enforce spending only at verified local businesses.

3. **Minimal Fees**: Unlike credit card transactions that might charge 2-3% per transaction, Solana transactions cost fractions of a cent.

Gamification Elements and Mechanics

To illustrate how blockchain-powered gamification works in our tourism model, let's break down the technical aspects:

1. **Digital Wallets**: Tourists receive a simple digital wallet within our application when they purchase the game. This wallet holds their tokens and records all transactions on the Solana blockchain.

2. **Smart Contracts for Achievements**: When tourists complete certain activities, smart contracts automatically award additional tokens or badges. For example:

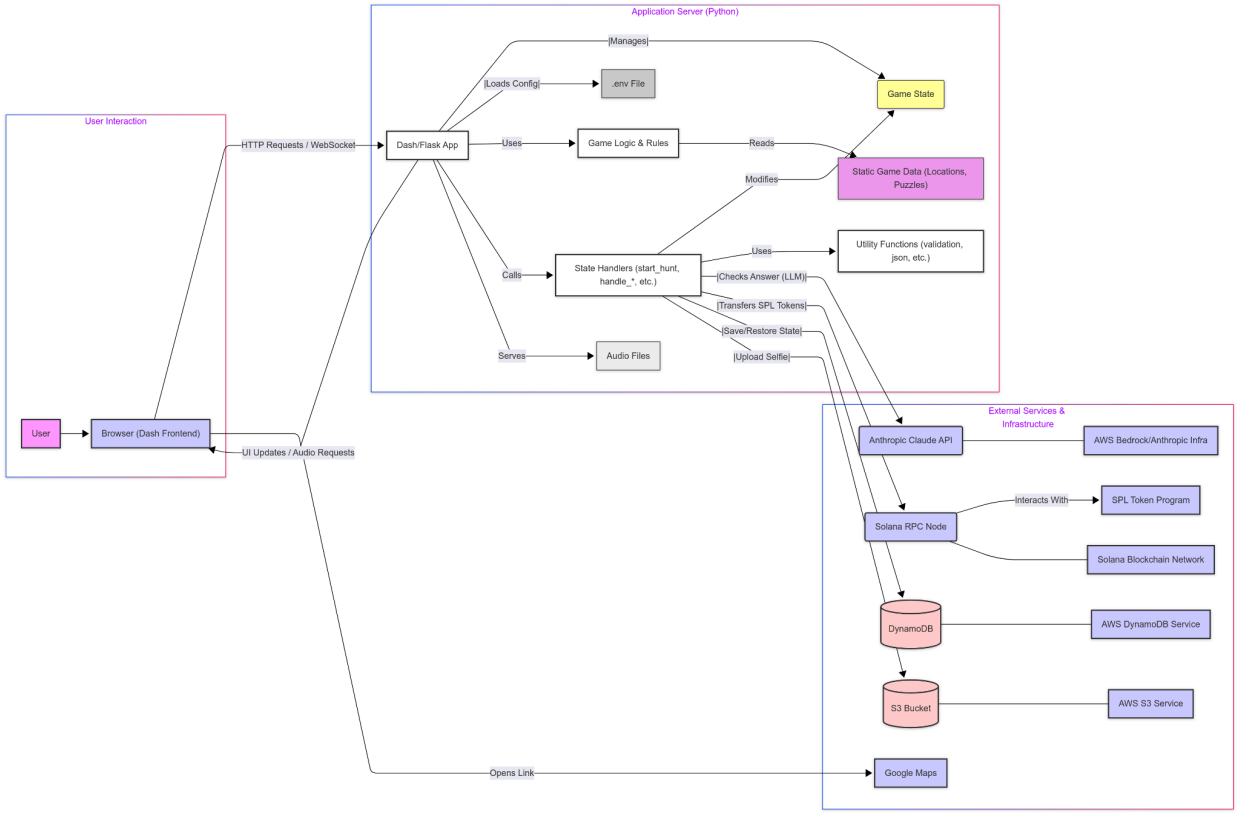
- Visiting five different local restaurants might trigger a "Local Foodie" badge and bonus tokens
- Participating in a beach cleanup could unlock an "Eco-Warrior" achievement and additional rewards

3. **Leaderboards and Challenges**: The application includes competitive elements where tourists can participate in community challenges, with rankings visible on transparent blockchain-verified leaderboards.

Gamification strategies focusing on promoting sustainability and climate awareness have become prevalent. Companies use game mechanics to encourage eco-friendly practices and corporate social responsibility. This is where gamification can impact for good with challenges and quests that make a difference (Gamification Nation, 2024).

Diving into local and cultural experiences can truly enrich a traveller's journey, as they'll not only gain valuable insights but also contribute to the preservation of unique traditions and customs. Gamification in tourism can encourage you to explore these authentic experiences by rewarding your sustainable travel practices.

By participating in local events, learning about traditional crafts, or dining at family-owned eateries, you'll be able to immerse yourself in the local culture while supporting community-based businesses. Gamification strategies like collecting points for visiting cultural sites or engaging with locals through interactive apps will make it even more enjoyable for you to delve into these experiences. By accumulating points through such activities, you could unlock special rewards like discounts at other sustainable establishments or access to exclusive events (Smartico, 2024).



We strategically chose Python—the world's leading programming language—for this project to demonstrate the power and accessibility of integrating blockchain technology like Solana SPL tokens into familiar development ecosystems. This Python-centric approach aims to dramatically expand the audience for web3 technologies beyond specialized developers. We believe this is key to accelerating adoption. In the spirit of collaboration and transparency.
The project is open sourced and hosted on GitHub for the community to explore, utilize, and enhance (https://github.com/traveltrackie/superteam-ireland).

AWS Fargate Cloud Infrastructure

Our application is hosted on AWS Fargate, which provides several key advantages:

1. **Serverless Architecture**: The platform operates without managing the underlying server infrastructure, allowing developers to focus on application functionality.

2. **Auto-scaling**: The system automatically adjusts to accommodate usage spikes during peak tourist seasons.

3. **Low Latency**: The infrastructure delivers sub-200 millisecond response times worldwide, ensuring a smooth user experience essential for gamification.

4. **Global Availability**: AWS's global network ensures the platform remains accessible regardless of the tourism destination.

Blockchain Integration with Local Businesses

For local businesses to participate in our ecosystem, we've simplified the technical integration process:

1. **QR Code System**: Local vendors receive a unique QR code that tourists scan to make payments, requiring minimal technical infrastructure beyond a smartphone.

2. **Merchant Dashboard**: A web-based dashboard allows businesses to track incoming payments, manage inventory, and redeem tokens for local currency.

3. **Verification Smart Contract**: A blockchain-based verification system ensures only legitimate local businesses can participate, preventing multinational corporations from entering the closed ecosystem.

Blockchain can bring a new level of transparency to sustainable tourism by tracking the entire supply chain of products and services. Companies are already utilizing blockchain to ensure that accommodations, transport providers, and tour operators meet certain sustainability standards (Ecobnb, 2024).

Technical Safeguards Against Leakage

To ensure our system effectively prevents economic leakage, we implement several technical safeguards:

1. **Geofenced Tokens**: The tokens are programmed to be spendable only within specific geographical areas, ensuring money stays in the destination.

2. **Local Business Verification Protocol**: Before joining the network, businesses undergo a verification process to confirm they are locally owned and operated.

3. **Transparent Supply Chain Tracking**: For restaurants and shops, the system can optionally track and reward those sourcing from local producers, further reducing import leakage.

By combining these technical components, our solution creates a secure, efficient, and user-friendly system that redirects tourism spending back into local economies while enhancing the tourist experience through gamification.

This approach not only addresses the immediate problem of economic leakage but also creates a sustainable model for tourism that benefits local communities in the long term.

Benefits and Impact: Creating Value for All Stakeholders

Our blockchain-based "Community-First" tourism solution delivers significant benefits across multiple stakeholders, addressing the economic leakage problem while enhancing the overall tourism ecosystem.

For Local Communities and Economies

1. **Reduced Economic Leakage**

The Adventure Travel Trade Association (ATTA) found that it takes four adventure travel tourists to generate $10,000 USD for a local economy. The report also found you would need a full 96 cruise tourists to generate that same sum (Much Better Adventures, 2024).

By creating a closed-loop token system that can only be spent at verified local businesses, our solution ensures that a significantly higher percentage of tourism spending remains within the destination economy.

2. **Community Empowerment**

Economic leakage hinders the empowerment of local communities. When tourism is dominated by external entities, local communities have limited decision-making power and control over their own resources and cultural assets. This restricts their ability to shape the development of tourism in a way that aligns with their priorities, values, and long-term sustainability (Skal Europe, 2024).

Our solution returns this control to local stakeholders by creating a system that prioritizes local businesses.

3. **Job Creation and Entrepreneurship**

Limited local economic development occurs when a substantial portion of tourism revenue leaves the destination. The lack of reinvestment in local businesses and infrastructure hampers the creation of new jobs, limits entrepreneurship, and stifles the diversification of the economy beyond the tourism sector. This can result in a stagnant or underdeveloped local economy (Skal Europe, 2024).

By increasing the flow of tourism dollars to local businesses, our solution stimulates job creation and entrepreneurial opportunities within the community.

4. **Cultural Preservation**

Economic leakage contributes to the loss of cultural integrity and authenticity within the destination. When local businesses and communities are unable to benefit fully from tourism revenue, they may be less incentivized to preserve and promote their unique cultural heritage. This leads to the erosion of traditional practices, loss of authenticity, and a transformation of cultural expressions solely to cater to tourists' expectations (Skal Europe, 2024).

When local communities see direct economic benefits from tourism, they have greater incentives and resources to preserve and celebrate their cultural heritage.

5. **Economic Resilience**

Forma's vision extends beyond a single location, with plans to collaborate with progressive governments and cities worldwide. Their goal is to attract top talent to the ecosystem while upskilling local populations. The initiative represents a novel approach to blockchain adoption, focusing on tangible economic benefits and community engagement (Solana Compass, 2024).

By diversifying income streams and reducing dependence on multinational corporations, communities become more economically resilient to external shocks.

For Tourists

1. **Enhanced Authentic Experiences**

Diving into local and cultural experiences can truly enrich a traveler's journey, as they'll not only gain valuable insights but also contribute to the preservation of unique traditions and customs. Gamification in tourism can encourage you to explore these authentic experiences by rewarding your sustainable travel practices.

By participating in local events, learning about traditional crafts, or dining at family-owned eateries, you'll be able to immerse yourself in the local culture while supporting community-based businesses. Gamification strategies like collecting points for visiting cultural sites or engaging with locals through interactive apps will make it even more enjoyable for you to delve into these experiences.

By accumulating points through such activities, you could unlock special rewards like discounts at other sustainable establishments or access to exclusive events. This way, gamification incentivizes exploring uncharted territories and immersing yourself in the unique culture of your destination while promoting sustainable tourism practices that benefit both travelers and communities alike (Smartico, 2024).

2. **Gamified Discovery**

The gamification elements make tourism more engaging and enjoyable. Tourists discover hidden gems they might otherwise miss, as the platform incentivizes exploration beyond standard tourist attractions.

3. **Value for Money**

When tourists purchase the game for €25 and receive €20 worth of tokens, they're effectively getting a 20% discount on local experiences. This value proposition makes participation attractive while still contributing to platform sustainability.

4. **Social Impact**

Imagine the thrill of knowing your vacation choices directly contribute to protecting precious ecosystems and wildlife. By participating in conservation-focused tourism, you can take an active role in preserving our planet while enjoying unique and unforgettable experiences.

Incentivizing conservation efforts through gamification encourages more sustainable travel practices, which ultimately benefit both the environment and local communities.

One way to engage in this type of tourism is by choosing destinations or accommodations that offer rewards for eco-friendly actions, such as planting trees or participating in beach clean-ups (Smartico, 2024).

Tourists gain the satisfaction of knowing their spending directly benefits local communities and potentially local charities through unspent token donations.

For Destination Management Organizations and Governments

1. **Sustainable Tourism Development**

This approach critically discusses the transformative capacity of blockchain technology to foster sustainable tourism practices within the context of rapid growth in the global tourism industry. Although the recent growth experienced in the tourism sector is economically beneficial, it introduces significant environmental and social challenges, necessitating innovative solutions for sustainable development (Elgar Online, 2024).

2. **Data-Driven Decision Making**

It underscores the capacity of blockchain to enhance transparency and traceability, thereby addressing some of the most pressing sustainability challenges faced by the industry (Elgar Online, 2024).

The blockchain's transparent nature provides valuable data on tourist spending patterns, popular attractions, and economic impact, enabling more informed policy decisions.

3. **Reduced Social Tensions**

It's common that money from tourism is spent in small defined and popular areas. Overtourism has been high on the agenda for a few years now and will continue to be a consideration

post-pandemic. Visiting less well-known areas spreads the positive benefits of the tourism dollar outside of well-trodden obvious locations (Terra Sur Travels, 2024).

By ensuring local communities benefit more directly from tourism, social tensions between residents and tourists are reduced, creating a more harmonious tourism ecosystem.

4. **Digital Infrastructure Development**

Implementing this solution encourages broader digital literacy and infrastructure development in the destination, building capacity that extends beyond tourism.

Environmental Benefits

1. **Reduced Carbon Footprint**

As a proof-of-stake blockchain, Solana uses less energy than conventional proof-of-work networks. Less energy consumption means lower carbon emissions. Since December 2023, the Solana network has reduced its carbon footprint by 69% through on-chain purchase of carbon credits and innovative biodiversity credits.

Users can observe the network's energy performance directly through a real-time emissions dashboard, recently updated to comply with new Markets in Crypto Assets (MiCA) regulations. These efficiencies, coupled with the Solana Foundation's dedication to sustainability and a burgeoning decentralized environmental sector, make Solana a popular solution for environmental projects. Despite the industry's rumored reputation for high energy usage, not all blockchain networks are created equal, and the stereotype is generally not accurate (Solana, 2024).

2. **Promotion of Sustainable Practices**

Gamification strategies focusing on promoting sustainability and climate awareness will become more prevalent. Companies will use game mechanics to encourage eco-friendly practices and corporate social responsibility. This is where gamification can impact for good with challenges and quests that make a difference. More apps and platforms in this space are expected to make sustainability a fun as well as transparent experience, where actions are measurable and trackable. Corporate Social Responsibility (CSR) and possibly some Marketing departments will lead this trend, using game mechanics to encourage eco-friendly practices among employees and customers. Companies can use it to showcase their commitment to the environment and social responsibility, enhancing brand image and employee morale. B corporations are also popping up in all fields, which effectively subscribe to a sustainable action strategy and live by it (Gamification Nation, 2024).

Economic Impact Metrics

To measure the success of our solution, we will track several key metrics:

1. **Leakage Reduction Rate**: The percentage decrease in economic leakage compared to traditional tourism models.
2. **Local Business Participation**: The number and diversity of local businesses enrolled in the ecosystem.
3. **Tourist Engagement**: Adoption rates, average token spend, and gamification participation metrics.
4. **Community Economic Benefits**: Increases in local business revenue, job creation, and entrepreneurship rates.
5. **Social Impact**: Contributions to local charities and community development initiatives.

By focusing on these metrics, we can continually refine and improve the system to maximize its positive impact on local communities while enhancing the tourist experience.

Conclusion: Reimagining Tourism for Equitable Growth

Tourism has long been touted as a pathway to economic development for communities around the world. However, the uncomfortable reality of economic leakage has meant that many destinations see only a fraction of tourism spending actually benefit local economies. As we've explored in this white paper, the leakage rates can be staggering—reaching as high as 80% in some regions. This means that for every $100 spent by tourists, as little as $20 remains in the local community.

Our blockchain-based "Community-First" approach represents a paradigm shift in how tourism economies can function. By leveraging the Solana blockchain's speed, efficiency, and environmental sustainability, we've designed a solution that fundamentally reshapes tourism spending patterns. The combination of low-friction digital tokens, gamification elements, and direct connections to local businesses creates a closed-loop ecosystem that ensures tourism dollars remain where they should—in the communities that make destinations worth visiting.

Achieving sustainable tourism is a process that focuses on numerous goals and faces many challenges. The advent of disruptive technology like blockchain could help to tackle some challenges in sustainable tourism development and address its goals. Blockchain technology could contribute to sustainable tourism. Precisely, it has the potential to disrupt tourism operations and boost local economy, manage food supply chain and mitigate food waste, achieve tourists' satisfaction, affect the tourists' sustainable behaviour, and address awareness rise issues. Blockchain technology has a potential to contribute to sustainable tourism development as well as the SDGs (ResearchGate, 2021).

The technical architecture we've outlined is not merely theoretical. it's built on proven technologies and concepts. Solana's blockchain provides the necessary speed and efficiency for practical tourism applications, while gamification techniques have already demonstrated their effectiveness in engaging users and encouraging desired behaviors. Combined with AWS Fargate's cloud infrastructure, we have created a platform that is both powerful and accessible.

One of the most significant outcomes of similar initiatives was the high level of local participation, with 62% of attendees being local. This strong local engagement demonstrated effectiveness in introducing technology to a new market and fostering grassroots interest in development. Such projects have generated substantial economic impact, with over half a million dollars in direct investment flowing into the local economy. This investment spanned various sectors, including tourism, food and beverage, and local businesses (Solana Compass, 2024).

Looking forward, we envision this solution scaling across diverse tourism destinations worldwide. The technical framework is adaptable to different cultural contexts and economic conditions, making it suitable for implementation in both developed and developing nations. As adoption grows, the network effects will strengthen the ecosystem, creating increasingly powerful incentives for both tourists and local businesses to participate.

In a world where tourism continues to grow as a global industry, we have a responsibility to ensure that its benefits are equitably distributed. Our blockchain-based solution represents not just a technological innovation, but a reimagining of tourism's fundamental economic structure—one that places local communities at the center rather than on the periphery. By connecting tourists directly with local businesses through a gamified, token-based ecosystem, we can transform tourism into a truly sustainable force for equitable economic development.

The time has come to move beyond merely acknowledging the problem of economic leakage in tourism and to implement practical, effective solutions. With blockchain technology, gamification, and a community-first approach, we can create a tourism model that works for everyone—preserving local cultures, protecting environments, empowering communities, and providing authentic experiences for travelers.

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