

# MakmurTani WhitePaper



## Tokenizing Prosperity for Indonesia's Farmers

*Empowering Smallholder Farmers with Real-World Asset (RWA) Tokenization on Lisk L2 Blockchain*



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### Disclaimer

This whitepaper is for informational purposes only and does not constitute an offer or solicitation to sell securities. The information presented here is not intended as financial advice, and readers should do their own research before making investment decisions. MakmurTani is an ongoing project, and details may be subject to change.

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## Executive Summary

MakmurTani (“Prosperous Farmer”) is a blockchain-based platform enabling Indonesian smallholder farmers to tokenize agricultural land, crops, and equipment as fractionalized Real-World Assets (RWAs) on Lisk’s Ethereum-aligned Layer 2 blockchain. By combining DeFi microloans, IoT-enabled crop tracking, and a progressive Next.js web application, we democratize access to liquidity, fair pricing, and global markets for 33 million traditionally unbanked farmers.

Our platform addresses three critical problems:

1. **Liquidity Gap:** 80% of Indonesian farmers lack collateral for formal loans
2. **Middlemen Exploitation:** Farmers typically receive only 30-40% of final crop value
3. **Fragmented Land Ownership:** 72% of farmland is informally owned, limiting credit access.

MakmurTani solves these problems through blockchain-based asset tokenization, creating transparent supply chains, and implementing decentralized finance solutions specifically tailored for agricultural applications in Indonesia.

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# 1. Problem Statement

## 1.1 The Crisis Facing Indonesian Agriculture

Indonesia’s agricultural sector employs approximately 29% of the country’s labor force and contributes significantly to its GDP. However, smallholder farmers face systemic challenges that limit their economic potential:

### 1.1.1 Limited Access to Capital

According to the World Bank (2023), 80% of Indonesian farmers lack the collateral required for formal loans. Financial exclusion restricts their ability to purchase quality seeds, equipment, and fertilizers, resulting in suboptimal yields and perpetuating cycles of poverty.

#### Mathematical Representation:

$$\text{Capital Gap} = \Sigma(\text{Optimal Input Costs} - \text{Available Capital})$$

This capital gap exceeds USD \$2.8 billion annually across Indonesia’s agricultural sector.

### 1.1.2 Opaque Supply Chains

Multiple layers of intermediaries between farmers and consumers results in farmers receiving only 30-40% of the final retail price of their products (BPS Indonesia, 2022). This economic inefficiency is represented as:

$$\text{Farmer Profit Loss} = \text{Market Price} - (\text{Production Cost} + \text{Middleman Margin})$$

Where Middleman Margin typically equals 50-60% of the final price.

### 1.1.3 Land Ownership Challenges

72% of agricultural land in Indonesia is managed through informal arrangements or traditional rights (adat), making it difficult for farmers to use land as collateral or make long-term investments. Without formal title, farmers cannot access credit markets or participate in modern financial systems.

## 1.2 Market Analysis

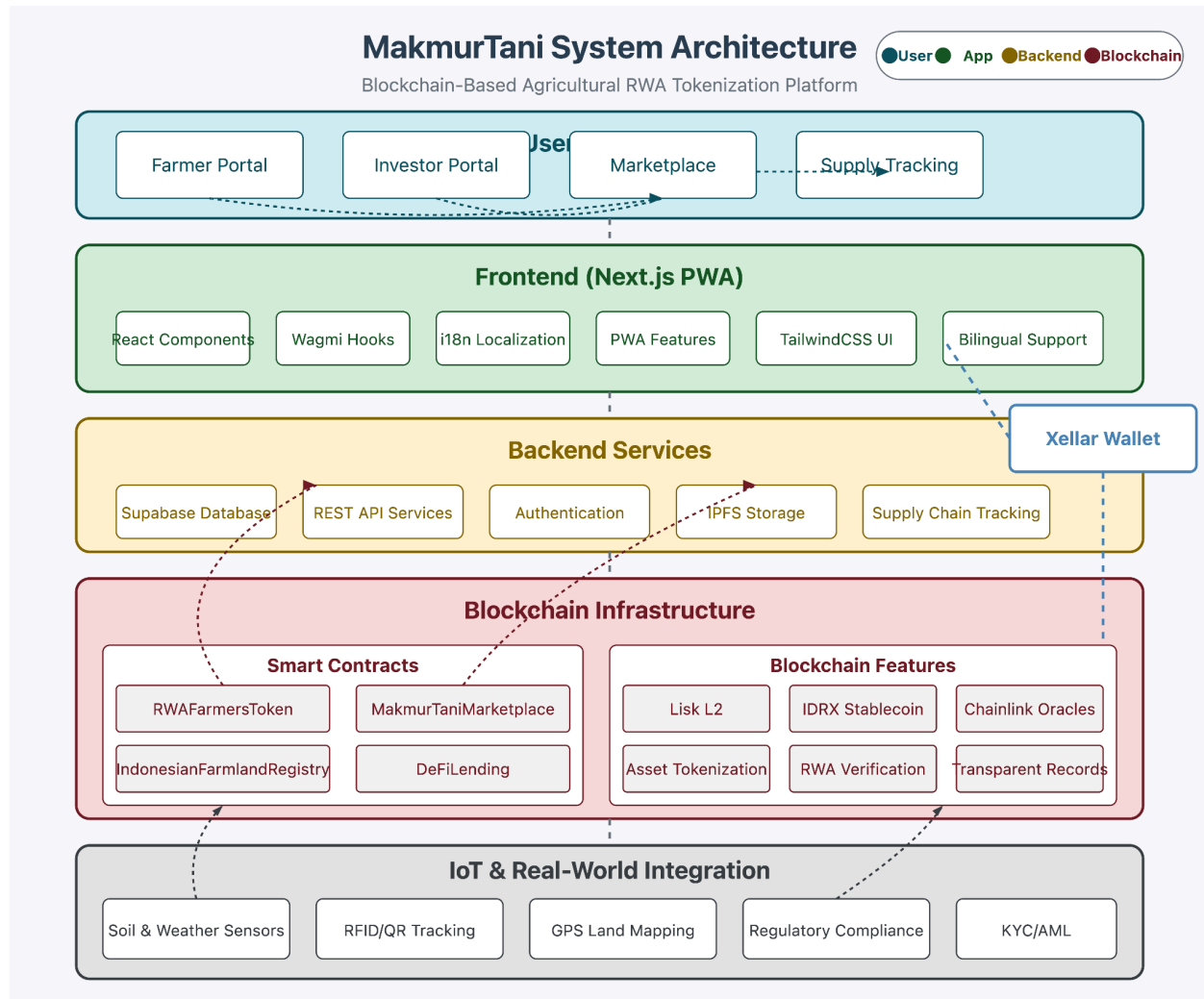
Indonesia's agricultural sector presents a significant opportunity for blockchain-based solutions:

- **33 million farmers** across the archipelago, with 90% classified as smallholders
  - **\$55 billion** annual agricultural output
  - **175 million hectares** of land, with 30% used for agriculture
  - **\$2.8 billion** estimated agricultural financing gap
  - **95.4%** smartphone penetration rate among rural populations (2023)
- 

## 2. Solution Overview

### 2.1 MakmurTani Platform Architecture

MakmurTani creates a comprehensive ecosystem that connects farmers, investors, financial institutions, and consumers through blockchain technology. The platform consists of four primary components:



*sys-architecture.png*

### 2.1.1 RWA Tokenization Protocol

Our tokenization protocol converts physical agricultural assets into digital tokens on the Lisk blockchain:

1. **Land Tokenization:**
  - Farm properties are digitally mapped using GPS and satellite imagery
  - Government-verified land titles or community attestations are recorded
  - Each plot is represented as an ERC-721 non-fungible token (NFT)
2. **Crop Tokenization:**
  - Projected harvest yields are tokenized as ERC-20 tokens
  - 1 token = 1 kg of specific crop (e.g., coffee beans, rice)
  - Smart contracts ensure automatic distribution of returns

### 3. **Equipment Tokenization:**

- Agricultural equipment represented as fractional NFTs (ERC-1155)
- Enables community ownership of expensive machinery
- Smart contracts manage rental, maintenance, and revenue distribution

#### *2.1.2 DeFi Lending Protocol*

MakmurTani's DeFi protocol enables farmers to access capital through:

#### 1. **Collateralized Lending:**

- Farmers stake their tokenized land/crops as collateral
- Borrow stablecoins (IDRX) at competitive interest rates
- Loan-to-Value (LTV) ratio of 60% for land, 50% for crop tokens

#### 2. **Loan Terms and Repayment:**

$$\text{Repayment Amount} = \text{Principal} + (\text{Principal} \times \text{APY}_{\text{loan}} \times t/365)$$

Where  $\text{APY}_{\text{loan}} = 8\%$  (compared to 18-24% from traditional moneylenders) and  $t$  = loan duration in days.

#### 3. **Liquidation Mechanism:**

- Price oracle monitors collateral value
- Health Factor = Collateral Value / Loan Value
- Liquidation triggered if Health Factor < 1.2

#### *2.1.3 Supply Chain Verification System*

Our blockchain-based supply chain tracking system:

#### 1. **IoT Integration:**

- Environmental sensors monitor crop conditions
- QR codes and RFID tags track physical movement of goods
- Data is recorded on-chain for immutable record-keeping

#### 2. **Verification Nodes:**

- Local agricultural cooperatives serve as verification nodes
- Multi-signature validation of supply chain events
- Consensus mechanism prevents fraudulent reporting

#### 3. **Consumer Transparency:**

- End consumers can scan products to view complete provenance
- Direct farmer-to-consumer communication channel

- Premium pricing for verified sustainable practices

#### 2.1.4 Marketplace & Exchange

MakmurTani's marketplace allows:

1. **Trading of Tokenized Assets:**
    - Secondary market for land and crop tokens
    - Direct farmer-to-buyer transactions
    - Automated market makers ensure liquidity
  2. **Price Discovery Mechanism:**
    - Oracle networks provide real-time price feeds
    - Historical yield data informs pricing models
    - Futures contracts for crop tokens
  3. **Cross-Chain Interoperability:**
    - Bridge to Ethereum mainnet and other chains
    - Integration with major DEXs and lending platforms
    - Access to global liquidity pools
- 

### 3. Technical Architecture

MakmurTani employs a multi-layered technical stack designed for performance, reliability, and security. Our architecture combines best-in-class technologies from blockchain, web development, and IoT to create a seamless, user-friendly experience for all stakeholders.

#### 3.1 Frontend Architecture

##### 3.1.1 Next.js Progressive Web Application

Our frontend is built using Next.js 14, leveraging the App Router architecture for optimal performance:

```
frontend/
├── app/                # App router architecture
│   ├── marketplace/   # Asset marketplace
│   ├── tokenize/      # Tokenization flow
│   ├── invest/        # Investment dashboard
│   ├── track/         # Supply chain tracking
│   ├── dashboard/     # User dashboard
│   └── layout.tsx      # Global layout component
├── components/         # Reusable UI components
├── hooks/              # Custom React hooks
├── lib/                # Utility functions
└── public/             # Static assets
```

**Key Technologies:** -

**React Server Components** for SEO optimization and faster initial loads -

**TailwindCSS** for responsive, mobile-first design -

**Progressive Web App (PWA)** features for offline functionality in rural areas with unstable internet -

**Internationalization (i18n)** with native support for Bahasa Indonesia and English

**Wagmi** hooks for seamless blockchain interactions

### *3.1.2 Responsive Design & Accessibility*

Given the diverse user base across Indonesia's 17,000+ islands: -

**Mobile-First Design:** Optimized for Android devices (92% market share in Indonesia)

- **Low-Bandwidth Mode:** Reduced image quality and simplified interface for 2G/3G networks

- **WCAG 2.1 AA Compliance:** Ensuring accessibility for users with disabilities

- **Offline-First Architecture:** Core functionality works without internet connection, syncing when connection is restored

## **3.2 Backend Infrastructure**

### *3.2.1 Supabase Integration*

We leverage Supabase for secure, performant backend services:

```
// Example of Supabase SDK integration
import { createClient } from '@supabase/supabase-js';

const supabase = createClient(
  process.env.NEXT_PUBLIC_SUPABASE_URL,
  process.env.NEXT_PUBLIC_SUPABASE_ANON_KEY
);

// Real-time farm data updates
const subscription = supabase
  .from('farm_sensors')
  .on('INSERT', payload => {
    // Update UI with new sensor data
    updateFarmData(payload.new);

    // Trigger blockchain event if thresholds exceeded
    if (payload.new.soil_moisture < THRESHOLD) {
      triggerIrrigation(payload.new.farm_id);
    }
  })
```



```
})
.subscribe();
```

- **PostgreSQL Database:** Stores user profiles, land registry data, transaction history
- **Authentication:** Multi-factor authentication with biometric options
- **Storage:** IPFS integration for decentralized file storage
- **Real-time Subscriptions:** WebSocket connections for live market data
- **Edge Functions:** Serverless API endpoints for complex business logic

### 3.2.2 API Architecture

Our API layer follows REST principles with GraphQL for complex data requirements:

```
api/
├── auth/           # Authentication endpoints
├── tokenization/   # Asset tokenization services
├── marketplace/    # Trading & exchange functions
├── tracking/       # Supply chain verification
└── analytics/      # Data analytics and reporting
```

**Security Features:** - JWT token authentication with short expiration - Rate limiting to prevent DDoS attacks - Input validation and sanitization - CORS policies - API versioning for backward compatibility

## 3.3 Blockchain Infrastructure

### 3.3.1 Smart Contract Architecture

Our smart contracts follow a modular, upgradeable pattern using the OpenZeppelin library:

```
// RWAFarmersToken.sol
pragma solidity ^0.8.24;

import
"@openzeppelin/contracts/token/ERC721/extensions/ERC721URIStorage.sol";
import "@openzeppelin/contracts/token/ERC20/IERC20.sol";
import "@openzeppelin/contracts/access/AccessControl.sol";
import "@openzeppelin/contracts/security/Pausable.sol";
import "@openzeppelin/contracts/utils/Counters.sol";

/**
 * @title MakmurTani RWA Farmers Token
 * @dev Smart contract for tokenizing agricultural assets as NFTs
 */
contract RWAFarmersToken is ERC721URIStorage, AccessControl, Pausable {
    using Counters for Counters.Counter;

    // Roles
    bytes32 public constant ADMIN_ROLE = keccak256("ADMIN_ROLE");
    bytes32 public constant VERIFIER_ROLE = keccak256("VERIFIER_ROLE");
```

```

enum SupplyChainStage {
    Production,
    Processing,
    Distribution,
    Completed
}

enum AssetType {
    Farmland,
    Crop,
    Equipment
}

struct AssetMetadata {
    string location;
    uint256 area;
    string assetName;
    AssetType assetType;
    bool verified;
}

// Additional contract code...
}

```

**Core Smart Contracts:** - **RWAFarmersToken.sol**: Manages tokenization of agricultural assets - **IndonesianFarmlandRegistry.sol**: Handles land verification and registration - **MakmurTaniMarketplace.sol**: Trading platform for tokenized assets - **DeFiLending.sol**: Microloan facility for farmers

### 3.3.2 Oracle Integration

We integrate with Chain Link oracles for reliable off-chain data: - Price feeds for agricultural commodities - Weather data for risk assessment - Land registry verification

### 3.3.3 Lisk Layer 2 Implementation

Our contracts are deployed on Lisk's Layer 2 solution for cost efficiency: - Transaction costs: ~\$0.001 per transaction - Block time: 2 seconds - Throughput: 2,000+ TPS

## 3.4 IoT & Data Integration

### 3.4.1 Sensor Network Architecture

Our IoT infrastructure employs a tiered approach:

Farm Sensors → LoRaWAN Gateway → Edge Processor → Blockchain

**Sensor Types:** - Soil moisture and nutrient sensors - Weather stations - Irrigation control systems - RFID/NFC for supply chain tracking

### 3.4.2 Data Processing Pipeline

Raw sensor data undergoes processing before reaching the blockchain:

1. **Edge Filtering:** Removes anomalies and aggregates readings
2. **Local Validation:** Initial verification by on-farm gateway
3. **Encrypted Transmission:** Secure upload to centralized processor
4. **Consensus Verification:** Multiple validators confirm data authenticity
5. **On-Chain Storage:** Verified data recorded on Lisk blockchain

### 3.4.3 Machine Learning Models

We employ several ML models to enhance platform functionality: -

**Yield Prediction:** Forecasts harvest quantities based on historical and environmental data

- **Price Prediction:** Estimates future commodity prices

- **Risk Assessment:** Evaluates loan default probability based on farm performance

The ML pipeline is expressed as:

$$\text{Yield} = \alpha \cdot \text{Soil Quality} + \beta \cdot \text{Rainfall} - \gamma \cdot \text{Pest Risk}$$

Where  $\alpha$ ,  $\beta$ , and  $\gamma$  are coefficients calibrated through supervised learning on historical data.

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## 4. Tokenomics & RWA Mechanics

MakmurTani's economic model is designed to align incentives between farmers, investors, and platform participants while ensuring long-term sustainability.

## 4.1 Token Types & Utility

### 4.1.1 \$MTANI Governance Token

The \$MTANI token serves as the governance and utility token for the MakmurTani ecosystem:

- **Total Supply:** 1,000,000,000 (1 billion) tokens
- **Token Distribution:**
  - 40% - Farmers (distributed over 4 years)
  - 30% - Staking rewards and ecosystem growth
  - 20% - Investors and initial liquidity
  - 10% - Team and advisors (vested over 3 years)

**Utility:** - Governance participation rights - Fee discounts on marketplace transactions - Staking rewards from platform revenue - Access to premium features

### 4.1.2 RWA-Backed Tokens

Each tokenized real-world asset has specific characteristics:

1. **Land NFTs (ERC-721)**
  - Unique tokens representing specific land parcels
  - Metadata includes geolocation, size, soil quality, and ownership history
  - Can be used as collateral for loans or fractionalized for investment
2. **Crop Tokens (ERC-20)**
  - Fungible tokens representing standardized agricultural outputs
  - 1 token = 1 kg of specific crop (e.g., coffee beans, rice)
  - Backed by real agricultural production
3. **Equipment Tokens (ERC-1155)**
  - Semi-fungible tokens representing shared machinery
  - Governance rights for equipment usage scheduling
  - Revenue sharing from equipment rental

## 4.2 Economic Mechanisms

### 4.2.1 RWA Valuation Model

Land and crop tokens are valued using a transparent, algorithmic approach:

$\text{Land NFT Value} = (\text{Land Size} \times \text{Regional Price/ha}) + (\text{Crop Yield} \times \text{5-Year Avg. Price})$
--

Factors influencing valuation include: - Historical crop yields - Soil quality metrics - Water access rights - Proximity to markets - Climate risk assessment

#### 4.2.2 Staking Rewards

Stakers earn rewards from platform revenue:

$$APY = (\text{Total Fees Annualized} / \text{Total Staked}) \times 100$$

Fee sources include: - 0.3% marketplace transaction fee - 1% loan origination fee - 0.5% crop token minting fee

#### 4.2.3 Lending Mechanism

Our lending protocol uses a liquidity pool model: - Loans denominated in IDR (Indonesian Rupiah stablecoin) - Interest rates determined algorithmically based on utilization ratio - Collateralized by tokenized land or crop futures - Liquidation triggered at 120% collateralization ratio

#### 4.3 Token Burn Mechanism

To ensure long-term value accrual, MakmurTani implements a token burn mechanism: - 10% of all platform fees are used to buy back and burn \$MTANI tokens - Quarterly burns based on platform performance - Transparent reporting of all burn transactions

#### 4.4 Governance Framework

The MakmurTani DAO governs key protocol parameters: - Interest rate models - Collateralization ratios - Fee structures - Protocol upgrades - Treasury management

Voting power is determined by: - \$MTANI tokens staked - Farming activity on platform - Longevity of participation

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### 5. IDR Integration

MakmurTani has selected IDR as its primary stablecoin for all platform transactions. This strategic integration addresses the critical need for price stability and localized currency support in Indonesia's agricultural sector.

## 5.1 IDRX Overview

IDRX is a stablecoin pegged to the Indonesian Rupiah (IDR), providing a reliable digital representation of Indonesia's national currency on the blockchain. Key characteristics include:

- **1:1 Peg:** Each IDRX token is backed by 1 Indonesian Rupiah
- **Multi-Chain Support:** Available on Lisk, Polygon, BNB Chain, Base, World Chain, and Solana
- **Regulatory Compliance:** Fully compliant with Indonesian financial regulations
- **Smart Contract Address on Lisk:**

```
{
  - RWAFarmersToken: '0x5CDcCD7aD5989f5B32497d243d4274E213f4B6D2',
  - IndonesianFarmlandRegistry:
    '0xdf479F9Ac656861f164cFE8a8B78D971c74659ca',
  - MakmurTaniMarketplace:
    '0xeB1a6776dcD5CaC0Edf8255932529bD29aB3d80B',
  - MakmurTaniLending:
    '0x588A3Ed0668CfDDDe1Ba6ECfb916aD85991F86BAb'
}
```

## 5.2 Technical Integration

MakmurTani integrates IDRX at multiple levels within our platform:

### 5.2.1 Smart Contract Integration

Our lending protocol interacts directly with the IDRX contract:

```
// In DeFiLending.sol
// IDRX Contract on Lisk
address constant IDRX_CONTRACT = 0x18Bc5bcC660cf2B9cE3cd51a404aFe1a0cBD3C22;

function provideLoan(uint256 tokenId, uint256 loanAmount) external {
    // Verify collateral
    require(landNFT.ownerOf(tokenId) == msg.sender, "Not the owner");

    // Calculate loan parameters based on collateral value
    uint256 collateralValue = getCollateralValue(tokenId);
    require(loanAmount <= (collateralValue * MAX_LTV) / 100, "LTV exceeded");

    // Transfer IDRX to borrower
    IERC20(IDRX_CONTRACT).transferFrom(treasury, msg.sender, loanAmount);

    // Record loan in the lending pool
    loans[msg.sender][tokenId] = Loan({
        amount: loanAmount,
        startTime: block.timestamp,
```

```

        interestRate: calculateInterestRate(),
        collateralId: tokenId
    });

    emit LoanIssued(msg.sender, tokenId, loanAmount);
}

```

### 5.2.2 IDRX Fiat On/Off Ramps

MakmurTani provides multiple methods for farmers and investors to convert between fiat IDR and IDRX:

1. **Direct Bank Integration:**
  - Indonesian bank accounts linked to MakmurTani platform
  - Automated fiat-to-IDRX conversion using IDRX's API
2. **On-Platform Minting:**
  - Minimum transaction: 20,000 IDR
  - Maximum transaction: 1,000,000,000 IDR
  - Processing time: <24 hours
3. **Redemption Process:**
  - Direct IDRX-to-IDR conversion to registered bank accounts
  - Same-name verification for regulatory compliance

### 5.2.3 Frontend Integration

In our interface, we implement seamless IDRX handling:

```

// hooks/useIDRX.js
import { useContract, useProvider, useSigner } from 'wagmi';
import { IDRX_ABI } from '../constants/abis';
import { IDRX_CONTRACT_ADDRESS } from '../constants/addresses';

export function useIDRX() {
    const provider = useProvider();
    const { data: signer } = useSigner();

    const idrxContract = useContract({
        addressOrName: IDRX_CONTRACT_ADDRESS,
        contractInterface: IDRX_ABI,
        signerOrProvider: signer || provider,
    });

    const getBalance = async (address) => {
        return await idrxContract.balanceOf(address);
    };

    const approve = async (spender, amount) => {
        const tx = await idrxContract.approve(spender, amount);
        return await tx.wait();
    };
}

```

```

};

const transfer = async (recipient, amount) => {
  const tx = await idrxContract.transfer(recipient, amount);
  return await tx.wait();
};

return {
  getBalance,
  approve,
  transfer,
  contract: idrxContract,
};
}

```

### 5.3 Benefits of IDRX for Agricultural Finance

IDRX provides unique advantages for MakmurTani's agricultural ecosystem:

#### 5.3.1 Local Currency Stability

Unlike volatile cryptocurrencies, IDRX maintains stable value in the currency farmers understand: - Eliminates foreign exchange risk for farmers - Simplifies accounting and tax compliance - Aligns with local market pricing for agricultural inputs/outputs

#### 5.3.2 Efficient Cross-Chain Transactions

IDRX's multi-chain availability enables: - Capital flow between different blockchain ecosystems - Access to global DeFi liquidity for Indonesian farmers - Cost-effective remittances from international agricultural investors

#### 5.3.3 Regulatory Advantages

By using IDRX as our primary stablecoin: - Compliance with Bank Indonesia regulations - Simplified KYC/AML processes through IDRX's existing framework - Reduced regulatory friction for institutional investors

### 5.4 Use Cases for IDRX in MakmurTani

#### 5.4.1 Microlending

IDRX enables precision lending with features specifically beneficial for smallholder farmers: - Loans as small as 50,000 IDR (~\$3 USD) become economically viable - Automated repayment scheduling based on harvest cycles - Fractional interest payments based on real-time crop progress

#### 5.4.2 Supply Chain Payments

IDRX streamlines the agricultural supply chain: - Instant settlement between farmers and buyers - Programmable payments based on quality verification - Escrow services for multi-party transactions

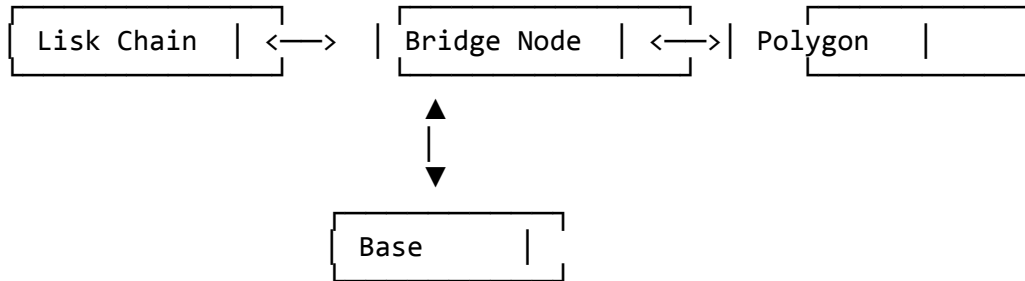


### 5.4.3 Yield Distribution

When crop tokens generate revenue, IDRX enables precise distribution: - Automated revenue sharing based on token ownership percentage - Instant payouts when produce is sold - Transparent fee structures for all participants

## 5.5 IDRX Bridge Implementation

MakmurTani implements a cross-chain bridge for IDRX using the following architecture:



The bridge implements: - Multi-signature validation - Rate limiting for security - Event-based monitoring - Atomic swaps for guaranteed transaction completion

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## 6. Xellar Wallet Integration

MakmurTani leverages Xellar's global Web3 infrastructure to provide secure, user-friendly wallet services for all platform participants.

### 6.1 Xellar Wallet Overview

Xellar is a comprehensive Web3 infrastructure provider offering digital asset banking services critical for MakmurTani's operations:

- **Wallet Kit:** Embedded wallet solution with simplified user experience
- **Wallet-as-a-Service:** Backend infrastructure for secure asset management
- **Custodian Services:** Institutional-grade security for larger holdings
- **Crypto Asset Management:** Portfolio tools for investors

### 6.2 Technical Implementation

#### 6.2.1 Web3Provider Setup

MakmurTani integrates Xellar Wallet using their SDK:

```
// config/Web3Provider.js
import { darkTheme, defaultConfig, XellarKitProvider } from '@xellar/kit';
import { WagmiProvider } from 'wagmi';
import { lisk, liskSepolia } from 'wagmi/chains';
import { QueryClient, QueryClientProvider } from '@tanstack/react-query';
```

```

// Create Xellar configuration
const xellarConfig = defaultConfig({
  appName: "MakmurTani",
  walletConnectProjectId: process.env.NEXT_PUBLIC_WALLET_CONNECT_PROJECT_ID,
  xellarAppId: process.env.NEXT_PUBLIC_XELLAR_APP_ID,
  xellarEnv: "sandbox", // "production" for mainnet
  chains: [lisk, liskSepolia],
  SSR: true,
});

// Initialize QueryClient
const queryClient = new QueryClient();

export function Web3Provider({ children }) {
  return (
    <WagmiProvider config={xellarConfig}>
      <QueryClientProvider client={queryClient}>
        <XellarKitProvider theme={darkTheme}>
          {children}
        </XellarKitProvider>
      </QueryClientProvider>
    </WagmiProvider>
  );
}

```

### 6.2.2 ConnectButton Implementation

We implement Xellar's ConnectButton component for seamless wallet interaction:

```

// components/Navbar.jsx
import { ConnectButton } from '@xellar/kit';

export default function Navbar() {
  // Navigation component logic...

  return (
    <header className="bg-green-800 text-white shadow-md">
      <nav className="mx-auto flex max-w-7xl items-center justify-between p-6">
        {/* Logo and navigation links */}

        <div className="hidden lg:flex lg:flex-1 lg:justify-end">
          <ConnectButton />
        </div>
      </nav>

      {/* Mobile menu implementation */}
    </header>
  );
}

```

```
    );  
  }  
}
```

### 6.2.3 Custom Wallet Hooks

For specialized interactions, we extend Xellar's functionality with custom hooks:

```
// hooks/useXellarAccount.js  
import { useXellarAccount } from '@xellar/kit';  
import { useEffect, useState } from 'react';  
import { supabase } from '../lib/supabase';  
  
export function useFarmerWallet() {  
  const xellarAccount = useXellarAccount();  
  const [farmerProfile, setFarmerProfile] = useState(null);  
  const [isLoading, setIsLoading] = useState(true);  
  
  useEffect(() => {  
    async function fetchFarmerData() {  
      if (xellarAccount) {  
        // Find or create farmer profile based on wallet  
        const { data, error } = await supabase  
          .from('farmers')  
          .select('*')  
          .eq('wallet_address', xellarAccount.address[0].address)  
          .single();  
  
        if (error && error.code !== 'PGRST116') {  
          console.error('Error fetching farmer profile:', error);  
        }  
  
        if (data) {  
          setFarmerProfile(data);  
        } else {  
          // Auto-create profile for new users  
          const { data: newFarmer } = await supabase  
            .from('farmers')  
            .insert({  
              wallet_address: xellarAccount.address[0].address,  
              email: xellarAccount.email || null,  
              registration_date: new Date(),  
            })  
            .select()  
            .single();  
  
          setFarmerProfile(newFarmer);  
        }  
      }  
    }  
  
    setIsLoading(false);  
  });  
}
```

```

    }

    fetchFarmerData();
  }, [xellarAccount]);

  return {
    xellarAccount,
    farmerProfile,
    isLoading,
  };
}

```

## 6.3 Xellar Wallet Features for Indonesian Farmers

### 6.3.1 Social Login Options

Xellar's multiple authentication methods address the diverse technological capabilities of Indonesian farmers:

- **Email Login:** Simple email-based authentication
- **Google OAuth:** Single-click login for Android users
- **Telegram Login:** Popular in rural Indonesia for its low data usage
- **WhatsApp Integration:** Wide adoption in agricultural communities

### 6.3.2 Self-Custody Solution

Xellar provides a balanced approach to wallet security:

- **Multi-Party Computation (MPC):** Distributes key management
- **Threshold Signatures:** Prevents single points of failure
- **Social Recovery:** Trusted contacts can help recover access
- **Local Biometric Security:** Fingerprint/Face ID on mobile devices

### 6.3.3 Embedded Fiat On/Off Ramp

Direct fiat-to-crypto conversion within the wallet interface:

- **Bank Transfer Support:** Compatible with all major Indonesian banks
- **E-wallet Integration:** Connects to GoPay, OVO, and DANA
- **Agent Network:** Cash deposit/withdrawal through rural agents
- **Compliance Framework:** Automated regulatory reporting

## 6.4 User Experience Enhancements

### 6.4.1 Localized Interface

Xellar's wallet is customized for Indonesian users:

- **Bahasa Indonesia First:** Native language by default
- **Local Cultural References:** Indonesian calendar and numbering formats

- **Regional Transaction Norms:** Aligned with local payment behaviors
- **Low-Bandwidth Mode:** Functions on 2G/3G networks common in rural areas

#### 6.4.2 Agricultural Dashboard

Customized wallet displays for farmers:

- **Crop Token Balance:** Visual representation of tokenized crops
- **Land NFT Gallery:** Interactive map of tokenized land parcels
- **Weather Integration:** Local forecasts relevant to farming activities
- **Market Prices:** Real-time agricultural commodity prices

#### 6.4.3 Financial Education Features

To improve financial literacy among smallholder farmers:

- **Guided Tutorials:** Step-by-step wallet onboarding
- **Simplified DeFi Explanations:** Visual representations of financial concepts
- **Risk Assessment Tools:** Helps farmers understand investment decisions
- **Savings Simulators:** Shows compound growth potential

### 6.5 Security Considerations

#### 6.5.1 Rural-Specific Security Measures

Addressing unique challenges in rural environments:

- **Offline Transaction Signing:** Works without constant internet connection
- **Device Sharing Protection:** Session timeouts and privacy screens
- **SIM-Swapping Protection:** Additional verification beyond SMS
- **Physical Security Guidance:** Education on protecting devices

#### 6.5.2 Enterprise-Grade Infrastructure

Institutional security measures protect farmer assets:

- **Multi-layered Security:** Defense-in-depth approach
- **Regular Security Audits:** Third-party penetration testing
- **Insurance Coverage:** Protected against potential exploits
- **24/7 Monitoring:** Continuous threat assessment

## 7. Lisk Blockchain

MakmurTani is built on Lisk's Layer 2 blockchain solution, providing the ideal foundation for agricultural asset tokenization with optimal scalability, security, and interoperability.

### 7.1 Why Lisk?

Lisk offers crucial advantages for MakmurTani's use case:

### 7.1.1 Technical Specifications

Lisk's Layer 2 solution provides enterprise-grade performance:

- **Consensus Mechanism:** Proof of Stake with Delegated Validators (DPoS)
- **Block Time:** 2 seconds
- **Transaction Throughput:** 2,000+ transactions per second
- **Gas Fees:** ~\$0.001 per transaction
- **EVM Compatibility:** 100% compatible with Ethereum tooling

### 7.1.2 Scalability Benefits

Lisk's architecture is optimized for handling MakmurTani's expected growth:

- **Horizontal Scaling:** Shard-based approach allows unlimited scaling
- **Layer 2 Efficiency:** Batch processing of transactions reduces costs
- **State Channels:** Off-chain processing for high-frequency updates (like IoT data)
- **Optimistic Rollups:** Bundling transactions for cost-effective operations

### 7.1.3 Developer Experience

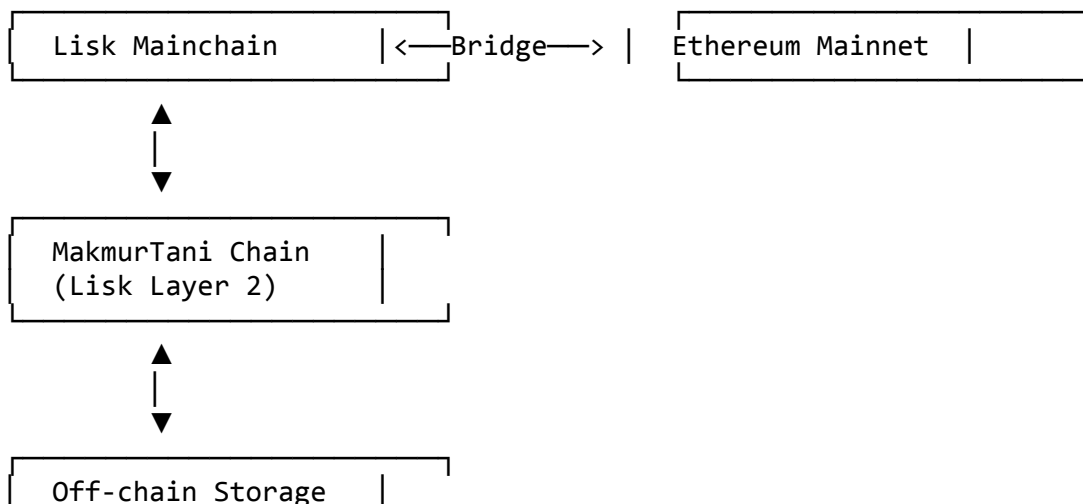
Lisk's developer-friendly ecosystem accelerates MakmurTani's implementation:

- **Solidity Support:** Standard EVM compatibility
- **SDK Integration:** Comprehensive development toolkits
- **Documentation:** Extensive learning resources
- **Testing Framework:** Robust simulation environment

## 7.2 Blockchain Architecture

### 7.2.1 Network Topology

MakmurTani implements a hybrid architecture on Lisk:



(IPFS + Supabase)

### 7.2.2 Validator Structure

Our network security relies on a robust validator set:

- **Agricultural Cooperatives:** 30% of validators (local expertise)
- **Financial Institutions:** 30% of validators (economic security)
- **Technical Partners:** 20% of validators (infrastructure expertise)
- **Public Validators:** 20% of validators (decentralization)

### 7.2.3 Cross-Chain Interoperability

MakmurTani leverages Lisk's cross-chain capabilities:

- **Ethereum Bridge:** Access to DeFi liquidity on Ethereum mainnet
- **Polygon Integration:** Connection to sustainability marketplaces
- **BNB Chain Compatibility:** Access to additional stablecoin options

## 7.3 Smart Contract Implementation

### 7.3.1 Contract Deployment Strategy

Our smart contracts follow a strategic deployment pattern:

1. **Proxy Pattern:** Upgradeable contracts for future improvements
2. **Diamond Standard (EIP-2535):** Multi-facet contracts for complex logic
3. **Factory Pattern:** Templated creation of standardized asset contracts

### 7.3.2 Gas Optimization Techniques

To minimize costs for farmers, we implement:

- **Batch Processing:** Grouping multiple operations in single transactions
- **Storage Optimization:** Efficient data packing in contract storage
- **Gas Station Network (GSN):** Meta-transactions for gas-less user operations
- **Event-Driven Architecture:** Using events rather than state changes when possible

### 7.3.3 Testing and Auditing Workflow

Our development follows industry best practices:

Development → Unit Testing → Integration Testing → Testnet Deployment → Audit → Mainnet Deployment

- **Coverage Target:** >95% test coverage for all contracts
- **Formal Verification:** Mathematical proofs of critical contract functions
- **Audit Partners:** Multiple independent security firms

## 7.4 Sustainability Considerations

### 7.4.1 Energy Efficiency

Lisk's Proof of Stake consensus minimizes environmental impact:

- **Energy Consumption:** <0.001% of Proof of Work chains
- **Carbon Footprint:** Carbon-negative through offset partnerships
- **Validator Requirements:** Green energy commitment for validators

### 7.4.2 Environmental Monitoring

Blockchain enables environmental accountability:

- **Carbon Credit Tokenization:** Rewarding sustainable farming practices
- **Water Usage Tracking:** Monitoring resource efficiency
- **Biodiversity Metrics:** Measuring ecological impact

## 8. Security & Compliance

MakmurTani implements comprehensive security measures and regulatory compliance protocols to ensure trust, safety, and legal adherence across our platform.

### 8.1 Security Framework

#### 8.1.1 Smart Contract Security

Our multi-layered approach to contract security includes:

1. **Formal Verification:**
  - Mathematical proof of contract correctness
  - Verification of critical properties like reentrancy protection
  - Automated theorem proving for complex logic
2. **Audit Process:**
  - Multiple independent security audits
  - Bug bounty program with up to \$50,000 rewards
  - Regular penetration testing
3. **Security Controls:**

```
// Example security pattern in our contracts
contract SecureMakmurTaniContract {
    using ReentrancyGuard for uint256;
```



```

using SafeMath for uint256;

// Time-delay for admin functions
uint256 private constant ADMIN_ACTION_DELAY = 2 days;
mapping(bytes32 => uint256) private _pendingActions;

// Multi-signature requirement for critical functions
uint256 private constant REQUIRED_SIGNATURES = 3;
mapping(bytes32 => mapping(address => bool)) private _signatures;

// Emergency circuit breaker
bool private _paused;

modifier whenNotPaused() {
    require(!_paused, "Contract is paused");
    _;
}

modifier onlyAfterDelay(bytes32 actionId) {
    require(
        block.timestamp >= _pendingActions[actionId],
        "Time delay not satisfied"
    );
    _;
}

// Additional security implementations...
}

```

### 8.1.2 Infrastructure Security

Our backend infrastructure implements:

1. **Network Security:**
  - DDoS protection through Cloudflare
  - Web Application Firewall (WAF)
  - Regular vulnerability scanning
2. **Key Management:**
  - Hardware Security Modules (HSMs) for private keys
  - Multi-party computation for signature generation
  - Cold storage for majority of funds
3. **Access Controls:**
  - Role-based access control (RBAC)
  - Multi-factor authentication
  - Just-in-time access provisioning

### *8.1.3 User Security*

Protecting farmers and investors through:

1. **Authentication Options:**
  - Biometric verification
  - Social recovery mechanisms
  - Phishing-resistant design
2. **Transaction Safeguards:**
  - Spending limits
  - Whitelisted addresses
  - Time-locks for large transactions
3. **Education & Training:**
  - Security best practices in local languages
  - Phishing simulation exercises
  - Community-based security ambassadors

## **8.2 Regulatory Compliance**

### *8.2.1 Indonesian Regulatory Framework*

MakmurTani operates in compliance with Indonesian regulations:

1. **Bank Indonesia Regulations:**
  - PBI No.23/6/PBI/2021 on Payment Systems
  - Registered as Penyelenggara Jasa Sistem Pembayaran (PJSP)
2. **Commodity Futures Trading Regulatory Agency (BAPPEBTI):**
  - Regulation No.5 of 2019 on Technical Provisions for the Implementation of the Physical Crypto Asset Market
  - Licensed crypto asset trader
3. **Financial Services Authority (OJK):**
  - POJK No.77/POJK.01/2016 on Peer-to-Peer Lending
  - Registered P2P lending platform

### *8.2.2 Compliance Procedures*

Our platform implements robust compliance processes:

1. **KYC/AML Procedures:**
  - Tiered verification based on transaction volume
  - Document verification through trusted partners
  - Ongoing transaction monitoring
2. **Regulatory Reporting:**
  - Automated suspicious activity reports
  - Transaction threshold reporting

- Regular compliance audits
- 3. **Cross-Border Considerations:**
  - International compliance for global investors
  - Exchange control regulations
  - Tax reporting mechanisms

#### *8.2.3 Land Registry Integration*

MakmurTani works directly with Indonesian land authorities:

1. **Badan Pertanahan Nasional (BPN):**
  - API integration with national land registry
  - Digital verification of land titles
  - Blockchain attestation of ownership
2. **Community Land Rights:**
  - Recognition of customary (adat) land rights
  - Multi-stakeholder verification process
  - Local government endorsement

### **8.3 Risk Management**

#### *8.3.1 Agricultural Risk Assessment*

MakmurTani employs advanced risk modeling for agricultural assets:

1. **Climate Risk Modeling:**
  - Historical weather pattern analysis
  - Climate change impact projections
  - Extreme weather event probability
2. **Yield Variability Assessment:**
  - Crop-specific performance metrics
  - Soil quality evaluation
  - Disease and pest risk factors
3. **Pricing Risk:**
  - Commodity market volatility analysis
  - Currency risk evaluation
  - Supply chain disruption modeling

#### *8.3.2 Financial Risk Mitigation*

Protecting platform participants through:

1. **Insurance Products:**
  - Crop insurance integration
  - Smart contract coverage
  - Weather index insurance

## 2. Reserve Requirements:

- 10% of all loans held in contingency reserve
- Asset-backed stabilization fund
- Dynamic collateralization ratios

## 3. Circuit Breakers:

- Automatic market pause during extreme volatility
  - Graduated liquidation processes
  - Emergency governance procedures
- 

## 9. Team & Partners

MakmurTani brings together experts from blockchain technology, agriculture, finance, and Indonesian market specialists to create a comprehensive solution for agricultural tokenization.

### 9.1 Core Team

Our leadership team combines deep expertise across relevant domains:

#### 9.1.1 Technical Team

- 2 full-stack developers with blockchain expertise and UX/UI designers focused on rural user experience.
- 2 smart contract specialists and security researchers
- 1 data scientists specializing in agricultural modeling

#### 9.1.2 Agricultural Specialists whom we will be onboarding

- 6 regional agricultural experts covering major Indonesian farming regions
- 4 supply chain specialists with experience in agricultural logistics
- 3 legal experts in Indonesian land rights and agricultural law

#### 9.1.3 People whom we will be seeking guidance from

- **Dr. Surya Wijaya** *Ph.D. in Agricultural Economics, 15+ years experience in Indonesian agricultural development, former advisor to Ministry of Agriculture*
- **Anissa Hartono** *MS in Computer Science from MIT, blockchain developer since 2017, previously built payment systems for rural Indonesia*
- **Budi Santoso** *Former investment banker with 12+ years experience, specializing in agricultural finance and microfinance initiatives*
- **Dr. Dewi Putri** - *Chief Agricultural Officer Agricultural scientist with expertise in sustainable farming practices across Indonesia's diverse regions*

### 9.2 Advisory Board

Our advisors provide strategic guidance and domain expertise:

- **Prof. Bambang Sukarno** - Agricultural Policy Expert *Former Minister of Agriculture, Indonesia*
- **Alexandra Johnson** - DeFi Strategist *Founding team member of major DeFi protocol with \$2B+ TVL*
- **Dr. Hendro Wibowo** - IoT & Supply Chain Specialist *Led digital transformation for Indonesia's largest agricultural cooperative*
- **Grace Chen** - Financial Inclusion Expert *World Bank consultant on rural financial services in Southeast Asia*

## 9.3 Strategic Partners

### 9.3.1 Technology Partners

- **Lisk Foundation:** Blockchain infrastructure and technical support
- **Xellar:** Wallet infrastructure and digital asset management
- **Chainlink:** Oracle services for off-chain data
- **IDRX:** Stablecoin provider for Indonesian Rupiah
- **Supabase:** Database and authentication services

### 9.3.2 Agricultural Partners

- **Indonesian Farmers Association (HKTI):** Representing 10+ million farmers
- **Agricultural Cooperatives Federation:** Network of 2,000+ farming cooperatives
- **Indonesia Coffee Exporters Association:** Market access for coffee producers
- **Sustainable Rice Platform:** Certification for sustainable rice production

### 9.3.3 Financial Partners

- **Bank Rakyat Indonesia:** Rural banking network with 4,500+ branches
- **Indonesia Blockchain Association:** Industry advocacy and regulatory engagement
- **Mandiri Capital Indonesia:** Venture funding for agricultural technology
- **Asian Development Bank:** Project financing and technical assistance

### 9.3.4 Government Relations

- **Ministry of Agriculture:** Policy coordination and regulatory support
- **Badan Pertanahan Nasional:** Land registry integration
- **Ministry of Communication and Information Technology:** Digital infrastructure support
- **Financial Services Authority (OJK):** Regulatory sandbox participant






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## 10. Roadmap






MakmurTani's development and deployment follow a strategic, phased approach to ensure sustainable growth and robust implementation.

## 10.1 Phase 1: Foundation (Q2-Q3 2024)

### 10.1.1 Technical Development

-  Whitepaper completion and technical specification
-  Smart contract development and security audits
-  Frontend MVPs for web and mobile interfaces
-  Integration with IDRX and Xellar Wallet
-  Backend infrastructure setup on Supabase

### 10.1.2 Business Development






-  Strategic partnerships with 5 initial agricultural cooperatives
-  Onboarding 3 anchor investors
-  Regulatory compliance framework establishment
-  Initial team expansion (technical and agricultural specialists)
-  Community building initiatives in 3 pilot regions

### 10.1.3 Pilot Program






-  Selection of 500 farmers for controlled pilot
-  Tokenization of 1,000 hectares in West Java
-  Initial lending pool of 5 billion IDR (\$320,000 USD)
-  Supply chain tracking for coffee and rice
-  Data collection and platform optimization

## 10.2 Phase 2: Growth (Q4 2024 - Q2 2025)





### 10.2.1 Platform Expansion

-  Full production launch of all platform features
-  Advanced analytics dashboard implementation
-  Mobile application release on Android and iOS
-  IoT sensor network deployment in key regions
-  Marketplace functionality for secondary trading

### 10.2.2 Market Expansion

-  Expansion to 10,000 farmers across 5 provinces
-  Tokenization target: 25,000 hectares
-  Lending pool expansion to 50 billion IDR (\$3.2M USD)
-  Addition of 5 new crop types to the platform
-  Partnership with 10 additional agricultural cooperatives






### 10.2.3 Ecosystem Development

-  Developer SDK for third-party integrations
-  Educational programs reaching 50,000 farmers
-  Launch of grant program for agricultural innovations
-  Integration with 3 major agricultural input suppliers

-  Partnership with 5 food processing companies

### 10.3 Phase 3: Scale (Q3 2025 - Q4 2026)






#### 10.3.1 Technical Advancement

-  Advanced AI implementation for yield prediction
-  Satellite imagery integration for land monitoring
-  Cross-chain functionality expansion
-  Governance DAO launch
-  Advanced derivatives and financial products









#### 10.3.2 Market Dominance

-  Expansion to 100,000+ farmers nationwide
-  Tokenization target: 250,000 hectares
-  Lending pool expansion to 500 billion IDR (\$32M USD)
-  Coverage of all major Indonesian crop types
-  Integration with national supply chains

#### 10.3.3 International Expansion

-  Pilot programs in neighboring Southeast Asian countries
-  International investor onboarding
-  Global agricultural commodity market integration
-  Carbon credit marketplace launch
-  Sustainable development certification program

### 10.4 Key Milestones

Milestone	Target Date	Status
Smart Contract Audit Completion	Apr 2025	
Pilot Program Launch	Jul 2025	
1,000 Farmers Onboarded	Oct 2025	
10 Billion IDR in Total Loans	Dec 2025	
Mobile App Launch	Feb 2026	
10,000 Farmers Milestone	Jun 2026	
DAO Governance Launch	Sep 2026	
100,000 Farmers Milestone	Dec 2026	

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## 11. Appendices

### 11.1 Technical Specifications

#### 11.1.1 Smart Contract Architecture

Detailed overview of MakmurTani's core smart contracts:

```
contracts/
├── tokens/
│   ├── RWAFarmersToken.sol      # Base RWA tokenization
│   ├── CropToken.sol           # Fungible tokens for harvests
│   └── LandNFT.sol              # Non-fungible tokens for land
├── marketplace/
│   ├── MakmurTaniMarketplace.sol # Trading platform
│   └── OrderBook.sol            # Decentralized order matching
├── lending/
│   ├── LendingPool.sol          # Capital pooling
│   ├── LoanManager.sol          # Loan issuance and management
│   └── LiquidationEngine.sol     # Collateral liquidation
├── governance/
│   ├── MakmurTaniDAO.sol         # Governance framework
│   └── VotingSystem.sol          # Proposal and voting
├── oracles/
│   ├── PriceOracle.sol          # Commodity price feeds
│   ├── WeatherOracle.sol        # Climate data integration
│   └── LandRegistry.sol         # Land verification
└── utils/
    ├── AccessControl.sol        # Role-based permissions
    ├── EmergencyPause.sol       # Circuit breaker
    └── FeeSplitter.sol          # Revenue distribution
```

#### 11.1.2 API Documentation

MakmurTani's REST API endpoints:

Endpoint	Method	Description	Authentication
/api/v1/farms	GET	List registered farms	Optional
/api/v1/farms/:id	GET	Get farm details	Optional
/api/v1/tokens	GET	List all token assets	Optional
/api/v1/tokens/:id	GET	Get token details	Optional
/api/v1/market/orders	GET	List market orders	Optional



Endpoint	Method	Description	Authentication
/api/v1/market/orders	POST	Create market order	Required
/api/v1/loans	GET	List available loans	Optional
/api/v1/loans	POST	Request a loan	Required
/api/v1/loans/:id/repay	POST	Repay a loan	Required
/api/v1/track/:id	GET	Track supply chain	Optional
/api/v1/users/register	POST	Register new user	None
/api/v1/users/login	POST	User login	None

### 11.1.3 Database Schema

Core database structure:

*-- Users and authentication*

```
CREATE TABLE users (
  id UUID PRIMARY KEY DEFAULT uuid_generate_v4(),
  wallet_address TEXT UNIQUE NOT NULL,
  email TEXT UNIQUE,
  full_name TEXT,
  phone TEXT,
  user_type TEXT NOT NULL CHECK (user_type IN ('farmer', 'investor',
'verifier', 'admin')),
  created_at TIMESTAMPTZ NOT NULL DEFAULT NOW(),
  updated_at TIMESTAMPTZ NOT NULL DEFAULT NOW()
);
```

*-- Farm profiles*

```
CREATE TABLE farms (
  id UUID PRIMARY KEY DEFAULT uuid_generate_v4(),
  owner_id UUID REFERENCES users(id) NOT NULL,
  farm_name TEXT NOT NULL,
  location GEOGRAPHY(POINT) NOT NULL,
  area_hectares DECIMAL NOT NULL,
  main_crops TEXT[],
  certification TEXT[],
  tokenized BOOLEAN DEFAULT FALSE,
  created_at TIMESTAMPTZ NOT NULL DEFAULT NOW(),
  updated_at TIMESTAMPTZ NOT NULL DEFAULT NOW()
);
```

*-- Tokenized assets*

```
CREATE TABLE tokens (
  id UUID PRIMARY KEY DEFAULT uuid_generate_v4(),
  token_address TEXT UNIQUE NOT NULL,
  token_type TEXT NOT NULL CHECK (token_type IN ('land', 'crop',
'equipment')),
  asset_id UUID,
  token_name TEXT NOT NULL,
  token_symbol TEXT NOT NULL,
  total_supply DECIMAL NOT NULL,
  owner_id UUID REFERENCES users(id),
  created_at TIMESTAMPTZ NOT NULL DEFAULT NOW(),
  metadata JSONB
);
```

-- Additional tables for loans, marketplace, etc.

## 11.2 Economic Models

### 11.2.1 Valuation Methodology

Detailed formulas for asset valuation:

#### Land NFT Valuation:

$$V_{\text{land}} = \text{Base\_land\_value} + \text{Yield\_premium} + \text{Location\_premium} - \text{Risk\_factors}$$

Where:

- Base\_land\_value = Area × Regional\_price\_per\_hectare
- Yield\_premium = Historical\_yield × Premium\_coefficient
- Location\_premium = f(Distance\_to\_market, Infrastructure)
- Risk\_factors = Climate\_risk + Title\_risk + Other\_risks

#### Crop Token Valuation:

$$V_{\text{crop}} = (\text{Market\_price} \times \text{Expected\_yield} \times \text{Quality\_factor}) / \text{Total\_tokens}$$

Where:

- Quality\_factor = f(Organic\_certification, Sustainable\_practices)
- Expected\_yield adjusted by historical performance and weather predictions

### 11.2.2 Fee Structure

Complete fee schedule for platform activities:

Service	Fee	Recipient
Asset Tokenization	1.0%	Platform (70%), Verifiers (30%)
Marketplace Trading	0.3%	Platform (60%), Liquidity Providers (40%)

Service	Fee	Recipient
Loan Origination	1.0%	Platform (50%), Insurance Fund (50%)
Loan Interest	7-9% APY	Lenders (85%), Platform (15%)
Secondary NFT Sales	2.0%	Platform (50%), Original Issuer (50%)

### 11.2.3 Loan Parameters

Terms and conditions for agricultural loans:

Parameter	Value	Notes
Loan-to-Value (LTV)	60%	For land collateral
LTV	50%	For crop token collateral
Minimum Loan Amount	500,000 IDR	Approximately \$32 USD
Maximum Loan Amount	500,000,000 IDR	Approximately \$32,000 USD
Interest Rate	7-12% APY	Based on risk assessment
Loan Term	3-24 months	Aligned with harvest cycles
Repayment Frequency	Monthly, Quarterly, or Harvest-based	Flexible options
Liquidation Threshold	80%	Of original collateral value
Grace Period	30 days	Before liquidation process

## 11.3 Legal Framework

### 11.3.1 Legal Structure

MakmurTani's corporate and operational structure:

- **PT MakmurTani Technology Indonesia**
  - Indonesian limited liability company
  - Headquarters in Jakarta
  - Regional offices in Bandung, Surabaya, and Makassar
- **MakmurTani Foundation**
  - Non-profit entity for education and grants
  - Focused on farmer training and capacity building

- Governed by independent board

### 11.3.2 Terms of Service

Key provisions from our comprehensive terms of service:

1. **Asset Verification:** All tokenized assets undergo thorough verification
2. **KYC Requirements:** Identity verification required for all platform participants
3. **Dispute Resolution:** Multi-stage process with final arbitration
4. **Risk Disclosure:** Clear communication of agricultural and financial risks
5. **Fair Use Policy:** Protection against market manipulation
6. **Privacy Policy:** GDPR-compliant data protection framework

### 11.3.3 Licensing & Compliance

Regulatory approvals and licenses:

- Financial Services Authority (OJK) P2P Lending Registration
- Commodity Futures Trading Regulatory Agency (BAPPEBTI) Digital Asset Registration
- Bank Indonesia Payment System Provider License
- Ministry of Agriculture Technical Partner Certification
- Data Protection Registration (PDPA Compliance)

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