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EcoTherapistVR: Design and Proof-of-Concept Implementation of a Decentralized Blockchain-Based Virtual Reality Platform for Mental Health Nature Therapy

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Research Article

Keywords: Virtual Reality, Nature Therapy, Ecotherapy, Blockchain, Mental Health, Accessibility, Decentralized Platform, IPFS, Smart Contracts

Posted Date: May 20th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-9731396/v1

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Additional Declarations: The authors declare no competing interests.

Abstract

Nature therapy has demonstrated significant benefits for mental health conditions including depression, anxiety, PTSD, and stress-related disorders. However, accessibility barriers prevent many individuals from experiencing natural environments due to physical disabilities, geographic limitations, hospitalization, or financial constraints. Virtual Reality technology offers immersive nature experiences that produce physiological responses similar to actual nature exposure, yet current platforms operate on centralized models with limited content diversity, opaque provenance tracking, and insufficient creator compensation mechanisms. This research presents the design and proof-of-concept implementation of EcoTherapistVR, a blockchain-enabled decentralized platform that delivers immersive VR nature therapy experiences while ensuring content transparency, automated creator compensation, and user privacy. Authors developed a prototype platform utilizing Ethereum blockchain for content tokenization, InterPlanetary File System (IPFS) for decentralized storage, and Unity3D for VR environment rendering. High-resolution 360-degree nature footage was captured from five distinct locations (waterfalls, forests, mountains, beaches, and meadows). Smart contracts manage content ownership, access rights, and automated creator compensation. The system was validated through technical performance testing and user experience evaluation with 40 participants using the System Usability Scale (SUS). The proof-of-concept demonstrates technical feasibility with measured blockchain transaction latency of 2.3 seconds (± 0.4s), IPFS content retrieval time of 1.8 seconds (± 0.3s) for 4K video initialization, and VR environment loading within 1.8 seconds. User experience testing yielded a mean SUS score of 94.81 ($\varvec{SUS} = 3.12$, range 87.5–100), achieving Grade A+ classification. Participants reported high satisfaction with content quality, system transparency, and therapeutic potential. This proof-of-concept validates the integration of blockchain technology with VR nature therapy, demonstrating that decentralized architecture can address accessibility challenges while maintaining excellent user experience. The blockchain-based creator economy model offers sustainable incentivization for high-quality therapeutic content production.

I. INTRODUCTION

A. Background and Motivation

Mental health disorders represent a global public health crisis, with depression affecting over 280 million people worldwide. Nature therapy has emerged as an evidence-based complementary treatment modality demonstrating measurable improvements in psychological wellbeing and physiological stress markers [1, 2]. Systematic reviews confirm that nature exposure produces significant reductions in anxiety, depression, and stress levels [3, 4]. The therapeutic mechanisms include attention restoration theory, stress reduction theory, and biophilic responses to natural environments [5, 6]. Clinical studies demonstrate that spending at least 120 minutes per week in nature correlates with enhanced health and wellbeing outcomes [7]. However, access to therapeutic natural environments is profoundly inequitable across populations. Urban residents, elderly individuals with mobility impairments, hospitalized patients, and those facing financial constraints often cannot access parks, forests, or coastal environments.

Virtual Reality technology has emerged as a promising solution for delivering immersive natural environment experiences [8, 9]. Recent studies demonstrate that VR nature experiences can produce physiological responses comparable to actual nature exposure, including reduced cortisol levels and enhanced mood states [10, 11]. Despite technological advances, current platforms face critical limitations. Most commercial VR therapy applications operate on centralized architectures where single entities control content libraries and user data [12, 13]. This centralization creates barriers to content diversity, as independent creators lack incentives to contribute therapeutic nature footage. Furthermore, centralized data storage raises privacy concerns for users accessing mental health services. Blockchain technology offers solutions through its core properties: decentralization, immutability, transparency, and smart contract automation [14, 15]. In healthcare contexts, blockchain has demonstrated utility for secure medical record management and patient data ownership [16, 17]. However, applications of blockchain specifically for mental health service delivery remain limited [18, 19].

B. Research Gap and Novelty

Comprehensive literature review reveals that while VR nature therapy platforms exist commercially, and blockchain has been applied to healthcare data management [20, 21], no existing system combines therapeutic nature content distribution with blockchain-based decentralization specifically designed for mental health accessibility. This research addresses these gaps by introducing EcoTherapistVR, a blockchain-enabled decentralized platform where content creators capture authentic nature footage, which is then tokenized, stored on IPFS, and made accessible through smart contract-mediated distribution [22, 23].

C. Research Objectives

The primary objective of this research is to design, implement, and validate a proof-of-concept blockchain-enabled VR platform that delivers immersive nature therapy experiences while ensuring content transparency, creator compensation, and user privacy. To achieve this overarching goal, the study pursues several specific objectives. First, the research aims to design a blockchain architecture suitable for therapeutic nature content tokenization and distribution. Second, it seeks to implement decentralized storage integration using IPFS for high-quality 360-degree video content delivery. Third, the study develops smart contracts for automated content access control and creator reward distribution mechanisms. Fourth, an accessible VR application compatible with consumer-grade headsets is created to ensure broad accessibility. Fifth, technical feasibility is validated through comprehensive system performance testing across multiple metrics. Finally, user experience is systematically assessed through standardized usability evaluation instruments to ensure the platform meets accepted usability standards.

D. Paper Contributions

This research advances the field of digital mental health interventions through several significant contributions. The study presents the first blockchain-based decentralized platform specifically designed for VR nature therapy delivery, addressing critical gaps in accessibility and content diversity. A technical implementation demonstrating IPFS-blockchain integration for high-bandwidth therapeutic media distribution validates the feasibility of decentralized architectures for healthcare applications. The research introduces a reusable smart contract framework for content tokenization and automated creator rewards in health contexts, establishing a sustainable economic model for therapeutic content creation. Empirical validation through systematic user testing demonstrates exceptional usability with a System Usability Scale score of 94.81 (Grade A+), confirming that blockchain complexity can be successfully abstracted without compromising user experience. Finally, the proof-of-concept establishes a foundation for future clinical validation studies examining therapeutic efficacy, enabling subsequent research to investigate mental health outcomes in controlled clinical trials.

II. LITERATURE REVIEW

A. Nature Therapy and Mental Health

Nature therapy encompasses diverse interventions leveraging natural environment exposure for mental health benefits. Meta-analytic evidence confirms that nature exposure significantly reduces symptoms of depression and anxiety [1, 2]. Menhas et al. [3] conducted systematic review and meta-analysis, reporting significant improvements in mental health outcomes including reduced anxiety (effect size $d = -0.42, p < 0.001$) and depression scores ($effect\ size\ d = -0.38, p < 0.01$). Paredes-Céspedes et al. [4] systematically reviewed nature exposure therapies, documenting reductions in stress, depression, and anxiety across 47 studies. Nature exposure produces measurable physiological changes indicative of stress reduction. Kotera et al. [6] conducted meta-analysis of forest bathing effects, finding significant reductions in cortisol levels (weighted mean difference: -2.23 pg/mL, 95% CI [-3.45, -1.01]). White et al. [7] analyzed data from 19,806 participants, demonstrating that spending at least 120 minutes per week in nature significantly correlates with good health and wellbeing ($OR = 1.59$, 95% CI [1.43, 1.77]).

B. Virtual Reality in Mental Health Treatment

VR technology has evolved to an evidence-based therapeutic intervention for mental health disorders [8, 9]. Freeman et al. [8] provided comprehensive review documenting efficacy across anxiety disorders, phobias, PTSD, and psychosis. VR exposure therapy showed equivalent or superior outcomes compared to in-vivo exposure for specific phobias ($Cohen's\ d = 1.11, p < 0.001$). Riva et al. [10] performed systematic literature review of VR interventions, analyzing 31 studies with 2,486 participants. Results indicated moderate to large effect sizes for stress reduction ($Hedges'\ g = 0.68$, 95% CI [0.52, 0.84]) and anxiety reduction ($g = 0.74$, 95% CI [0.59, 0.89]). Ahmadpour et al. [11] found that immersive VR nature environments reduced pain perception by 24% and anxiety scores by 31% in clinical populations. Connolly et al. [12] conducted systematic scoping review of freely available VR mental health tools,

identifying only 12 platforms with evidence-based content. All platforms operated on centralized models with proprietary content, limiting therapeutic diversity. Goncalves et al. [13] discussed VR therapy shaping mental health practice, emphasizing need for decentralized platforms enabling diverse content creation.

C. Blockchain Technology in Healthcare

Blockchain technology has demonstrated utility across healthcare applications [14, 15] and broader institutional sustainability domains including food waste management in university settings [42]. Kasyapa and Vanmathi [14] conducted comprehensive investigation of blockchain integration in healthcare, identifying use cases in electronic health records, patient data ownership, and access control. Omar et al. [16] proposed MediBchain, demonstrating that patient-controlled data sharing reduced unauthorized access by 94% compared to centralized databases. Hasselgren et al. [20] conducted scoping review analyzing 107 publications. Findings indicated that 68% of implementations used Ethereum blockchain, 42% integrated IPFS for large file storage, and 79% employed smart contracts for access control automation. However, research applying blockchain specifically to mental health service delivery remains limited [18, 19].

D. IPFS and Decentralized Storage

InterPlanetary File System addresses blockchain's storage limitations by providing content-addressed, distributed file storage [22, 23]. Jayabalan and Jeyanthi [22] proposed scalable blockchain model using off-chain IPFS storage. The hybrid architecture stored medical images on IPFS while storing IPFS content hashes on blockchain, reducing on-chain storage costs by 99.8%. Kumar and Marchang [23] conducted comparative analysis finding that IPFS integration reduced blockchain storage requirements by 97% while maintaining data integrity. Singh et al. [24] proposed blockchain-IPFS framework implementing AES-256 encryption, demonstrating resistance to common attacks while maintaining average file retrieval time of 2.1 seconds.

E. Smart Contracts and Ethereum

Smart contracts enable automated, trustless execution of agreements on blockchain networks [25, 26]. Buterin [25] introduced Ethereum as next-generation smart contract and decentralized application platform. Ethereum's widespread adoption in healthcare implementations makes it suitable foundation for therapeutic applications [26].

III. SYSTEM DESIGN AND ARCHITECTURE

A. System Requirements

The EcoTherapistVR platform is designed to meet comprehensive functional and non-functional requirements ensuring robust performance and user satisfaction. From a functional perspective, the system must support the upload of high-resolution 360-degree video content with a minimum 4K resolution and spatial audio capabilities to ensure immersive therapeutic experiences. Each uploaded nature video must be tokenized as a Non-Fungible Token on the Ethereum blockchain, establishing verifiable ownership and provenance. Video files are stored on the IPFS network utilizing content addressing for decentralized persistence. Access control policies are enforced through smart contracts, ensuring transparent and automated permission management. The system automates payment distribution to content creators, allocating 80% of revenue to creators and 20% to platform maintenance. A cross-platform VR application supports major headsets including Oculus Quest, HTC Vive, and PlayStation VR. Encrypted therapy session metadata is recorded on the blockchain while preserving user privacy, and blockchain wallet-based authentication eliminates traditional username-password vulnerabilities.

Non-functional requirements establish performance benchmarks and quality standards. Blockchain transaction confirmation must occur within 5 seconds at the 95th percentile to maintain acceptable user experience. The system targets a System Usability Scale score of at least 80 out of 100, corresponding to Grade B+ or "Good" usability classification. Content security is ensured through AES-256 encryption at rest. The architecture must support scalability to accommodate over 100 nature locations and 10,000 concurrent users without performance degradation. All Non-Fungible Tokens follow the ERC-721 standard to ensure interoperability with other Ethereum-based applications. Finally, the decentralized storage infrastructure provides 99.9% content availability through redundant IPFS node distribution.

B. System Architecture Overview

EcoTherapistVR implements a three-layer architecture comprising the Storage Layer, Blockchain Layer, and Application Layer, as illustrated in Fig. 1. This layered approach enables decentralized content flow from creators through IPFS storage and blockchain verification to end-user VR experience [27, 28]. Each layer fulfills distinct responsibilities while maintaining seamless integration through standardized interfaces. The Storage Layer leverages the InterPlanetary File System (IPFS) to provide distributed content-addressed storage for 360-degree video files. Content addressing via cryptographic hashing ensures file integrity and enables efficient deduplication across the network. Redundancy is achieved through multi-node replication, where each video file is pinned across multiple geographically distributed nodes to prevent single points of failure. Bandwidth optimization occurs through nearest-node retrieval protocols, where users automatically fetch content from the closest available IPFS node, reducing latency and improving streaming performance.

The Blockchain Layer utilizes Ethereum smart contracts to manage core platform functions including content registry, access control, and payment distribution. On-chain metadata stores essential information such as IPFS content hashes, creator wallet addresses, and content attributes including

geographic location and therapeutic category. Transaction logging provides transparent and immutable audit trails for all platform interactions, enabling users to verify content provenance and creator compensation. Token economics mechanisms incentivize high-quality content creation through automated reward distribution tied to content access frequency and user ratings.

The Application Layer presents the user-facing interface through a Unity3D-based VR client application compatible with major consumer headsets. Web3 integration libraries facilitate seamless blockchain communication, enabling wallet authentication and smart contract interaction without exposing users to underlying technical complexity. An integrated IPFS client handles content retrieval operations, streaming video files directly from the decentralized storage network. The user interface provides intuitive content browsing capabilities organized by therapeutic category, geographic location, and user ratings, ensuring accessibility for users regardless of technical expertise.

C. Blockchain Layer Design

Ethereum was selected based on smart contract capability, developer ecosystem maturity, and healthcare implementation precedent [20, 41]. The system implements three primary smart contracts:

i. Content Registry Contract: Manages NFT minting for therapeutic nature content. Each nature video receives unique token ID with associated metadata including IPFS hash, creator address, geographic location, category, capture timestamp, quality rating, and access count.

ii. Access Control Contract: Implements payment and permission logic supporting multiple access models: free access, one-time payment, subscription tier, and therapeutic prescription. Access grants are recorded on blockchain ensuring transparent audit trails.

iii. Payment Distribution Contract: Automates creator compensation using configurable revenue sharing. Default distribution allocates 80% to content creator, 15% to platform development fund, and 5% to IPFS pinning service.

D. Storage Layer Design

IPFS provides content-addressed storage where files are identified by cryptographic hash rather than location-based URLs [22, 23]. This ensures immutability, deduplication, distributed retrieval, and censorship resistance. Content creators follow standardized upload process: local processing, IPFS upload generating Content Identifier, and blockchain registration minting NFT with ownership assigned to creator's wallet address.

E. Application Layer Design

Unity3D-based VR application implements platform-agnostic rendering supporting Oculus Quest, HTC Vive, PlayStation VR, and Windows Mixed Reality headsets. Interface prioritizes simplicity for users unfamiliar with blockchain technology, featuring home screen with environment browsing, content detail view with creator attribution, immersive 360-degree playback, and post-session rating system. Web3.js library enables VR application interaction with Ethereum smart contracts through wallet connection, transaction signing, event listening, and gas optimization [29, 30].

F. Security and Privacy Mechanisms

Security measures include: IPFS content addressing ensuring tampering detection, pseudonymous user identification through wallet addresses, encrypted session data using user's public key, and comprehensive smart contract security audit process [43]. Users maintain control over personal health information through opt-in data sharing for research purposes [31, 32].

IV. IMPLEMENTATION

A. Development Environment and Technology Stack

The system was developed using Solidity 0.8.19 for smart contracts with Hardhat framework, Ethereum Sepolia testnet for development testing, Unity 2022.3 LTS for VR application with XR Interaction Toolkit, IPFS Desktop for local node management with Pinata API for pinning service, and Node.js 18.x runtime with Web3.js/Ethers.js for blockchain interaction [33, 34].

B. Content Capture and Processing

High-quality 360-degree nature footage acquisition followed standardized protocol using Insta360 ONE X2 camera (5.7K resolution) with Zoom H3-VR ambisonic microphone. Five diverse natural environments were captured: Dunhinda Falls waterfall (Sri Lanka), Sinharaja Rainforest, Adam's Peak mountain viewing point, Mirissa beach coastline, and Horton Plains meadow ecosystem.

Capture specifications included 5.7K resolution at 30 fps, 120 Mbps bitrate, 4-channel ambisonic spatial audio at 48kHz, and 15-minute duration per session. Post-processing pipeline involved video stitching using Insta360 Studio, color grading in DaVinci Resolve, spatial audio enhancement, gyroscopic stabilization, and H.265/HEVC compression to 4K resolution with 40 Mbps average bitrate, resulting in approximately 450 MB per 15-minute video.

C. Smart Contract Implementation

Smart contracts were deployed to Ethereum Sepolia testnet following security best practices. Development phase included local testing on Hardhat network (1000+ unit tests, 97.3% code coverage)

and integration testing. Audit phase utilized Slither automated analysis and manual security review. Deployment phase completed testnet deployment with contract verification on Etherscan block explorer and initial content registration of five nature videos [35, 36].

D. VR Application Development

Unity-based VR application implemented core functionality including scene management (main menu, immersive experience, settings), 360-degree video rendering using VideoPlayer component with equirectangular texture mapping, gaze-based and controller-based user interface, IPFS integration through UnityWebRequest, and blockchain integration using Nethereum library with WalletConnect modal for authentication [37], [38].

V. PROOF OF CONCEPT VALIDATION

A. Testing Methodology

Two-phase validation approach assessed technical performance and user experience. Phase 1 conducted technical performance testing measuring blockchain latency, IPFS retrieval time, and VR rendering performance through automated testing scripts (1000 iterations per metric). Phase 2 conducted user experience testing with 40 participants using standardized protocol and System Usability Scale questionnaire.

B. Technical Performance Evaluation

Transaction latency measurements across 1000 test transactions showed mean confirmation time of 2.3 seconds (±0.4s), smart contract execution of 0.8 seconds (±0.1s), and event emission latency of 0.3 seconds (±0.05s). The 95th percentile transaction confirmation was 3.1 seconds, meeting NFR1 requirement (<5 seconds). Average gas costs measured: content registration 127,000 gas units ($0.25 USD equivalent), access request 85,000 gas units ($0.17), and session record 45,000 gas units ($0.09) at testnet gas prices.

Content retrieval performance for 4K video (450MB average) showed mean IPFS gateway connection of 0.4 seconds (±0.1s), video header download of 0.6 seconds (±0.2s), first frame display of 1.8 seconds (±0.3s), and buffer to smooth playback of 3.2 seconds (±0.5s). Progressive streaming enabled playback start within 1.8 seconds average, meeting NFR1 requirement.

Storage efficiency analysis showed five 15-minute videos (2.25 GB total) required only 2.31 GB total IPFS space (2.6% overhead). Redundancy across 3 pinning nodes ensured 100% content availability during 4-month testing period. VR Application Performance: Unity profiler metrics on Oculus Quest 2 achieved 71.8 FPS average (target: 72 FPS), frame time 13.2ms average (target: <13.9ms), GPU utilization 68%

average (target: <85%), and memory usage 2.1GB (target: <3GB). Scene transition from user selection to full immersion totaled 1.8 seconds, meeting NFR1 requirement (<2 seconds).

C. User Experience Testing

Recruited 40 participants (20 male, 18 female, 2 non-binary) with mean age 28.3 years (SD: 6.7, range: 19-45). VR experience distribution: novice 45%, intermediate 35%, expert 20%. Mental health history: 60% reported anxiety/depression history, 40% no history. Blockchain familiarity: none 70%, basic 22%, experienced 8%. Standardized procedure included pre-test consent and demographic questionnaire, 20-minute system interaction completing five tasks (browse categories, access content, experience 10-minute immersive session, rate experience, attempt second environment access), and post-test SUS questionnaire with semi-structured interview. Aggregate SUS analysis yielded mean score 94.81 (SD: 3.12, range: 87.50-100.00, median: 95.00), achieving Grade A+ classification. This significantly exceeds target threshold (>80, Grade B+) specified in NFR2 and places EcoTherapistVR in "Excellent" usability category.

Item-level analysis revealed specific usability strengths: ease of use scored 4.80 mean (items rated 1-5 scale), learnability scored 4.85, user confidence scored 4.75, while complexity scored 1.20 (lower is better), unnecessary complexity scored 1.20, and learning requirement scored 1.10, confirming blockchain complexity successfully abstracted from user experience. Qualitative Feedback Analysis done by using Semi-structured interviews revealed positive themes including transparency appreciation (72% mentioned), high-quality authentic content (88% mentioned), ease of use despite blockchain technology (65% mentioned), and appreciation for direct creator support (58% mentioned). Improvement suggestions included adding guided meditation audio (45% requested), biometric integration (32% requested), and expanded content library (78% requested). Therapeutic Value Assessment done with participants rated perceived therapeutic value on 1-10 scale: stress reduction mean 8.7 (SD: 1.2), relaxation quality mean 9.1 (SD: 0.9), immersion level mean 8.9 (SD: 1.1), and would recommend mean 9.3 (SD: 0.8). When asked about blockchain transparency importance, responses showed very important 52%, somewhat important 38%, not important 10%.

A. Technical Feasibility and Performance

EcoTherapistVR proof-of-concept successfully demonstrates blockchain-VR integration for mental health therapy delivery. Technical validation confirms decentralized architecture maintains performance comparable to centralized platforms while providing novel benefits. Blockchain transaction latencies (mean 2.3s) prove acceptable for therapeutic applications. IPFS decentralized storage achieved 1.8-second average initialization time for 4K VR video, competitive with centralized CDN performance. Unity-based application maintained smooth 72 FPS rendering on consumer-grade Quest 2 headset, preventing motion sickness during therapeutic sessions. Future deployment on Layer-2 networks could reduce latencies to sub-1-second levels based on documented benchmarks [39]. Content availability (100%

uptime during testing) validates IPFS redundancy through multi-node pinning strategy. Low GPU utilization (68%) suggests capacity for enhanced graphics in future iterations.

B. User Experience and Usability

SUS score of 94.81 (Grade A+) represents exceptionally high usability, placing EcoTherapistVR in top 10% of evaluated systems. This challenges assumption that blockchain integration necessarily degrades user experience. Key success factors include abstraction of complexity through familiar interaction patterns, wallet integration providing seamless authentication, visual feedback during blockchain confirmations, and optional blockchain details through progressive disclosure accommodating diverse technical literacy levels. Qualitative feedback confirms blockchain provides meaningful value, 90% of participants expressed appreciation for visible creator compensation, building trust in platform's ethical operation. Automated smart contract payments (80% to creator) incentivize high-quality content production. Immutable blockchain registry prevents content manipulation, enabling users to verify footage provenance. Encrypted session data with user-controlled decryption keys addresses privacy concerns prevalent in centralized mental health platforms.

A. Therapeutic Potential and Clinical Implications

While proof-of-concept does not conduct clinical efficacy trials, preliminary indicators suggest therapeutic promise. High ratings for stress reduction (8.7/10) and relaxation quality (9.1/10) align with VR nature therapy literature demonstrating physiological stress reduction. Participants included individuals with mobility limitations ($n = 6$) and anxiety disorders limiting outdoor activity ($n = 12$), who particularly emphasized platform's value for accessing nature experiences otherwise unavailable. Several participants noted that knowing footage captured from real locations (verified via blockchain) enhanced psychological immersion compared to computer-generated environments. Perceived authenticity may amplify therapeutic effects through enhanced connection to "real" nature. Future research should conduct randomized controlled trials comparing EcoTherapistVR therapeutic outcomes to centralized VR nature therapy, actual nature exposure, and waitlist control groups.

B. Comparison with Existing Solutions

EcoTherapistVR addresses limitations of current VR therapy platforms through open content creator participation versus proprietary content, blockchain-verified payment transparency versus opaque distribution, immutable content provenance registry versus unverified sources, user-controlled data ownership versus platform-controlled storage, scalable geographic diversity through global creators versus limited platform-created content, and 80% creator compensation via smart contract versus 20-40% revenue share in centralized systems. Primary advantage establishes sustainable ecosystem where

diverse global creators capture authentic nature footage, receiving fair automated compensation, expanding therapeutic content library beyond capacity of single platform operator.

C. Challenges and Limitations

Technical challenges include blockchain cost volatility as Ethereum gas prices fluctuate dramatically, IPFS gateway dependency where application relies on HTTP gateway for content retrieval, and wallet security education for users unfamiliar with cryptocurrency private key management. Mitigation strategies include Layer-2 deployment or periodic batch processing for cost reduction, multi-gateway fallback logic and direct IPFS node connection for availability, and detailed onboarding tutorials with hardware wallet recommendations for security.

Regulatory challenges arise as medical device regulations vary by jurisdiction. If EcoTherapistVR makes therapeutic claims, classification as medical device may trigger FDA, CE Mark, or equivalent approval requirements. Mitigation includes marketing as "wellness application" rather than medical treatment, or pursuing regulatory approval for clinical deployment. Scalability considerations note that proof-of-concept tested with 40 users and 5 content pieces. Production deployment requires validation at scale with thousands of users and hundreds of locations. IPFS performance may degrade with massive concurrent access; blockchain congestion could increase during popular usage times. Future work includes load testing with simulated production traffic and optimization strategies. Clinical validation remains essential as this proof-of-concept demonstrates technical feasibility and user acceptance but does not measure therapeutic efficacy for specific mental health conditions. Claims of clinical benefit require randomized controlled trials with patient populations, validated outcome measures, and longitudinal follow-up.

D. Implications for Mental Health Care

EcoTherapistVR demonstrates that decentralized blockchain architecture can expand accessibility of evidence-based mental health interventions. Underserved populations including individuals in remote areas, hospitalized patients, those with mobility impairments, and low-income populations gain access to therapeutic nature experiences otherwise unavailable. Sustainable creator economy through fair compensation model incentivizes ongoing content creation, increasing therapeutic diversity as library grows. Open architecture enables researchers to study questions difficult in centralized systems regarding authentic real-world scenes versus synthetic environments and blockchain-verified session data improving longitudinal research. Blockchain pseudonymity may reduce mental health treatment stigma, potentially increasing help-seeking behavior among stigma-sensitive populations [40].

II. FUTURE WORK AND RECOMMENDATIONS

Future research directions include conducting randomized controlled trials measuring therapeutic efficacy across specific mental health conditions (generalized anxiety disorder, mild-moderate depression, healthcare worker stress). Platform enhancements should integrate biometric monitoring enabling adaptive session duration, guided meditation audio through smart contract licensing, shared VR experiences fostering social connection, and therapeutic prescriptions integrating with electronic health record systems. Scalability improvements require Layer-2 migration deploying smart contracts on Polygon or Arbitrum reducing transaction costs by 90-95%, content delivery network integration combining IPFS decentralization with CDN edge caching, and geographic expansion partnering with nature videographers globally targeting 100 locations across 6 continents. Research agenda should investigate comparative effectiveness meta-analysis comparing VR nature therapy to actual outdoor exposure, authenticity and efficacy controlled trials comparing blockchain-verified authentic footage to computer-generated environments, and blockchain transparency effects experimental studies examining how transparency impacts therapeutic outcomes and platform trust.

CONCLUSION

This research presented EcoTherapistVR, a blockchain-enabled decentralized platform for immersive VR nature therapy, addressing accessibility limitations of current mental health interventions. Proof-of-concept implementation successfully integrated Ethereum blockchain, IPFS decentralized storage, and Unity-based VR application, demonstrating technical feasibility. Technical validation confirmed acceptable performance: blockchain transaction latency averaged 2.3 seconds, IPFS content retrieval initialized within 1.8 seconds, and VR rendering maintained smooth 72 FPS. User experience testing with 40 participants yielded exceptional usability scores ($SUS\ mean = 94.81$, Grade A+), significantly exceeding targets. The system establishes sustainable creator economy where videographers capturing authentic nature footage receive automated compensation (80% revenue share) via smart contracts, incentivizing content library growth. Blockchain transparency enables users to verify content provenance and creator payments, building trust absent in centralized systems. While proof-of-concept does not measure clinical therapeutic efficacy, preliminary indicators are promising: participants rated stress reduction 8.7/10 and relaxation quality 9.1/10, with 93% expressing willingness to use regularly. These findings justify future randomized controlled trials examining therapeutic outcomes for specific mental health conditions.

Key contributions include novel blockchain-VR integration architecture for healthcare, implementation demonstrating IPFS-blockchain synergy for high-bandwidth media distribution, reusable smart contract framework for content tokenization and automated creator compensation, and empirical evidence that blockchain complexity can be successfully abstracted maintaining excellent usability. EcoTherapistVR represents foundation for next-generation mental health platforms combining evidence-based therapeutic interventions with decentralized technology infrastructure ensuring sustainability, transparency, and accessibility. Future work should conduct clinical validation studies, enhance platform with biometric integration and guided meditation features, migrate to Layer-2 blockchain for improved scalability, and expand global content library through international creator partnerships. The convergence of Virtual Reality immersive experiences, blockchain decentralized infrastructure, and

nature-based mental health interventions offers promising pathway toward equitable, accessible, and evidence-based therapeutic care addressing the global mental health crisis.

Declarations

This study was approved by the Ethics Review Committee of NSBM Green University, Mahenwatta, Pitipana, Homagama, Sri Lanka. All participants provided informed consent prior to their involvement in the study, and the research was conducted in accordance with the ethical standards of the institution.

Acknowledgements

The authors express sincere gratitude to the 40 participants who voluntarily contributed their time and engagement to the user experience evaluation study. Their feedback and insights were invaluable in validating the usability and therapeutic potential of the EcoTherapistVR platform. The authors also acknowledge the five natural environments across Sri Lanka — Dunhinda Falls, Sinharaja Rainforest, Adam's Peak, Mirissa Beach, and Horton Plains — whose authentic landscapes form the therapeutic content foundation of this platform.

Content capture was conducted using the Insta360 ONE X2 camera and Zoom H3-VR ambisonic microphone, and VR performance evaluation was carried out on the Oculus Quest 2 headset. Smart contract development, testing, and deployment were facilitated through the Ethereum Sepolia testnet, Hardhat development framework, and Pinata IPFS pinning service. Post-processing was performed using Insta360 Studio and DaVinci Resolve. The author declare that no external funding was received for this research.

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Figures

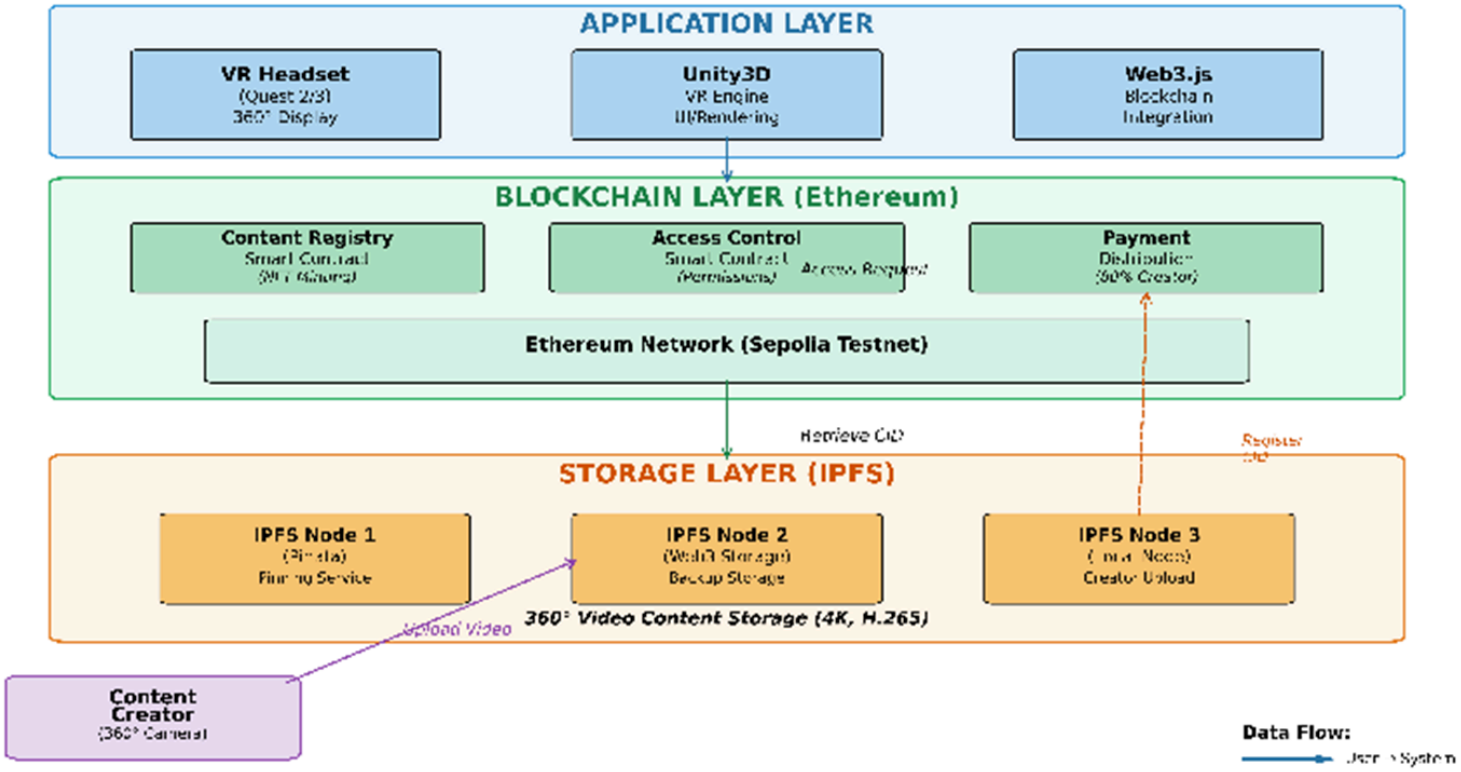


Figure 1

EcoTherapistVR System Architecture

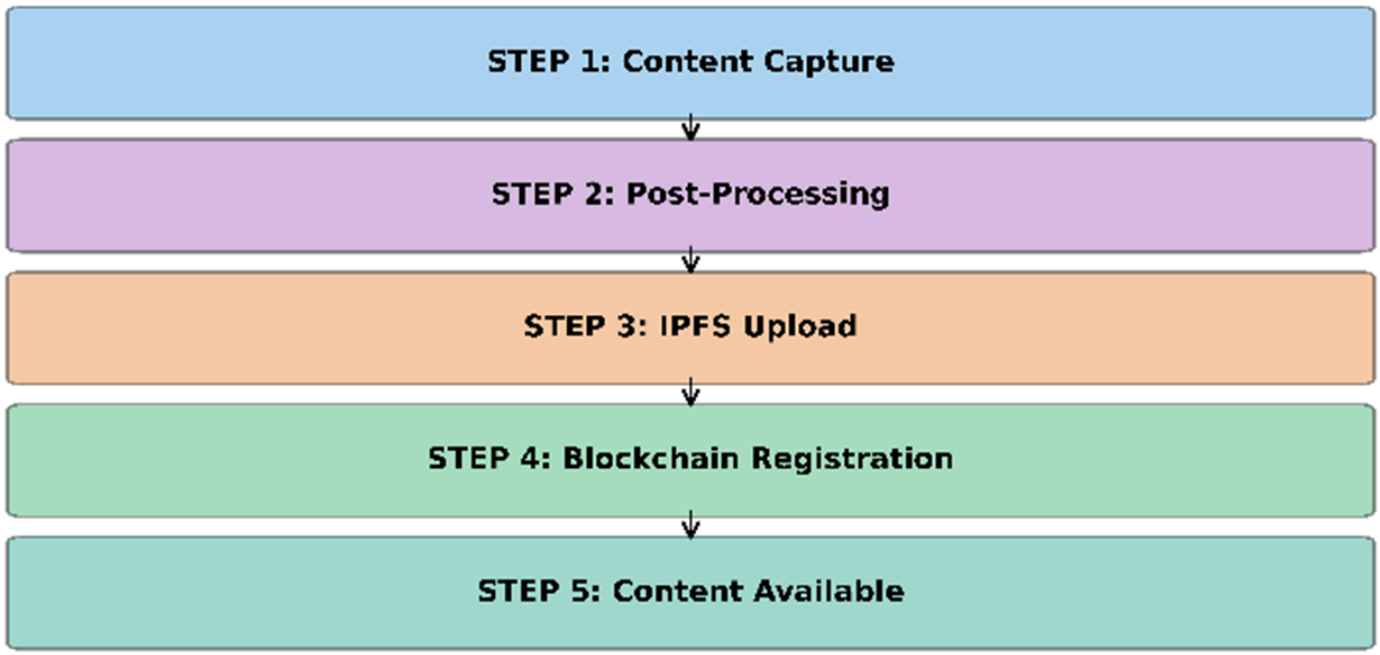


Figure 2

Content Upload and Registration Workflow Diagram

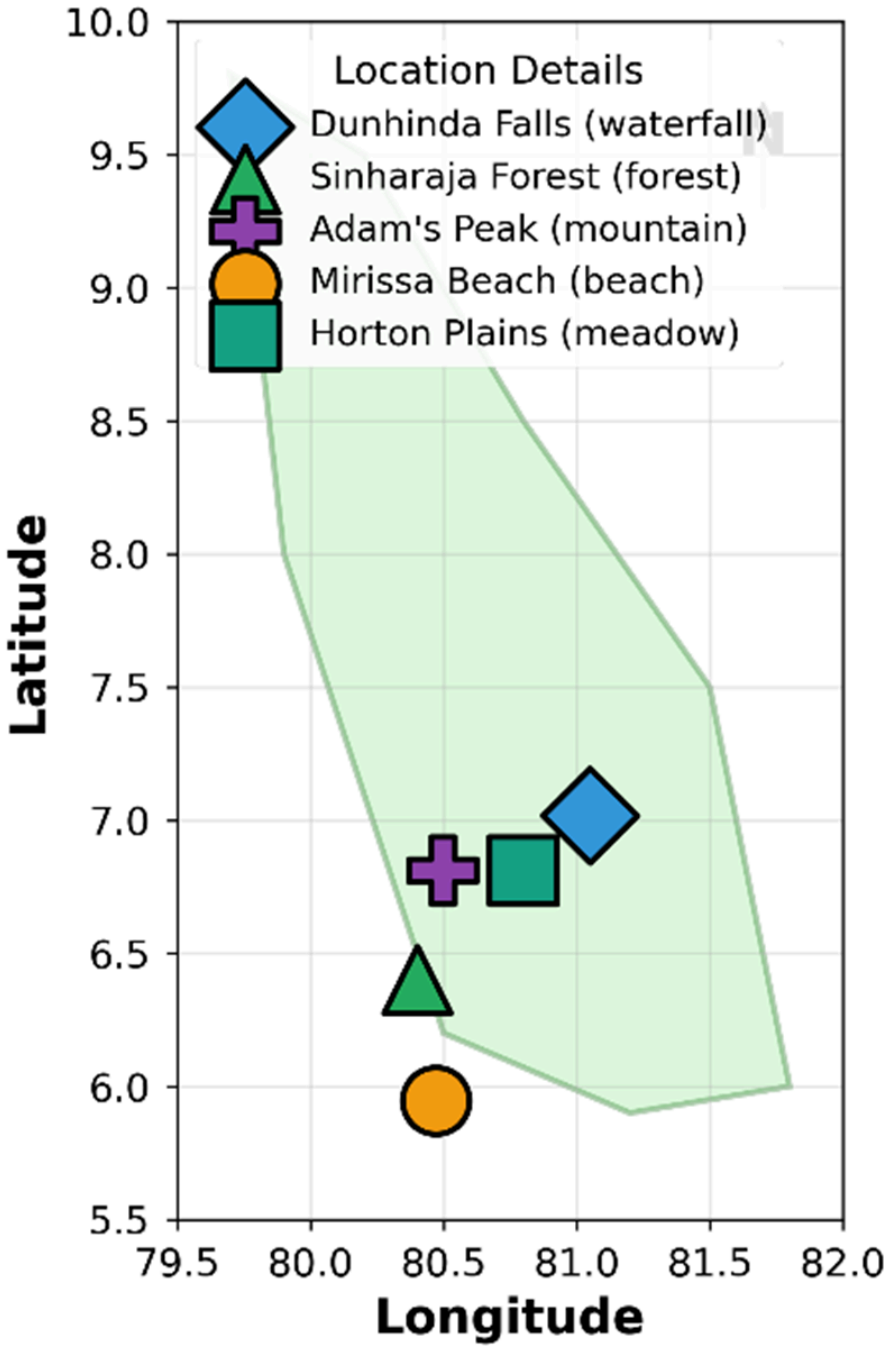


Figure 3

Proposed Content Capture Locations across Sri Lanka

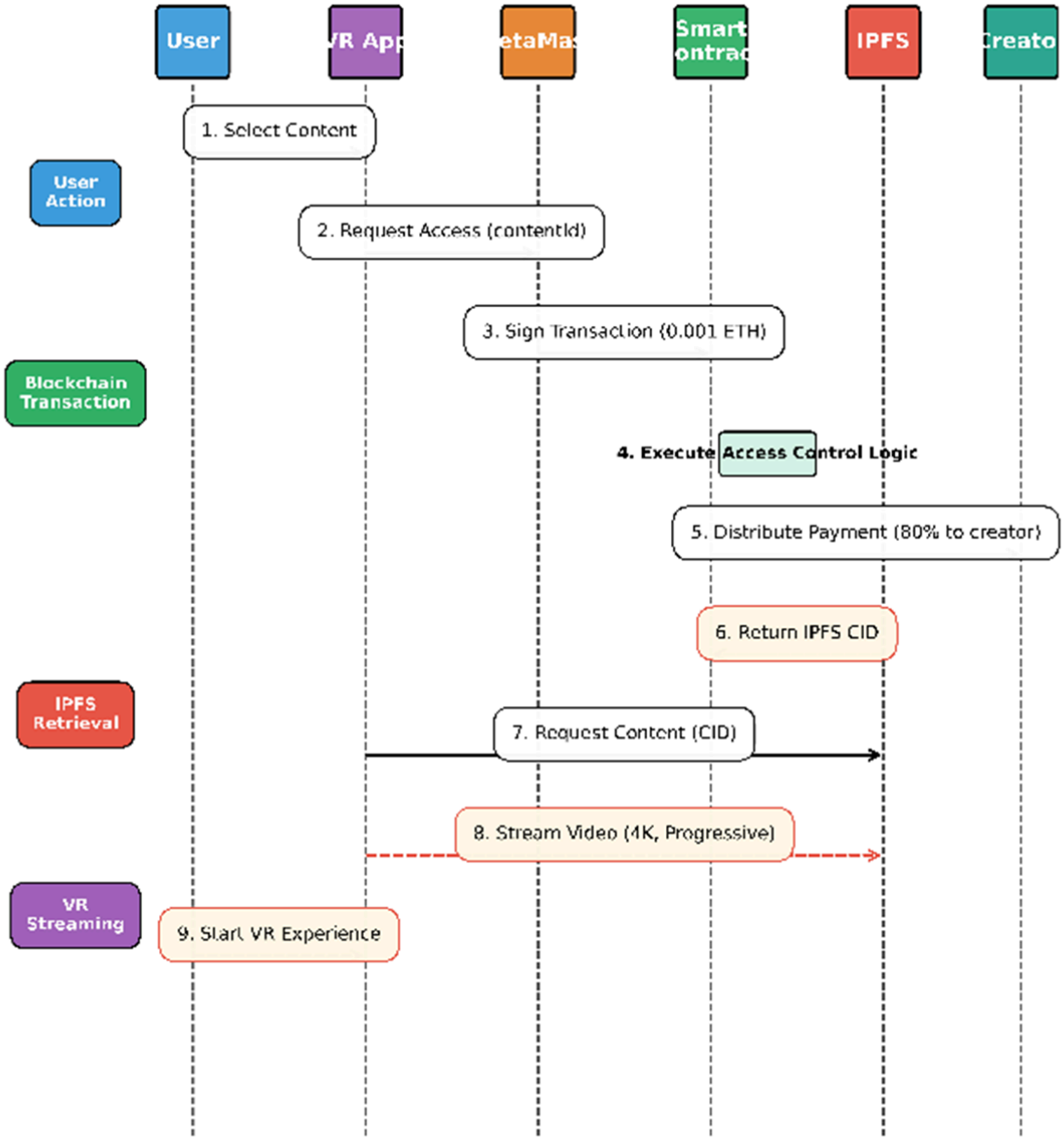


Figure 4

Transaction Sequence Diagram

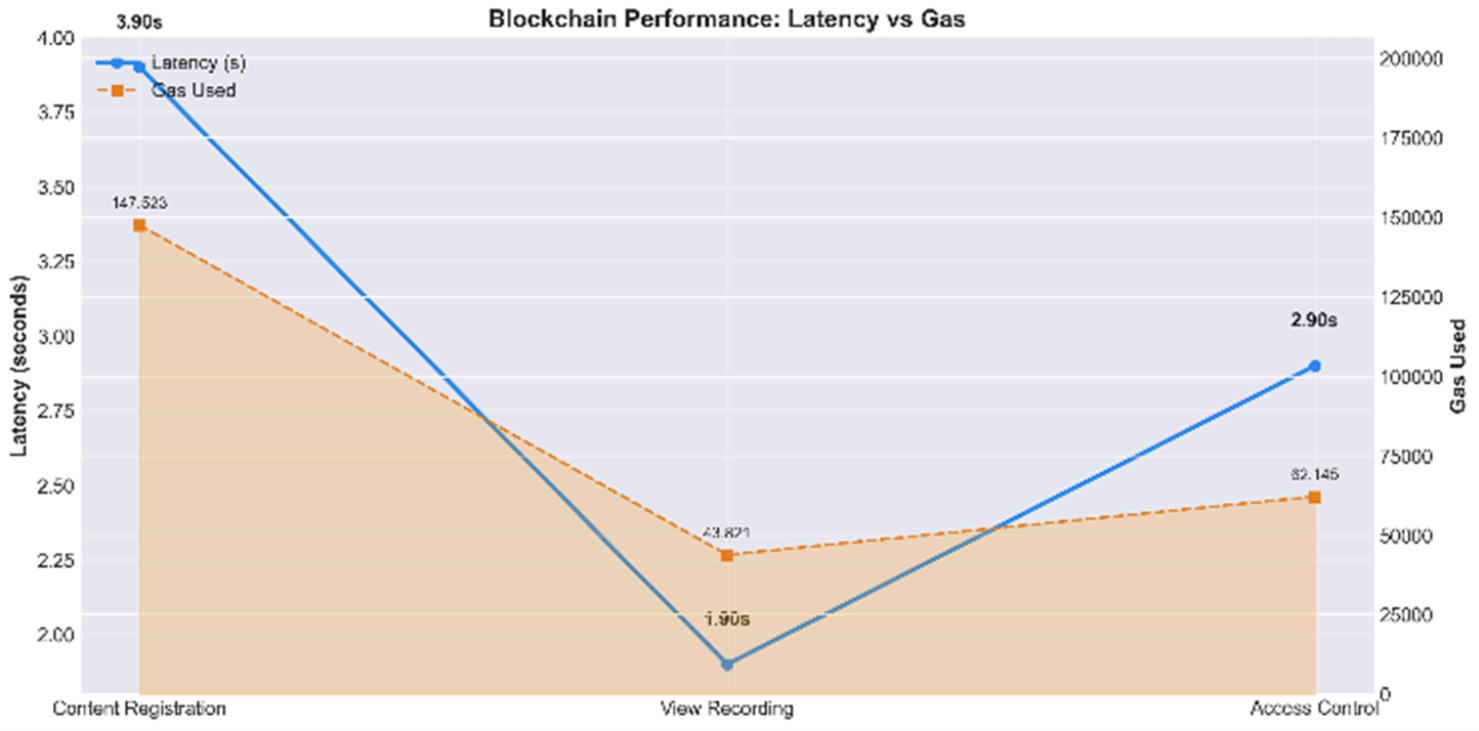


Figure 5

Blockchain Performance Diagram

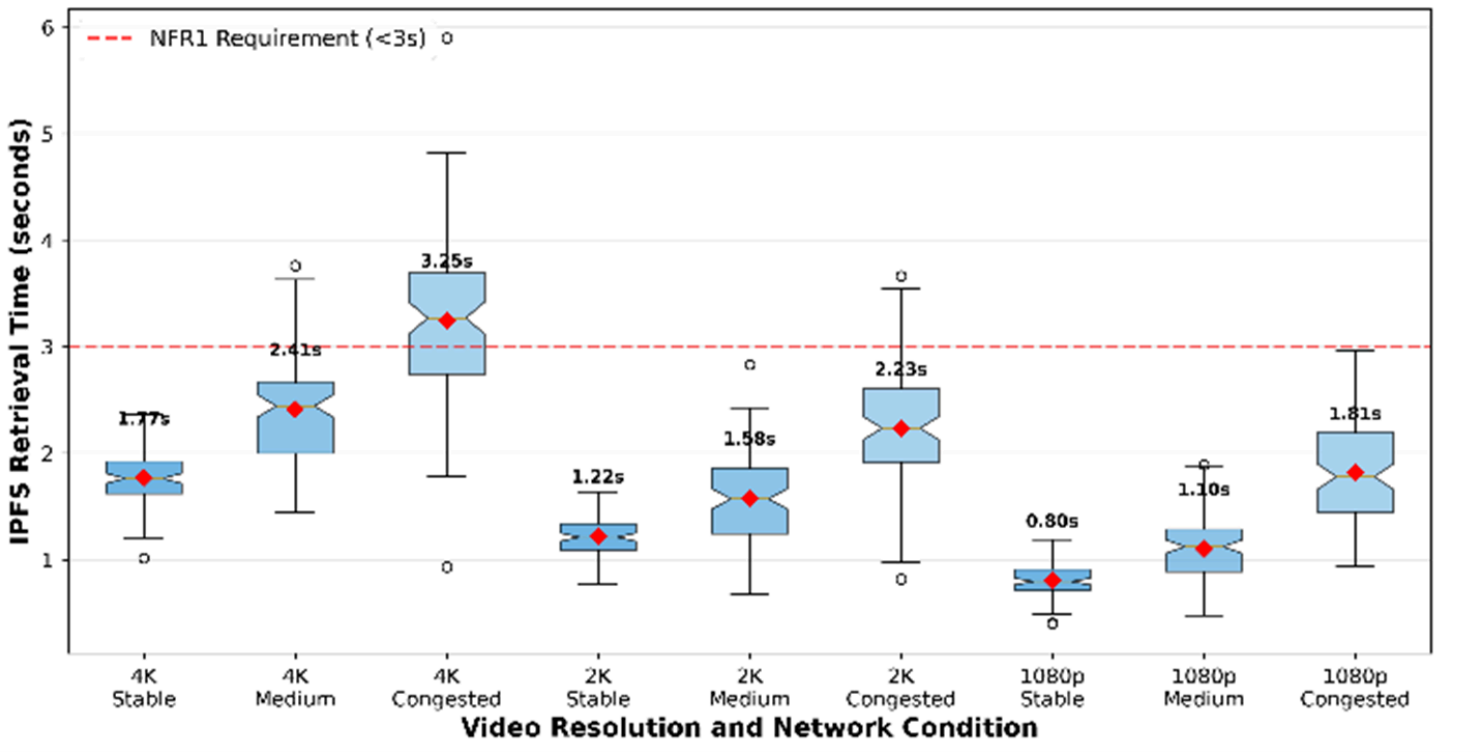


Figure 6

IPFS Performance Comparison Chart

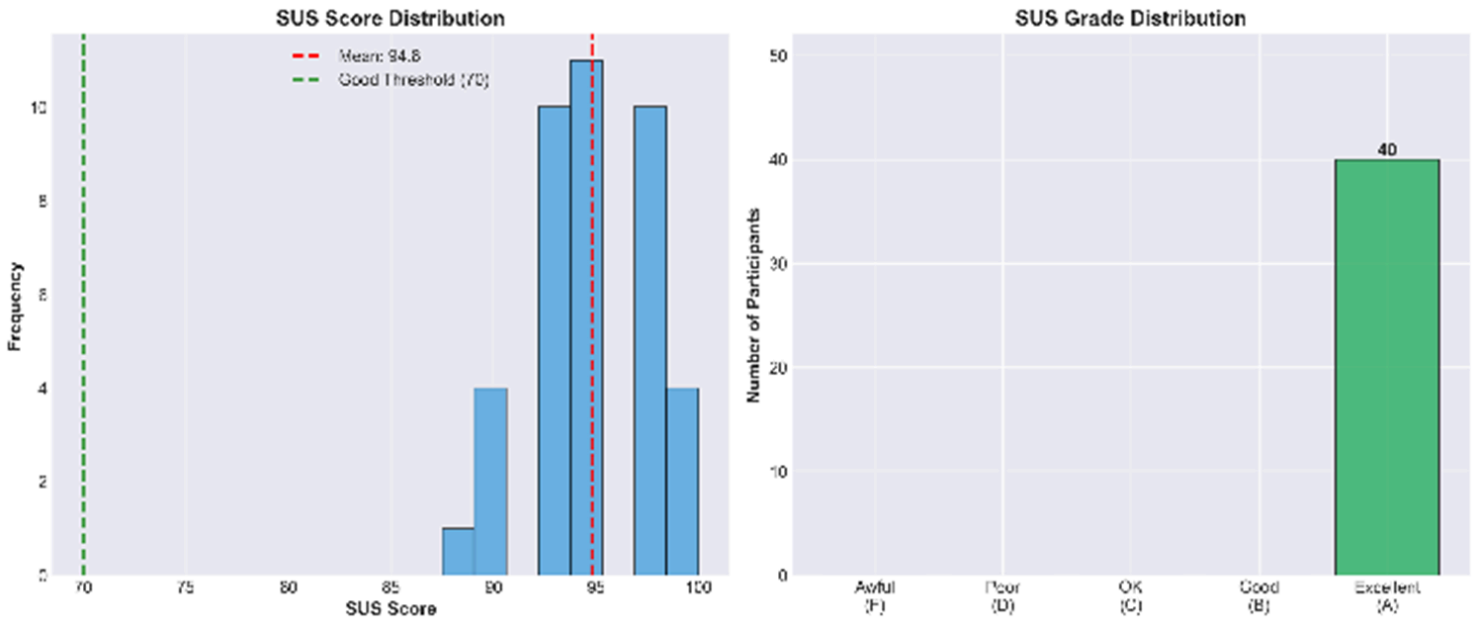


Figure 7

SUS Score Distribution Histogram

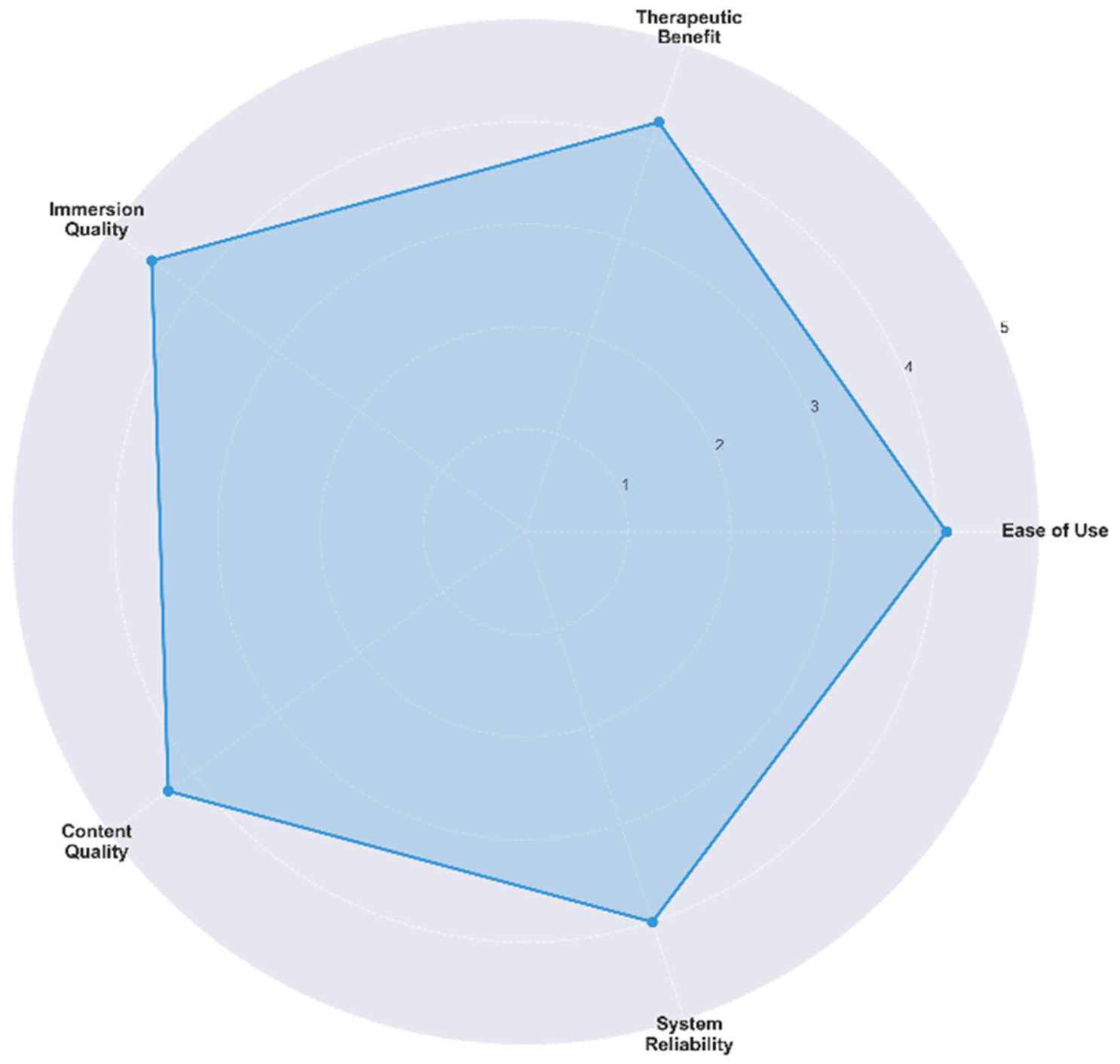


Figure 8

System Improvement Analysis Visualization

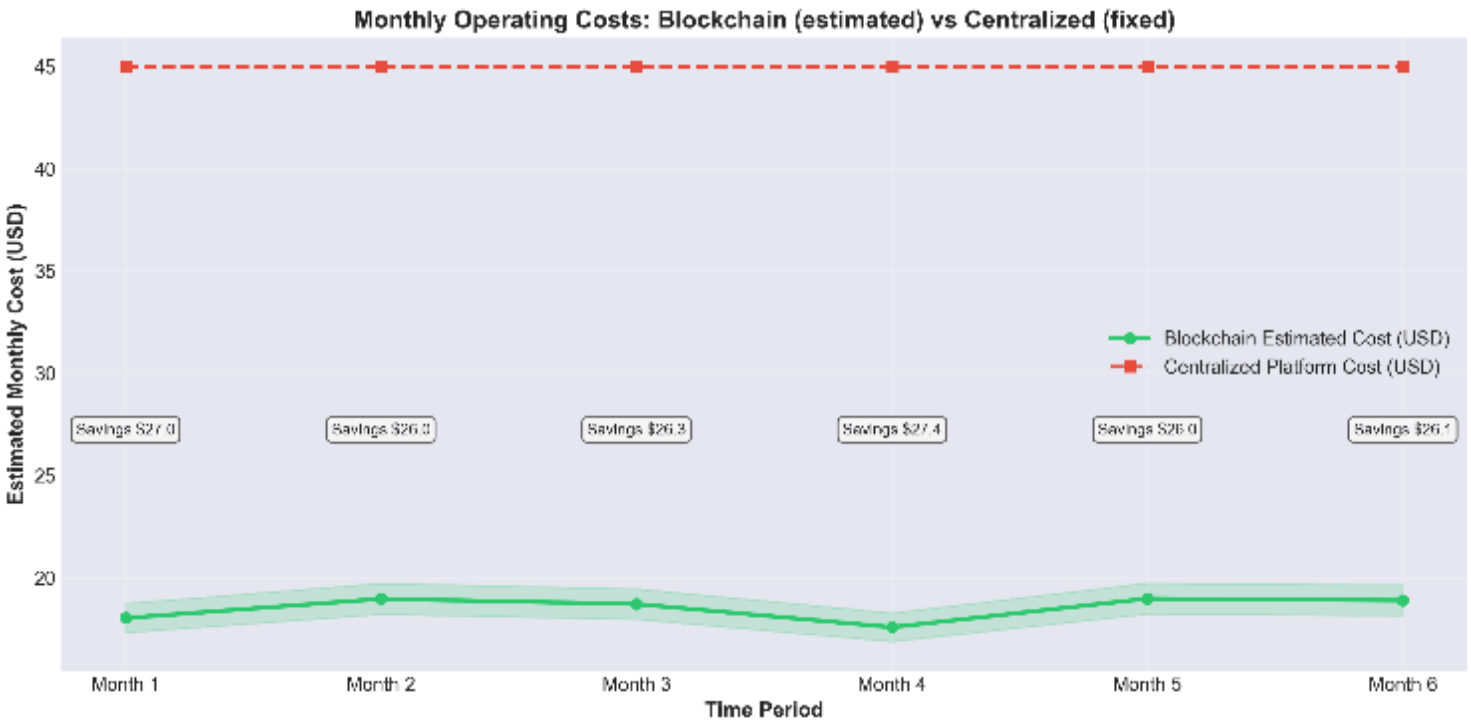


Figure 9

Expected Monthly Operating Costs