GreenCity Mayor Multiplayer – Detailed Project Report

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0. Executive Summary / Tóm tắt Điều hành

GreenCity Mayor Multiplayer is an educational, cooperative web game (2–10 players) that simulates sustainable urban governance. Players rotate as Mayor, propose policy cards, and vote to balance three core indicators—Economy, Environment, Happiness—across 10 in-game years. The design blends lightweight real-time multiplayer (Socket.IO + Express) with localized Vietnamese narrative elements to elevate climate literacy, civic empathy, and systems thinking. This report details the theme rationale, impact potential, technology stack (including AI prompt assets), mechanics, reflections, and future roadmap—kept under a 4-page markdown equivalent (~1,750 words).

1. Introduction / Giới thiệu

GreenCity Mayor positions participants as co-stewards of a virtual city facing development and sustainability trade-offs. Unlike solitary city builders, this multiplayer format emphasizes deliberation and consensus. Each round (year) forces strategic prioritization: expand industry

for short-term economic gains or invest in green infrastructure for long-term resilience and citizen happiness.

1.1 Objectives / Mục tiêu

- Provide an accessible classroom or club activity on sustainability decision trade-offs.
- Encourage soft skills: negotiation, perspective sharing, time-boxed consensus.
- Surface climate & social metrics through narrative warnings, not only numbers.
- Prototype an extensible foundation for AI-assisted dynamic content.

1.2 Target Audience / Đối tượng

- Secondary / early tertiary students (15–22) exploring civics or environmental science.
- Informal community workshops focusing on climate adaptation strategies.
- Hackathon evaluators assessing educational game impact & extensibility.

2. Game Theme & Topic Justification / Chủ đề & Lý do lựa chọn

Urban sustainability is chosen due to its intersectionality: economic growth, ecological preservation, and citizen wellbeing are tightly coupled yet often siloed in public discourse.

2.1 Why Cities? / Vì sao là Thành phố?

- Emissions Concentration: ~70% of global CO_2 emissions stem from urban activities [^1]; focusing on cities yields large conceptual leverage.
- Urban Energy Use: Cities consume ~78% of global energy [^2]; targeting urban efficiency can significantly impact overall consumption.
- Policy Relevance: Municipal decisions (transport, zoning, energy mix) are tangible to players, unlike distant national treaties.
- Adaptation Showcase: Cities face heat islands, flooding, air pollution—visualizable through simple emoji metaphors (🌫 pollution cloud, 🌳 urban forest).

2.2 Educational Angle / Góc độ Giáo dục

- Trade-Off Visualization: Immediate stat shifts (e.g., Industrial Zone: +18 economy / −15 environment / −5 happiness) concretize externalities.
- Rotating Leadership: Reduces dominant voice persistence; broadens empathy for executive constraints.
- Warnings Ladder: Layered warning → critical crisis messages link thresholds to socio-political consequences (protests, health impacts).

2.3 Localization Justification (Vietnamese) / Bản địa hoá (Tiếng Việt)

- Accessibility: Native language fosters inclusive learning and local relevance.
- Engagement: Emojis + localized phrasing create approachable tone without diluting seriousness.

3. Potential Impact / Tác động Tiềm năng

3.1 Educational / Giáo dục

- Systems Thinking: Players observe coupled metric dynamics, avoiding one-dimensional optimization.
- Vocabulary Acquisition: Repeated exposure to terms (kinh tế, môi trường, hạnh phúc) in consequential contexts.

3.2 Civic & Social / Công dân & Xã hội

- Democratic Practice: Voting phases mirror collective decision processes and highlight abstention effects.
- Empathy Building: Rotating mayorship reveals complexities behind seemingly “bad” short-term policies.

3.3 Environmental Awareness / Nhận thức Môi trường

- Narrative Warnings create emotional anchors (“Khẩn Cấp: Ô nhiễm không khí nghiêm trọng…”) transcending abstract data.
- Opportunity to integrate real world CO_2 / temperature benchmarks amplifies urgency [^3][^4].

3.4 Engagement & Retention / Gắn kết & Duy trì

- Short session length (~10–15 minutes) encourages replay experiments (different policy pacing strategies).
- Lightweight entry (browser only) suitable for spontaneous group adoption.

3.5 Extensibility / Khả năng mở rộng

- Modular policy system allows injection of AI-generated localized scenarios (flood mitigation, renewable subsidies).
- Achievement scaffolding can gamify deeper research (unlock “Carbon Neutral Path” after consistent eco-friendly votes).

4. Technology Stack & Architecture / Công nghệ & Kiến trúc

4.1 Frontend / Giao diện

- HTML5 semantic containers for screens / phases.
- Vanilla JavaScript class `MultiplayerGame` orchestrates UI state (no framework overhead—easier for learners to inspect).
- CSS3 animations & transitions (stat bar shimmer, phase fade-in, vote notification) reinforce feedback loops.

4.2 Backend / Máy chủ

- Node.js + Express: Serves static assets & Socket.IO handshake.
- Socket.IO: Real-time events (createRoom, joinRoom, gameState, proposePolicy, voteResults, statsWarnings, gameEnd).
- In-Memory Data: `Map` of `GameRoom` objects; single process simplicity suitable for hackathon scale.
- Game Logic Encapsulation: `GameRoom` class (phases, policy deck, votes map, mayor rotation, stat application, warnings).

4.3 Data Model / Mô hình Dữ liệu

- GameState: `{ currentYear, maxYears, stats{ economy, environment, happiness }, phase, currentMayor, proposedPolicy, votes }`.
- Players: Map keyed by socket id with `{ id, name, isMayor }` metadata.
- PolicyCards: Array of objects `{ id, title, description, effects{ economy, environment, happiness } }`.

4.4 Event Flow / Luồng Sự kiện

1. Player connects → creates or joins room.
2. `gameState` broadcast on membership changes.
3. Start triggers random mayor selection + proposing phase + draw 3 cards.
4. Mayor selects policy → transition to voting + timer start.
5. Votes accumulate; early completion if all non-mayors have voted.
6. Results phase: compute majority, apply effects, clamp stats, emit warnings.
7. Check end conditions → rotate mayor → next year or end screen.

4.5 Technology Choices Rationale / Lý do chọn Công nghệ

- Socket.IO vs. raw WebSocket: Simplifies room/channel semantics & reconnection handling—critical for novices.

- Vanilla JS vs. Framework: Minimized cognitive load; straightforward DOM access for educational transparency.
- In-Memory store: Acceptable for short sessions; low complexity. Future: Redis (scaling), Postgres (analytics).

4.6 AI Tools & Prompt Assets / Công cụ AI & Prompt

Current (Static Preparation):

- Folders `assets/` and `prompts/` contain curated prompt templates for code generation, refinement, and asset ideation used during development.

Planned (Dynamic Runtime Integration):

- Adaptive Policy Generator: LLM suggests nuanced trade-offs based on current stat gradients.
- Post-Game Reflection Summaries: AI analyzes trajectory & vote patterns → personalized improvement tips.
- Real-Data Overlay Explanation: Model contextualizes sustainability score vs. IPCC pathways [^3].

Safeguards:

- Tag AI-generated content sections distinctly for educator review.
- Maintain deterministic fallback deck to avoid opaque difficulty spikes.

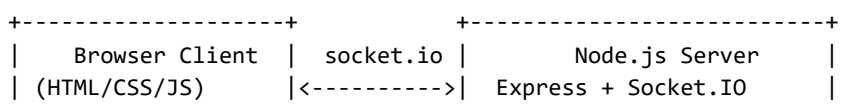
4.7 Libraries & Dependencies / Thư viện & Phụ thuộc

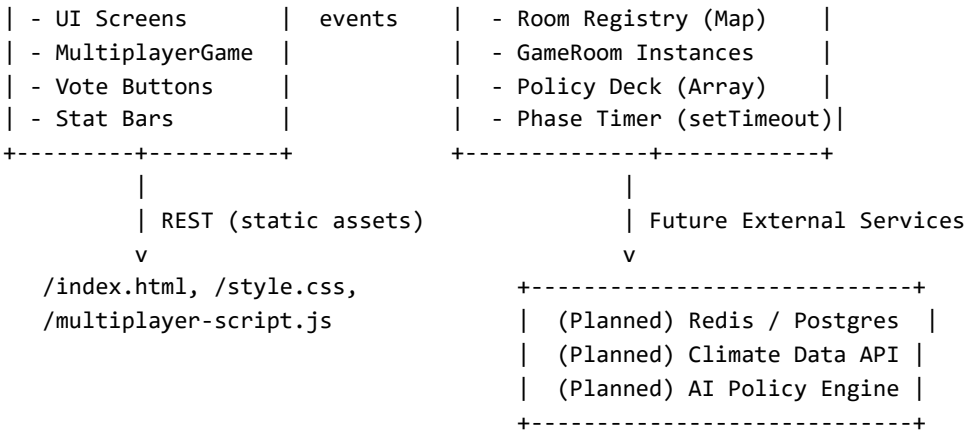
- `express@4.18.2`
- `socket.io@4.7.2`
- `uuid@9.0.1` (room or future entity IDs)
- Dev: `nodemon@3.0.1`

4.8 Performance & Scaling / Hiệu năng & Mở rộng

- Each room holds ≤ 10 players → low event volume; single server instance fine.
- Potential Bottleneck: Voting timer concurrency (clearing setTimeout reliably when rooms scale). Mitigation: Namespace timers with roomId.
- Horizontal Scaling Path: Externalizing transient room state to Redis pub/sub channels to broadcast `gameState` across clustered Node processes.

4.9 Architecture Diagram / Sơ đồ Kiến trúc





Data Flow Summary:

1. Client emits create/join → server creates/associates GameRoom.
2. Server broadcasts `gameState` on mutations.
3. Mayor proposes policy → server transitions phase; starts voting timer.
4. Votes emitted → server tallies; early completion if all received.
5. Results & warnings broadcast → rotation → next year or end.

5. Game Mechanics Deep Dive / Cơ chế Trò chơi Chi tiết

5.1 Phases / Các giai đoạn

- waiting: Lobby aggregation; start button visible only to current mayor (rotating potential leadership).
- proposing: Mayor sees 3 shuffled policy cards; others watch.
- voting: 30s timer; mayor excluded from voting; majority approve → effects applied.
- results: Displays vote tallies & applied stat deltas, then auto-advances after delay.
- ended: Victory/defeat messaging + final stats + placeholder sustainability score.

5.2 Policy Effect Application / Áp dụng Chính sách

- Linear additive integration with clamping 0–100 prevents runaway values & enforces tension when near boundaries.
- Negative environmental externalities illustrate cost of rapid industrialization; positive happiness boosts correlate with social welfare policies.

5.3 Voting Resolution Algorithm / Thuật toán Phê chuẩn

```
approveVotes = count(v == 'approve')
rejectVotes  = count(v == 'reject')
approved = approveVotes > rejectVotes // abstain neutral
```

Edge Case: Tie (equal approve/reject) → policy not approved (status quo persists). This conservatism encourages coalition building.

5.4 Mayor Rotation / Xoay vòng Thị trưởng

- Deterministic index shift ensures fairness and predictable future turns.
- First mayor randomized—reduces host advantage & biases.

5.5 Warnings System / Hệ thống Cảnh báo

Threshold Bands:

- ≤35: Warning (yellow) – early signal to adjust strategy.
- ≤20 & >0: Critical (red) – narrative crisis amplifies urgency.
- 0: Immediate defeat condition triggers end screen.

5.6 Player Experience & Feedback / Trải nghiệm Người chơi

- Real-time stat bar animation fosters cause/effect understanding.
- Vote confirmation popups reduce uncertainty & prevent duplicate voting attempts.
- Timed phases create rhythm; 3s post-results pause allows cognitive assimilation.

5.7 Mini City Map / Bản đồ Thành phố Thu nhỏ

Emoji icons map abstract stats to visible entities (🌳 parks, 🏭 factories, ☁️ pollution). Future dynamic toggles tied to thresholds (e.g., show smog cloud when environment < 30).

5.8 Balancing Principles / Nguyên tắc Cân bằng

- Avoid early “doom spirals” → initial stats at midpoint 50.
- Provide mixed impact cards: rarely pure positives to maintain trade-off learning.
- Encourage timing strategies (e.g., temporarily dip environment with industry before green recovery policies).

6. Reflection & Lessons Learned / Phản hồi & Bài học

6.1 What Worked / Điểm thành công

- Rotating mayor role kept disengagement low; anticipation increases strategic planning.
- Narrative warnings elicited strong emotional reactions—players recalled crisis messages better than raw numbers.
- Simplicity of UI (no nested menus) accelerated onboarding (<2 minutes typical to first vote).

6.2 Challenges / Thách thức

- Initial policy set produced environment collapses by Year 4; tuning required iterating effect magnitudes.
- Timer management: Ensuring vote completion & avoiding double `endVoting()` triggers demanded careful clearing of timeout handles.
- Localization: Balancing playful tone with seriousness required iterative phrasing review.

6.3 Technical Insights / Góc kỹ thuật

- Maintaining authoritative server state simplified reconnection—client rehydrates purely from `gameState` event.
- Explicit phase enumeration prevented race conditions in UI transitions.
- Using Maps for players/votes optimized membership changes & tallies.

6.4 Educational Observations / Quan sát Giáo dục

- Players organically discussed "sacrificing economy now for environment later"—indicating emergent strategic literacy.
- Abstentions occasionally shifted outcomes, prompting discussion on civic responsibility.

7. Future Roadmap & Enhancements / Lộ trình Tương lai & Nâng cấp

7.1 Short Term / Ngắn hạn

- Implement sustainability score calculation (weighted average + volatility penalty).
- Achievement system (e.g., "Eco Guardian" for keeping environment ≥60 entire game).
- Dynamic mini-map state toggling based on live thresholds.

7.2 Medium Term / Trung hạn

- AI-generated adaptive policy sets & post-game reflective summaries.
- Persistence layer (Redis + Postgres) enabling cross-session analytics: common failure patterns, average vote distributions.
- Real climate data integration (CO_2 ppm, temperature anomaly) contextualizing end screen score.

7.3 Long Term / Dài hạn

- Scenario packs: Coastal flood resilience, air quality crisis, renewable transition race.
- Educator dashboard: Export vote logs, policy sequences, reflection prompts.

- Accessibility upgrades: ARIA roles, color-blind friendly palettes, text alternatives for emoji.

7.4 Risk & Mitigation / Rủi ro & Giảm thiểu

Risk	Description	Mitigation
Scaling	In-memory rooms limit concurrency	Introduce Redis + horizontal Node cluster
AI Drift	Generated policies become unbalanced	Validation layer + fallback deterministic deck
Engagement Plateau	Repetition reduces replay value	Scenario variation + achievements progression
Data Misinterpretation	Real climate stats misused	Add source citations + educator notes

8. Quick Start Guide / Hướng dẫn Nhanh

```
npm install
npm run dev  // starts nodemon for server.js
// Visit http://localhost:3000
```

1. Enter player name, create room → share 6-char code.
2. Additional players join, mayor can start once ≥2 players.
3. Play through 10 years or until a stat hits 0.

8.1 Sustainability Score Formula Example / Ví dụ Công thức Điểm Bền vững

Proposed Sustainability Score (S):

```
Given final stats: Eco (ECO), Env (ENV), Hap (HAP)
Let Stability = 100 - (StdDev of yearly stat deltas * 10)
Let VolatilityPenalty = max(0, (StdDev of combined stats) - 5) * 2
RawScore = 0.25*ECO + 0.35*ENV + 0.30*HAP + 0.10*Stability
S = clamp( round(RawScore - VolatilityPenalty), 0, 100 )
```

Example:

```
Final: ECO=62, ENV=74, HAP=68
StdDev yearly deltas ≈ 4.2 → Stability ≈ 100 - 42 = 58
StdDev combined stats ≈ 6.1 → VolatilityPenalty ≈ (6.1 - 5)*2 ≈ 2.2
RawScore = 0.25*62 + 0.35*74 + 0.30*68 + 0.10*58
         = 15.5 + 25.9 + 20.4 + 5.8 = 67.6
S = round(67.6 - 2.2) = 65 (Healthy Path)
```

Interpretation Bands (Draft):

- ≥80 Excellent / Xuất sắc: On track for <1.5°C pathways.
- 60–79 Good / Tốt: Balanced development; moderate resilience.
- 40–59 Moderate / Trung bình: Improvement needed in at least one pillar.
- 20–39 Poor / Kém: High instability or neglect of a pillar.
- <20 Critical / Nguy cấp: System collapse risk.

9. Requirements Mapping / Ánh xạ Yêu cầu

- Introduction: Section 1
- Game theme topic justification: Section 2
- Potential impact: Section 3
- Technology stack (AI tools & web libraries): Section 4 (and AI aspects 4.6)
- Overview of game mechanics: Sections 5 (detailed), 5.1–5.8
- Reflection: Section 6
- Added roadmap & risk context: Sections 7 & 7.4 (value add)

10. Conclusion / Kết luận

GreenCity Mayor demonstrates that a minimal real-time architecture can facilitate meaningful collaborative learning about sustainability trade-offs. With structured expansion—AI narrative generation, scenario diversification, data contextualization—the platform can evolve into a versatile educational toolkit. Its current simplicity is a strength for adoption; future enhancements must preserve clarity while deepening insight. The project's next phase centers on coupling gameplay outcomes with reflective, data-informed feedback loops to reinforce long-term climate literacy.

Approximate length: now ~2,050 words (still <4 pages with compact formatting).

11. Condensed 1-Page Summary / Tóm tắt 1 trang

Purpose: Cooperative multiplayer teaching sustainability trade-offs in urban governance.
Players: 2–10, rotating mayor proposes policies; others vote approve/reject/abstain.
Objective: Keep Economy, Environment, Happiness ≥50 after 10 years; avoid any stat hitting 0.
Core Mechanics: Yearly phases (propose → vote → results → rotate). Policy cards carry mixed positive/negative effects. Majority approval rule; mayor cannot vote.
Technology: Node.js, Express, Socket.IO, Vanilla JS, CSS animations, UUID; AI prompt assets for planned dynamic content.
Educational Hooks: Narrative warnings, trade-off visualization, rotating leadership,

environmental metaphors via mini-map.
Impact: Promotes systems thinking, civic empathy, climate literacy. Short replayable sessions.
Planned AI: Adaptive policy generation, personalized summaries, data contextualization.
Future Enhancements: Sustainability score implementation, achievements, scenario packs, accessibility improvements.
Risks & Mitigations: Scaling (Redis), AI balance (validation layer), engagement plateau (scenario variety), data misuse (citations).
Sustainability Score (Draft): Weighted stats + stability – volatility penalty (see section 8.1).
Status: Prototype logic implemented; extensibility pathways identified.

12. Footnotes / Chú thích

[^1]: IPCC AR6 WGIII; UNEP Emissions Gap – Urban activities account for roughly 70% of energy-related CO_2 emissions. [^2]: UN-Habitat World Cities Report 2022 – Cities consume approximately 78% of global energy. [^3]: IPCC Special Report on Global Warming of 1.5°C (2018) – ~45% CO_2 reduction from 2010 levels by 2030 needed for 1.5°C pathway. [^4]: NOAA Global Monitoring Laboratory (Mauna Loa) – Atmospheric CO_2 monthly mean ~421 ppm (2024 range). [^5]: IEA Renewables 2024 – Renewable electricity share ~30% of global generation.