TerraData

Brainstorming & Scenario Storytelling

Game Title: TerraData: Sustainable Frontier

Concept: A single-player, browser-based simulation game where the player manages a farm in a climate-vulnerable region. The core gameplay loop involves making weekly decisions on irrigation, fertilization, and livestock management based on interpretations of simplified, real NASA satellite data. The goal is to maximize yield and profit while achieving a high "Sustainability Score" that measures water efficiency, soil health, and carbon footprint.

Scenario (Storytelling):

- **Setting:** The player inherits a struggling farm in the American Southwest (e.g., Arizona), a region facing increasing water scarcity and temperature stress.
- **Character:** An early-career farmer mentored by "Dr. Vega," a retired NASA agronomist who communicates via a tablet interface in the game. Dr. Vega introduces the player to the power of "looking at the farm from space."
- **The Challenge:** The first season is a tutorial. A heatwave is forecast. Dr. Vega guides the player to the **Data Tablet** in the game's UI.
    1. **Data Interpretation:** The player pulls up a simplified, color-coded map of their field based on real MODIS NDVI data. It shows patches of yellow (moderate stress) emerging.
    2. **Decision:** Dr. Vega explains that yellow could mean water stress or a nutrient deficiency. The player checks the **Soil Moisture Dashboard**, which uses historical SMAP data to show critically low moisture levels in the yellow areas.
    3. **Action:** Instead of flooding the entire field (a costly and wasteful action), the player uses a drag-to-select tool to apply precision irrigation *only* to the stressed zones, saving 40% of the water they would have used.
    4. **Consequence:** A week later (next game turn), the NDVI map updates. The precisely irrigated areas have returned to a healthy green. The player's

water usage metric remains low, and their sustainability score increases. They have successfully averted a yield loss and learned the value of data-driven intervention.

- **Progression:** As the player advances, scenarios become more complex: managing a balanced fertilizer schedule using nitrogen index maps, rotating livestock pastures based on pasture health data, and responding to extreme weather events forecast by GPM data. The game culminates in a "Sustainability Certification" if the player can maintain high yields with elite resource efficiency.

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1. Software Development Plan (SDP)

Project Title: TerraData: Sustainable Frontier - Educational Game
Version: 1.0
Date: October 26, 2023

1. Introduction:
This document outlines the plan for developing a browser-based educational game that integrates NASA open data to simulate and teach sustainable farming practices.

2. Project Objectives:

- **Educational:** Teach players how to interpret satellite data (NDVI, Soil Moisture, Precipitation) for agricultural decision-making.
- **Behavioral:** Encourage adoption of sustainable practices (precision irrigation, variable rate fertilization).
- **Technical:** Successfully integrate NASA APIs (GIBS, Worldview, EARTHDATA) into a responsive, offline-capable game engine.

3. Scope:

- **In-Scope:** Single-player campaign mode, three core mechanics (irrigation, fertilization, livestock), integration of 3 NASA data sets (MODIS/NDVI, SMAP, GPM), offline functionality via PWA, web-based deployment.
- **Out-of-Scope:** Multiplayer features, real-time data streaming (game will use pre-fetched and cached historical data sets), mobile app development (though

PWA will be mobile-friendly).

4. Development Methodology:
Agile-Scrum methodology with two-week sprints. This allows for iterative development and constant integration of NASA data feedback.

5. Team Structure & Responsibilities:

- **Project Manager:** Oversees timeline, budget, and stakeholder communication.
- **Game Designer:** Creates game mechanics, story, and UI/UX flow.
- **Full-Stack Developer (x2):** Implements front-end (game engine) and back-end (data API integration).
- **Data Scientist:** Processes and simplifies NASA data feeds into game-ready formats.
- **QA Tester:** Validates gameplay, data accuracy, and educational outcomes.

6. Project Timeline & Milestones:

- **Phase 1: Pre-Production (Weeks 1-4):** Finalize SRS, BRD, select game engine (Phaser.js or Unity WebGL), establish data pipeline.
- **Phase 2: Core Development (Weeks 5-16):**
  - Sprint 1-2: Build core game loop & farm simulation model.
  - Sprint 3-4: Integrate MODIS NDVI data visualization and mechanics.
  - Sprint 5-6: Integrate SMAP soil moisture data and precision irrigation.
  - Sprint 7-8: Integrate GPM precipitation data and weather event system.
- **Phase 3: Testing & Deployment (Weeks 17-20):** Alpha/Beta testing with target users, PWA optimization, deployment to a cloud platform (AWS/Azure).

7. Risk Management:

- **Risk:** NASA API latency or downtime.
  - **Mitigation:** Heavy caching of data; use of static historical data sets as a fallback.
- **Risk:** Overly complex gameplay alienating target audience.

   - **Mitigation:** Extensive user testing with non-gamers and farmers; progressive disclosure of game mechanics.

8. Budget & Resources:

- **Tools:** GitHub, Trello, Phaser.js/Unity, AWS S3 (for data caching), Google Earth Engine (for data processing).
- **Costs:** Primarily developer salaries and cloud hosting fees. NASA data and APIs are free to use.

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2. UML Diagram

Given the text-based format, I will describe a simplified **Component Diagram** which is most relevant for this system:

```
+--------------------------+
|  Player's Browser        |
| (Game Client - PWA)      |
+--------------------------+
| ▶ [Game UI Module]       |     (1) Fetches simplified, pre-processed
| ▶ [Data Cache (LocalStorage)] |    data from Backend API.
| ▶ [Game Engine Logic]    |      (2) Works offline using cached data.
+--------------------------+
          ▲
          | HTTPS (RESTful API)
          ▼
+----------------------------------------------+
|            Game Server (Backend)             |
+----------------------------------------------+
| ▶ [API Gateway]                              |
|  - Authenticates with NASA EARTHDATA Login   |
|  - Routes requests to appropriate microservice |
| ▶ [Data Proxy & Simplification Service]      | ← (A)
|  - Calls NASA CMR/GIBS APIs                  |
|  - Aggregates temporal/spatial data          |
|  - Converts NDVI values to simple 0-100 scores |
|  - Returns lightweight JSON/PNG to client    |
```

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| ▶ [User Progress Service]                |
|   - Tracks player decisions & sustainability score|
| ▶ [Simulation Model]                    | ← (B)
|   - Calculates crop growth, yield, water impact |
|   - Based on player actions + real satellite data|
+-------------------------------------------+
          ▲
          | (NASA APIs)
          ▼
+--------------------------+
|  NASA Data Sources       |
+--------------------------+
| ▶ GIBS (Tiled Imagery)   |
| ▶ CMR (Metadata Querying) |
| ▶ GPM/SMAP Data Archives  |
+--------------------------+
```

Key: (A) This component handles the heavy lifting of making complex data simple. (B) This component is the "brain" that simulates the farm's reaction to player choices and real data.

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3. Software Requirements Specification (SRS)

1. Functional Requirements:

- **FR1: User Authentication:** The system shall allow users to create an account and save progress.
- **FR2: Data Integration:** The system shall fetch, cache, and display simplified NDVI, soil moisture, and precipitation data from NASA APIs for the player's designated farm region.
- **FR3: Simulation Core:** The system shall simulate crop growth, soil moisture depletion, and yield based on player actions and integrated real-world data.
- **FR4: Action System:** The system shall allow players to perform actions: Precision Irrigation, Variable Rate Fertilization, and Livestock Pasture Rotation.

- **FR5: Educational Feedback:** The system shall provide a post-season report detailing yield, profit, water usage, and sustainability score, with insights on how data-driven decisions improved outcomes.

2. Non-Functional Requirements:

- **NFR1: Performance:** The game interface shall respond to player actions in under 2 seconds, even when fetching data.
- **NFR2: Offline Functionality:** The game shall be playable for up to 7 in-game days without an internet connection by using cached data and queuing actions.
- **NFR3: Usability:** The game shall be intuitive for non-gamers, with a UI that clearly distinguishes between data views and action buttons. It must achieve a System Usability Scale (SUS) score of >75.
- **NFR4: Data Accuracy:** The simplified data presented in-game must correctly reflect the trends of the underlying NASA scientific data.

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4. Business Requirements Document (BRD)

1. Business Objectives:

- Increase awareness and adoption of NASA's open-data platforms within the agricultural community.
- Create a innovative educational tool that can be used by extension services (e.g., USDA), ag universities, and NGOs.
- Improve digital literacy and data interpretation skills among future farmers.

2. Background & Strategic Fit:
The research identifies a clear gap between data availability and farmer adoption. This game directly addresses the barriers of complexity and accessibility, fitting strategically into NASA's Earth Science Education and Application goals.

3. Stakeholder Requirements:

- **Farmers/Students:** "I want to learn how satellite data can help me save water and fertilizer without reading a complex manual."

- **Educators:** "I need a engaging classroom tool that demonstrates the impact of climate and data on agriculture."
- **NASA:** "We need to increase the utilization and impact of our free, open-data resources."

4. Project Features (High-Level):

- Feature 1: Interactive Data Tablet displaying satellite imagery.
- Feature 2: Precision Application Tools for water and fertilizer.
- Feature 3: Sustainability Scoring System.
- Feature 4: Offline Mode.

5. Success Metrics:

- **Adoption:** 10,000 unique players in the first year.
- **Education:** Pre- and post-gameplay quizzes show a 40% improvement in understanding key concepts like NDVI and evapotranspiration.
- **Engagement:** Average session length of >15 minutes.

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5. Test Case

Test Case ID: TC_IRR_01
Test Feature: Precision Irrigation Mechanic
Description: Verify that applying water to a stressed zone (low soil moisture) improves its health (NDVI score).

Preconditions:

1. User is logged in.
2. Game is set to a "Dry Season" scenario.
3. The SMAP soil moisture map shows a specific zone in "red" (low moisture).

Test Steps:

Step	Action	Expected Result
1	Player selects the irrigation tool.	UI enters irrigation mode.

Step	Action	Expected Result
2	Player draws a zone covering only the red area.	Zone is highlighted. Water cost is calculated and displayed.
3	Player confirms the action.	Water resource is deducted. A " irrigation in progress" icon appears.
4	Player advances the game by 3 days.	The NDVI map updates. The previously red zone should now be in yellow or green. The farm's overall "Water Efficiency" metric should be high.

Postcondition: The farm state is saved. The sustainability score has increased.
Status: [ ] Pass [ ] Fail

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6. User Process Flow Explanation

Player: Maria, a college agriculture student.
Goal: Successfully complete the "Summer Drought" scenario.

1. **Login & Load:** Maria opens her browser, goes to `terra-data.game`, and logs in. Her saved farm loads.
2. **Weekly Review:** It's Week 5 of the growing season. A notification pops up: "Heatwave forecast! Check your fields." She clicks her **Data Tablet**.
3. **Data Interpretation:**
    - The tablet opens to a **Color-Coded NDVI Map** of her cornfield. She sees a large yellow patch.
    - She taps the yellow area. A sub-menu opens. She selects "Cross-Reference."
    - She chooses "Soil Moisture" from the list. The view changes to a SMAP-derived map, confirming the same yellow patch is now shown in red, indicating critically dry soil.
4. **Decision & Action:**
    - She closes the tablet and selects the **Precision Irrigation** tool from the main toolbar.

- On the field map, she carefully draws a shape around only the red/yellow zone. The game shows she will use 250 gallons, vs. 800 gallons to flood the whole field.
- She confirms the action. Her water budget decreases by 250.

5. **Consequence & Learning:**
   - She uses the "Simulate 1 Week" button.
   - After the week passes, a notification appears: "Crop Health Improved!" She opens the Data Tablet again. The map now shows the previously problematic area as a healthy, solid green.
   - A pop-up from Dr. Vega appears: "Excellent work, Maria! By using satellite data to target your irrigation, you saved over 500 gallons of water and prevented a 15% yield loss in that section of the field. This is the power of precision agriculture!"
6. **Progression:** Maria's sustainability score increases significantly. She feels a sense of accomplishment and has internalized the concrete value of using soil moisture data to guide irrigation decisions. She is ready for the next, more complex challenge.