Enhancement of Project AEDES

Inception Report for

UNICEF Philippines and UNICEF Digital Public Goods Alliance

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Introduction

Overview

In 2019, the Philippine government declared a national epidemic as it struggled to contain its worst dengue outbreak since 2012. Total cases reached 420,453 and deaths at 1,565, 78% increase in infections and 33% in deaths from 2018. 42% of deaths are children between 5 and 9 years old (Relief Web, 2019) and 2 more kids die of dengue fever in Zambales (Inquirer, 2021).

The battle against dengue epidemic is faced with the following problems:

PROACTIVE CASE DETECTION – There is no existing standardized tool for forecasting case counts and identifying possible vector-borne disease outbreak locations.

LACK OF DATA AVAILABILITY – Dengue data (vector-borne disease data, in general) is not easily accessible, while environmental data (climate, remote sensing) are scattered resources.

LACK OF AVAILABILITY OF OPEN-SOURCE TOOLS – Most tools/scripts are behind paywall, scattered resources or entail steep learning curves.

With manual reporting, release of data is delayed which hampers the health sector's ability to effectively deal with the threat. Prioritizing prevention is essential to mitigate the associated risks of dengue outbreak.

About Project AEDES

Project AEDES was developed in 2019 as a big data early warning and surveillance system for dengue. The system intends to nowcast probable dengue cases and dengue-related deaths using Google Search Trends, precipitation, and temperature readings from climate data. Google Search Trends represent the public interest and panics related to dengue. Moreover, to detect potential mosquito hotspots, the system utilizes FAPAR, NDVI, and NDWI readings from remote sensing. Information derived from such data would help prioritize interventions and resource allocation.

Current State

Since the platform was developed under the NASA International Space Apps Challenge, there are several known limitations and opportunity for enhancements, which includes the following:

- Manual data gathering and preparation
- Unavailability of current data
- Counter-intuitive dashboard for further elaboration
- Unclear policy usage of the information
- Lacks relevance due to limited scope of solution (i.e. dengue)

Objectives of the Project

Following the limitations stated above, the key improvements to the AEDES functionality are:

- Automation of data gathering from various sources, especially weather data which was sourced from an offline source (DOST-PAGASA)
- Addition of new weather, satellite, geospatial and socioeconomic data to enrich dataset
- Enhancing the predictive modeling by adding additional ML algorithms to improve model fitting performance
- Incorporating the INFORM Epidemic Risk Framework with data gathered by AEDES teams to generate location-based risk maps, and advise policy interventions to mitigate the impacts of dengue
- Improvement of User Interface to make it feel more like a consumer utility (e.g. Waze)

Enhanced AEDES Platform

Solutions and Enhancements

FORECASTING	HOTSPOT DETECTION	INFORM RISK MAPPING	OPEN API	PYTHON PACKAGE
• Predict future nunmber of cases/deaths of vector-borne diseases	• Identify locations of possible hotspots for outbreaks	• Map out risk framework using data representing human settlement situation (hazard and exposure, vulnerability, coping capacity)	• Publicly open pre-processed satellite, weather, socioeconomic, and health datasets	• Open source tools used for data collection, feature engineering and automated machine learning.

Technology Stack

Front-end Stack

- **W3-CSS -** Lightweight CSS framework for web-based and mobile-responsive front-end
- **AJAX -** Javascript asynchronous calls to back-end for data updates
- **ChartJS -**Chart data visualization library
- **MapboxJS** - Free tier of popular mapping library

Back-end Stack

- **PHP -** page routing and serving data access requests
- **Python -** perform machine learning (Scikit-Learn) and data analysis (Pandas)
- **PostgreSQL -** store and aggregate data
- **Jupyter -** data analysis and machine learning environment for Python

FRONT-END | BASICS

FRONT-END | FRAMEWORKS

FRONT-END | TOOLS

BACK-END

DATABASE | RDBMS

DEV-OPS | INFRASTRUCTURES

DEV-OPS | DEVELOP

DATA SERVICES

DATA MANAGEMENT SYSTEM

Data Architecture

Data Sources

Satellite and Map Data	Social Listening	Health-related/Other Secondary Data	Climate Data
• **NASA GIBS WMS** - dynamically expose and visualize various satellite layers and indicators • **Sentinel HUB** - access to and visualization of Sentinel satellite data • **OpenStreetMap** - access to clinics and hospitals around an area as well as their distances from points of interest	• **Google Trends** - access and extraction of public search interest • **Twitter** - access to dengue-related tweets	• **DOH Epi Bureau** - provision data on dengue cases and deaths	• **Wunderground** - access to historical weather data • **Accuweather** - access to live weather data

Licensing

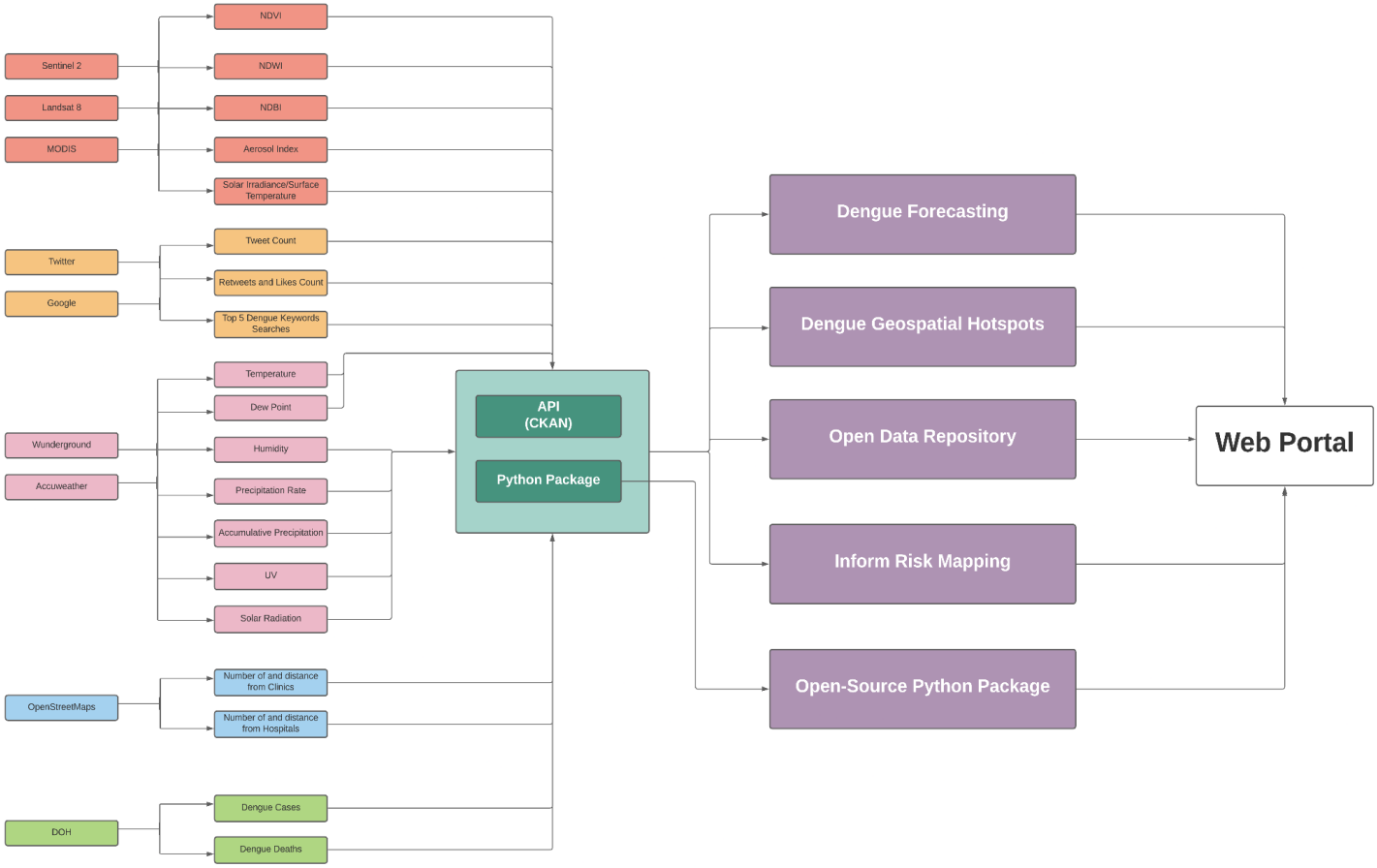
Open Data

- Satellite Data - Landsat 8 (NASA) and Sentinel-2 Copernicus (ESA)
- Wunderground Weather Data - Wunderground
- Google Search Trends - Google https://policies.google.com/terms
- Twitter Data - Twitter
- OpenStreetmap Data - OpenStreetmap
- Disease Surveillance Data - Department of Health (via Freedom of Information)

Freemium

- Accuweather Weather data - Accuweather

Data Model



High-Level Data Architecture

Sentinel 2 and Landsat 8 (NASA GIBS WMS/Sentinel HUB)

- Normalized Difference Water Index (NDWI), Fraction of Absorbed Photosynthetic Active Radiation (FAPAR), and Normalized Difference Vegetation Index (NDVI) extracted using QGIS
- Overlap of indicators provides data for mosquito hotspots which are ingested into Mapbox for visualization

Google Trends and Twitter Data

- Search interest on ‘dengue’, ‘dengue symptoms’, ‘dengue medicine’, and ‘dengue cure’
- Tweets on dengue
- Top search trends and tweet sentiments and engagements are visualized using ChartJS

DOH Epibureau

- Provision data on dengue case counts and deaths by region

Datasets

Project AEDES relies on the following datasets as input data to the dashboard:

Google Trends Data

The raw values, ranging between 0-100, represent search interest as the proportion of all searches of the inputted term for a given period of time and location. A value of 100 is the peak popularity of the term, 50 represents half of the popularity, and 0 means inadequate data.

Search data of related dengue words from Google Trends are collected at specific areas of interest using dengue top 5 dengue keywords as dictated by Google search trends.

Disease Surveillance Data

Monthly reported dengue cases and deaths of the selected regions from 2015 to 2018 were obtained from the public records of disease surveillance released by the Department of Health on their website.

Weather Data

Time-series data of multiple weather attributes such as temperature, precipitation rate, accumulation of precipitation, wind, solar radiation, etc. are collected from Wunderground and Accuweather.

Satellite Data

Process Sentinel2, Landsat, and MODIS band satellite data using python to determine stagnant water locations (NDW), high vegetation (NDVI), high built-up index (NDBI), air quality index (AEROSOL) and solar irradiance/surface temperature in the specified area of interest. The generated dataframe coinciding specific pairs of longitude and latitude are used to determine hotspots of dengue outbreak.

Twitter Data

Scrape dengue-related twitter data in order to capture time-series tweet count, engagements such as retweets and likes, and tweet sentiment such as positive, negative, or neutral.

OpenStreetMap Data

Availability of clinics and hospitals in an area are available through OpenStreetMap. Data include distance and count from points of interest.

Data Collection

Data are collected through Python, except for health-related data (e.g. dengue):

Data	Source
Time-series Temperature	https://www.accuweather.com/
Dew Point	https://www.wunderground.com/
Humidity	https://www.wunderground.com/
Wind Speed	https://www.wunderground.com/
Gust	https://www.wunderground.com/
Pressure	https://www.wunderground.com/
Precipitation Rate	https://www.wunderground.com/
Accumulative Precipitation	https://www.wunderground.com/
UV	https://www.wunderground.com/
Solar Radiation	https://www.wunderground.com/
time-series NDVI	https://modis.gsfc.nasa.gov/
time-series EVI	https://modis.gsfc.nasa.gov/
Tweet Count	twitter.com
Tweet Engagements (retweets, etc)	twitter.com
Tweet Sentiment (positive, negative, neutral)	twitter.com
Google trends	google.com
geospatial NDWI	https://landsat.gsfc.nasa.gov/
geospatial NDBI	https://landsat.gsfc.nasa.gov/
geospatial NDVI	https://landsat.gsfc.nasa.gov/
geospatial Aerosol Index	https://landsat.gsfc.nasa.gov/
Surface Temperature	https://landsat.gsfc.nasa.gov/
AOI Polygon Geojson	https://boundingbox.klokantech.com/
Hospitals and Clinics	https://www.openstreetmap.org
Dengue case count	https://doh.gov.ph/
Dengue deaths	https://doh.gov.ph/

Beneficiaries

The following LGUs will be targeted as the initial beneficiaries of the platform, who will help validate its impact and relevance.

LGU Coverage	Current Status
San Fernando, Pampanga	Inactive MOU – via PSPHP, need to revisit
CALABARZON	Existing engagement with DOST R4
Tacloban, Eastern Visayas	No relationship
Iloilo, Western Visayas	Initial linkage via DAP, Project SPARTA
Cotabato, BARMM	Initial linkage via TAF, UNDP, UNICEF Country Office

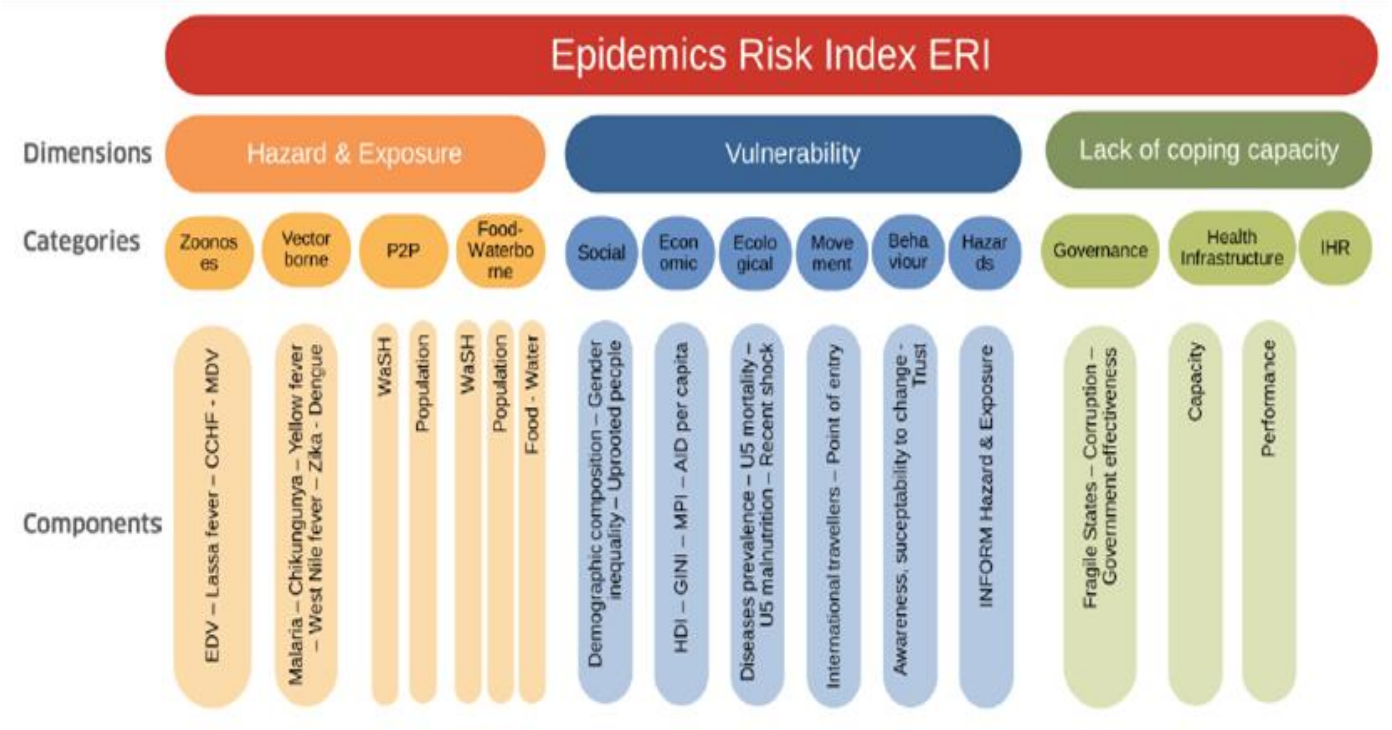
Risk-based Framework

To further strengthen the relevance of AEDES, one of the major enhancements is to integrate a risk assessment framework for dengue in regions and provinces of the Philippines using the INFORM Epidemic GRI Model. It has the potential to be adapted for evaluating dengue risk at both the national and local levels given that the model is applicable to several types of risks and epidemics.

About INFORM Epidemic GRI Model

The Index for Risk Management (INFORM) was developed by the JRC and endorsed by INFORM partners. It is a composite indicator that combines various indicators into three dimensions or risk: (2) Hazards, which captures the events that could occur and exposure to them; (2) Vulnerability, which shows the susceptibility of communities to the identified hazards; and (3) the Lack of Coping Capacity, which represents the lack of resources to lessen the impact.

Below figure shows the Epidemic Risk Index Conceptual Framework:



Given that the model follows a consensus-based methodology, it is an appropriate framework to follow for analyzing crisis risk at all levels (global, regional, or national).

Use-Cases

Following the INFORM model, the indicators shall be modified to suit the platform's purpose of being and early warning and surveillance system of epidemic outbreaks. It will be designed to achieve the following use-cases:

- **Hazards:** Monitor progress of epidemic, generate alerts
- **Vulnerabilities:** Prioritize areas with vulnerable groups, suggest demographic and geographic determinants of risk
- **Coping Capacity:** Prioritize areas for emergency aid, recommend infrastructure investment

INFORM AEDES Data

The following datasets per dimension are aimed to be used in the risk-based assessment, subject to data availability and sustainability.

Hazards	Vulnerabilities	Coping Capacity
Dengue Case incidence Flood Occurrence Temperature Precipitation COVID-19 Incidence Access to water Access to sanitation	Population ages 0-20 Poverty Index Population affected by natural disasters Population previously infected by dengue Mortality Land-use types Social listening Primary and secondary schools PhilHealth coverage Human mobility	Presence of health centers Presence of hospitals Number of health workers Health expenditure Vaccination coverage

Project Plan

Expected Outcomes

OUTCOME	DESCRIPTION
Data Collection and Processing	Database Management and Automated Data Ingest for Search Trends, Climate, Satellite, and Health Data which entails continuous research on alternate global open data sources.
Data Analysis	Incorporate Socio-Economic indicators using Dengue RISK INFORM in the predictive modeling and deploy to all regions. Enhancement of Dengue Case and Deaths Nowcasting.
Product Development	Redesign AEDES interface and functionalities which include information portals, publicly accessible APIs, and near-real-time daily updates. This will entail Dengue Trends Overview, Outbreak/Epidemic Monitoring (time-series projections, dengue hotspot map visualizations), At-Risk Community Assessment (risk ranking of regions and provinces, risk maps), and Actions and Recommendations.
Beneficiary Engagement	Validate impact and relevance through partnerships with local government units as initial beneficiaries. Engage with them through the formation of public health campaigns, target control activities, and on-site validation.

Risks

Risk (description)	Level of risk (high, low)	Probability (high, low)	Action planned to mitigate
Data (Timeliness, Accuracy)	High	Low	Reliance on credible 3rd parties (NASA, Landsat, ESA)
LGU Buy-in	Medium	Medium	Lobbying local government partnerships through UN system (UNDP, WHO, UNICEF)
Dedicated staffing due to reliance on volunteers	Medium	Low	Dedicated staffing costs to hire full time dedicated staff as part of the project (50% of funding)

Project Activities

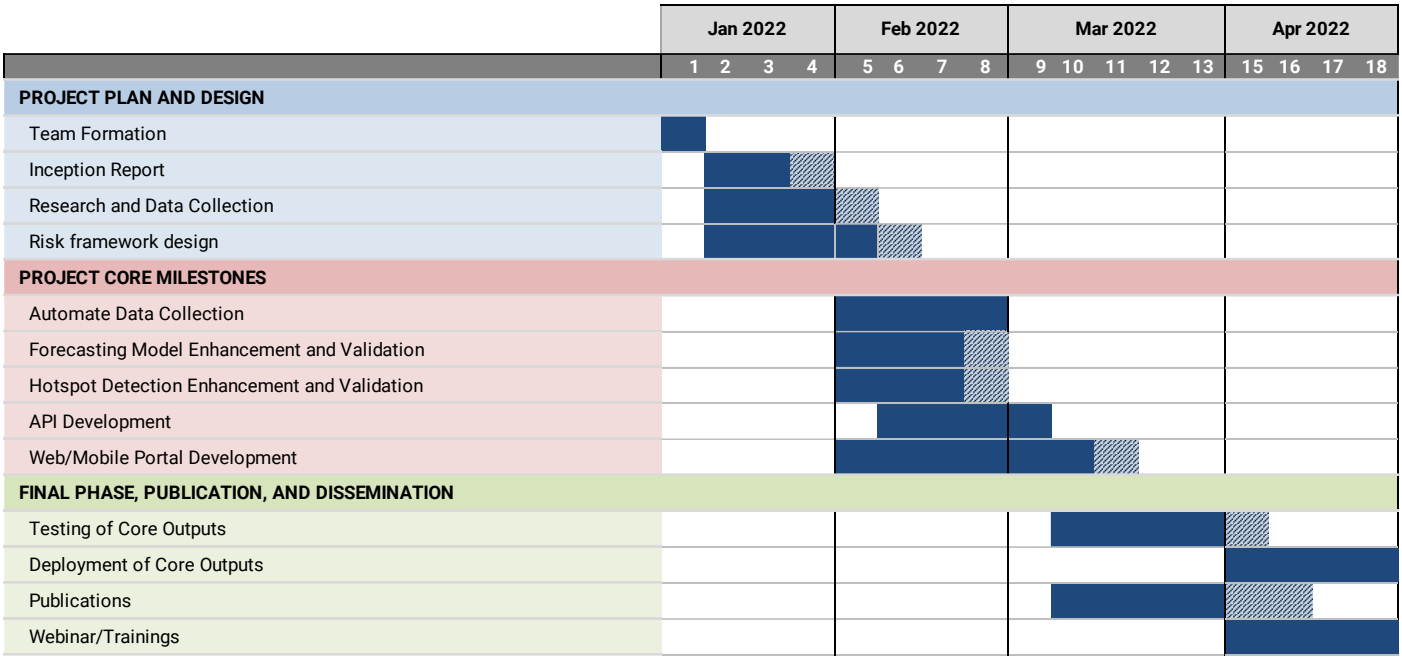
Duration	Feature details	Status	Result
1 month	API Development - Satellite (NDWI, NDVI, NDBI, Aerosol Index, Solar Irradiance/Surface Temperature) from Sentinel HUB, Landsat, Euro Data Cube	Refining	Automate data collection, repository, and feeder into application for remote sensing and dengue case count nowcasting/forecasting
	Socio-economic and weather data (hospitals, population, temperature, humidity, solar radiation, precipitation rate, cumulative precipitation)		
1 month	Risk INFORM Framework and Model Integration	Developing	Risk modeling incorporating hazard, vulnerability, and resilience indicators
0.5 months	Social Listening - Google Trends, Twitter count, engagements, sentiment	Refinement	Automated data gathering of social indicators
0.5 months	Dengue Trends Overview, Outbreak/Epidemic Monitoring, At-Risk Community Assessment, Action and Recommendations	Refinement	Descriptive, Predictive, and Prescriptive Modules
0.5 months	Dengue case and deaths nowcast enhancement	Refinement	Show results of prediction including more regions.
1.5 months	UI/UX Enhancement	Refinement	Mobile Responsive Web-App

Project Design

Milestone	Details
Team Formation and Kickoff	1. Finalize team skill requirements 2. Role design 3. Promote job openings 4. Recruit team members 5. Onboarding and debriefing
Automate data gathering	1. Finalize automation requirements and python package design 2. Automation design • Remote Sensing • Google Trends • Weather 3. Data ingestion design - dengue cases and deaths 4. Implement automation • Remote Sensing • Google Trends • Weather 5. Implement data ingestion - dengue cases and deaths 6. Automation testing and evaluation, and finalizing data gathering python package
Enhance nowcasting models	1. Nowcasting design 2. Data gathering • dengue cases and deaths • google trends, twitter data • weather and satellite data 3. Nowcasting modeling • correlations and linear regression • time-series forecasting • Automated Machine Learning 4. Nowcasting testing and evaluation 5. Nowcasting model deployment
Enhance mosquito hotspot detection model	1. Finalize hotspot detection requirements 2. Hotspot detection design 3. Data gathering • remote sensing • ground observations 4. Hotspot modeling through geospatial clustering with exogenous data 5. Hotspot model testing and evaluation 6. Hotspot model deployment
Web / mobile portal development and enhancement	1. Finalize web and mobile portal requirements 2. Design and wireframes 3. Portal development 4. Testing and evaluation 5. Portal deployment to production

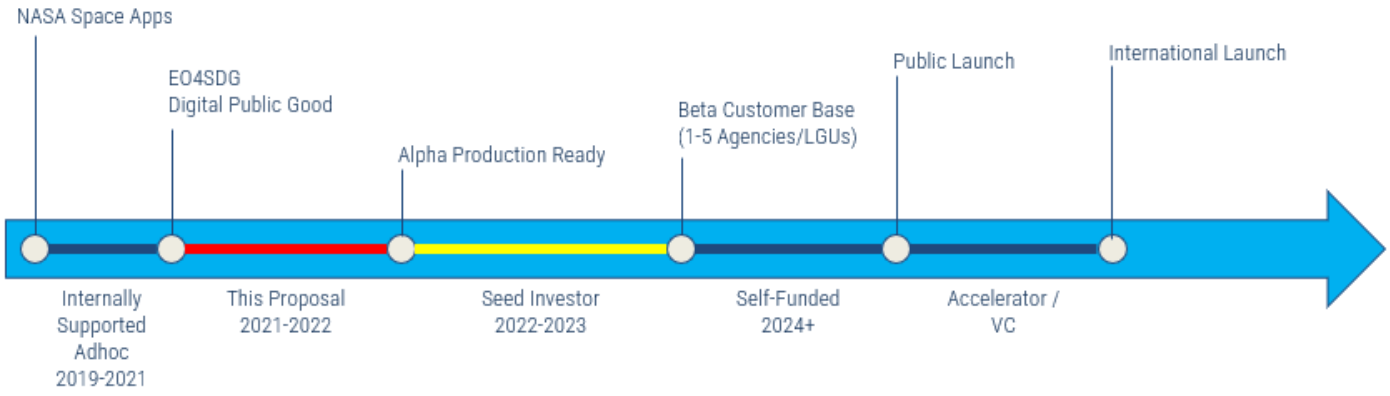
Implement INFORM Risk Framework	1. Finalize risk framework design 2. INFORM inputs data gathering 3. Implementation 4. Testing and evaluation 5. Model deployment
Publication and dissemination	1. Finalize publication requirements 2. Publication plan and design 3. Manuscript drafting and development 4. Editing and feedback 5. Publication 6. Webinar and training

Project Timeline



Development Roadmap

To appreciate the potential of Enhanced AEDES platform, below figure shows an initial development roadmap.



Organizational Profile

The following resources are involved in this project.

NAME	RESPONSIBILITIES	EMAIL
EMILY JO VIZMONTE, Project Coordinator and Research Lead	Manage and oversee the project implementation and provide oversight and direction to project activities.	emilyjo.vizmonte@cirrolytix.com
XAVIER PUSPUS, Data Science and Machine Learning Lead	Prepare data for processing and analysis, leverage machine learning techniques for interpretation and insight generation	xavier.puspus@cirrolytix.com
MARK NEIL PASCUAL, Platform Development and Engineering Lead	Develop the product design of the AEDES platform and manage the API infrastructure.	markneil.pascual@cirrolytix.com

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