Applying Predictive Analysis to Optimize Location of Food Distribution Sites

Session
Advancing Humanitarian and Peacekeeping Operations with GIS

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Predictive Analysis: Optimize the Food Distribution Site

Within our presentation the following questions should be addressed:

- What is Predictive Analysis (PA)?
- What types of geospatial analysis used at PA?
- How do these tools work?
- What problem did we solve with PA?
- How to implement this solution?
- What advantage did PA give us?
Predictive Analysis Toolset: Properties

- PA is **Spatial tools Add-In at ArcGIS Desktop**

- PA is a set of tools used by analysts to build models to predict the location of moving or stationary objects or events.

The Predictive Analysis Tools allow to:

- calculate the **walking distance** between two points

- estimate **the time** needed (or duration) for walking between two points

- **find** theoretically the **route or track** between two points

- PA tools work using the **raster model of spatial data** (DEM)
Predictive Analysis Toolset: Components

- PA includes the Speed Model Builder, Route Finder Tool, Distance/Speed Tool, Distance From and Time From

  - **Speed Model Builder**: apply estimates (or assumptions) about movement speeds and conditions.

  - The modeling uses the **Naismith’s rule** that provides a model for walking speed based on topography (Digital Elevation Models)

  - **Distance from**: estimates the linear distance from points, main roads

  - **Time from**: use the SpeedModel and Distance Model to derive a **Time raster layer**

  - **Route finder**: evaluates distance and time of travel under various SpeedModel iterations. It is a tool for finding shortest paths between locations

Digital Elevation Models
Each raster cell is coded with the distance from the nearest distribution center. The default symbolization shows “nearby” in red and “far away” in blue, with intermediate values in yellow and green. Other symbol renderings are available.
Predictive Analysis Toolset: Distance Analysis
The Speed Model Builder develops sophisticated travel-speed models that account for multiple environmental variables. We used the general principle of Naismith’s Rule for estimating speed that people can walk over different slope.
**Naismith’s rule**

The **Naismith assumption** is that people can walk relatively **quickly over flat terrain but more slowly over hilly terrain.**

[https://en.wikipedia.org/wiki/Naismith%27s_rule](https://en.wikipedia.org/wiki/Naismith%27s_rule)

<table>
<thead>
<tr>
<th>Slope Type</th>
<th>Slope (Degrees)</th>
<th>Speed (km/hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat</td>
<td>0-0.1</td>
<td>4.5</td>
</tr>
<tr>
<td>Low</td>
<td>0.1 – 2.5</td>
<td>4</td>
</tr>
<tr>
<td>Moderate</td>
<td>2.5 – 5</td>
<td>3</td>
</tr>
<tr>
<td>High</td>
<td>5-7.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Very High</td>
<td>7.5 – 10</td>
<td>2</td>
</tr>
<tr>
<td>Impassably high</td>
<td>&gt;= 10</td>
<td>0.4</td>
</tr>
</tbody>
</table>
The Time From layer is calculated from the distance raster and the speed model raster. This layer intersects the distance model and the speed model for every cell in the raster layers.

In the symbol, the light colors (green, yellow, red) are areas with short time to point (distribution center) and the darker color (blue) represents longer time.
### Predictive Analysis Toolset: Time Analysis

<table>
<thead>
<tr>
<th>ID</th>
<th>Start</th>
<th>End</th>
<th>Time (hr)</th>
<th>Status</th>
</tr>
</thead>
<tbody>
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<td>18.95985C</td>
<td>0.7243</td>
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</tr>
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<td>1.0837</td>
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<td>18.94155C</td>
<td>18.95985C</td>
<td>0.7243</td>
<td>Successful</td>
</tr>
</tbody>
</table>
How does the Predictive Analysis Toolset work

The Predictive Analysis is a series of analysis steps used to build models that can predict the location of moving objects or events.

How to apply this process in the Fararano project?
Fararano Project

- **Country:** Madagascar
- **Project Goal:** Food insecurity is reduced in 48 communes in rural Madagascar.
- **Purpose:** Health/Nutrition – Ag/Livelihoods - Resiliency
- **Donor:** USAID/Food for Peace (FFP)
- **Project Budget:** 138 M USD (Cash) **16,150 MT** (Food)
- **Implementing Period:** 5 years
- **Partners:** BDEM, ODDIT, CDD, CMB
- **Implementing Area:** 3. Regions – 7 Districts, 48 Communes – 464 Fokontany (Community)
- **Beneficiaries Targets:** 72,800 HH - 364,000 Population
- **Technology:** iFormBuilder – Zoho - GIS

http://arcg.is/1VT2lH0
Fararano Project: Targeted area (Commune level)

48 Communes - 464 Fokontany (Community)

Fararano works in all of communities for each Commune
Fararano: Targeted area (Community level)

464 Communities – 72 800 Households
Each Household is located by its GPS coordinates
Fararano Project: Food Distribution Context

Fararano project will provide food rations to pregnant/lactating women and children under 2 using the First 1000 days approach:

- Fararano plans to target 42,000 mother-child pairs by distributing food rations on a monthly basis
- Fararano implements approximately 200 distribution sites
- Recipients typically travel on foot to join the distribution centers.
- At an early distribution site, some individuals having to walk 18 km (one way) from village to the distribution site

Based on a nutritional analysis of need for women and children, each mother will receive 5kgs of CSB+ and 0.75kgs of Vegetable oil (VO) per month and children 3kg of CSB+ and 0.3 kg of VO.
Initially, distribution site identification is typically based on local context in respecting basic criteria defined by the project.

- existence of large space
- shelter,
- water supply
- large coverage of beneficiaries.
- distribution sites must also be accessible by 6 ton trucks
Food Distribution: What are the problems faced?

The identification of the appropriate distribution site location is the one major problem of the Project. Some unexpected negative effects occur and affect the project in term of effectiveness, efficiencies, indeed:

- More beneficiaries absent during the food distribution events (absenteeism)
- The number of target beneficiaries served for this assistance is not achieved
- Increased fuel costs associated with returning remaining food
- Commodity planning and supply chain are completely disturbed
- Beneficiary women are exposed in high risk violation because they leave home at 4am to join the distribution site

Sketch paper Map to identify distribution sites
Faced for these issues, CRS proposed applying Geospatial analysis to optimize site selection.
GIS solution proposed: Apply Predictive Analysis

The goals for this solution were:

• To optimize the placement of distribution sites based on a maximum walking distance 5km for beneficiaries

• To optimize the routes traveled by delivery trucks to the distribution sites.

• To increase the efficiency of all operations and transport

• To improve and develop the best intervention strategy for managing the food distribution
Inputs & Planning

Fararano uses the **eValuate platform** based on iFormbuilder for data collection, while capturing GPS coordinates.

Esri provides **iForm tools** to connect iFormbuilder data to ArcGIS Desktop.

**Datasets** preparation: Location of beneficiaries, Fokontany heads, rivers, roads and satellite imagery aids selection of potential sites.

**Buffers** 5km radius to estimate number of beneficiaries that would be near potential distribution sites.

**Local knowledge** of the area is critical to understand constraints.
Food Distribution: New Sites implemented

12 new sites proposed by predictive analysis algorithm
- 8 are created with 98% presence rate,
- 4 others are at implementation phase

The transport cost for these 8 sites are optimized because they are located on the food track itinerary.
Predictive Analysis: Lifecycle with Role

**DATA PREPARATION**
- DATA EXPLORATION
- BUILD MODELS
- VALIDATE MODEL SCENARIO
- PROPOSE SCENARIOS
- DEPLOY SCENARIO
- EVALUATE MONITOR RESULT
- IDENTIFY CONSTRAINT

**DATA**
- PREPARATION
- EXPLORATION
- BUILD
- PROPOSE
- VALIDATE
- DEPLOY
- EVALUATE
- MONITOR

**USES PA TO OPTIMIZE LOCATION OF FOOD DISTRIBUTION SITES**

**PROGRAM MANAGER**
- Makes Decisions
- Evaluates Processes
- Implements

**MEAL OFFICER PARTNER**
- Data Preparation
- Scenario Validation
- Deploy Scenario

**DATABASE ANALYST**
- Data Cleaning
- Data Analysis
- Data Visualization
- Report Creation

**GIS SPECIALIST**
- Exploratory Analysis
- Prepare Geodatabase
- Descriptive Segmentation
- Predictive Modeling

**IDENTIFY CONSTRAINT**

**DEPLOY SCENARIO**

**VALIDATE MODEL SCENARIO**

**PROPOSE SCENARIOS**

**BUILD MODELS**

**DATA EXPLORATION**

**DATA PREPARATION**

**PROGRAM MANAGER**

**MEAL OFFICER PARTNER**

**DATABASE ANALYST**

**GIS SPECIALIST**
Key Successes

- PA-enabled maps precisely identify beneficiary walk times
- PA allows staff to model and optimize multiple planning scenarios
- Web-based maps enable collaboration and effective management across organizations
- Improve business performance in terms of Food distribution
- Drive strategic decision making.
Challenges on implementing and scaling innovation

- Assure the availability of the referential datasets.
- Build the capacity on GIS, Data management for the technical staff
- Clarify Role and responsibility at all level
- Sustainability of this solution (License, Training, )
- Duplication of this solution in the another Project /Activities:
Summary

This solution is powerful in term of spatial analysis, the models provided for this solution are less expensive, scalable and sustainable could be readily adapted by Humanitarian Aid and Facilities Program.

The Implementation of this solution has

- Increased the mechanism for fostering Innovation in the different sectors in Madagascar
- Increased CRS visibility and its leadership in program Area
- Improved approach to manage the Food Distribution within 1000Days approach
- Improved the efficiencies in project operation.