

Bahir Dar University

Department of Geography and Environmental studies

Masters in Geo-Information Science

Course: Geocomputation and Spatial Science

Automating Irrigation Suitability and Investment Site Selection with ArcGIS pro Model Builder.

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1. Project Objective

The primary objective of this spatial analysis project is to design, calibrate, and execute an automated, multi-criteria spatial decision support system within ArcGIS Pro to identify optimal surface irrigation locations and strategic agribusiness investment zones across the West Gojjam Zone of the Amhara Region, Ethiopia. By systematically integrating complex biophysical factors—including topographic relief, local hydroclimatic variables, river networks, and soil fertility profiles—with critical socioeconomic market constraints such as transport corridors and urban distribution hubs, this project develops a robust spatial architecture. The resulting automated workflow translates multi-source environmental datasets into an actionable spatial plan, minimizing capital expenditures on water transport infrastructure, maximizing dry-season agricultural yields, and providing a scalable tool to assist regional planning departments in making sustainable economic development decisions.

2 Materials and Methods

2.1 Study Area Context

The geographical focus of this Geocomputation project is the West Gojjam Zone, situated within the Amhara Regional State in northwestern Ethiopia. This administrative territory is characterized by highly diverse agro ecological zones, ranging from rugged highland plateaus to low-lying drainage basins, and is intersected by critical hydrological networks including the perennial streams of the upper Blue Nile basin. Because of its high agricultural potential, variable topographic relief, and exposure to intense seasonal rainfall, West Gojjam serves as a priority economic corridor for smallholder irrigation development and targeted agribusiness expansion.

2.2 Data Inventory and Spatial Characteristics

To systematically evaluate land capacity for surface irrigation and subsequent investment profiling, six foundational spatial datasets were compiled from various national and international institutional repositories. Because these layers natively possessed different spatial resolutions, data types, and coordinate reference systems, they required a rigorous pre-processing phase to enforce absolute geometric and spatial alignment. The complete data inventory, along with native formats, spatial baselines, and institutional sources, is systematically structured in Table 1.

Table 1:Baseline Spatial Datasets and Institutional Sources

Dataset	Data Type	Native Resolution	Native Coordinate Reference System
MG_DEM	Raster	30 Meter	WGS 1984 UTM Zone 37N
Streams	Vector	Linear (0.0001 m)	WGS 1984 UTM Zone 37N
Land use	Raster	20 Meter	WGS 1984 UTM Zone 37N
Rainfall	Raster	5000 Meter	WGS 1984 UTM Zone 37N
Soil type	Raster	20 Meter	WGS 1984 UTM Zone 37N
SOC	Raster	5 Centimeter	WGS 1984 UTM Zone 37N
Roads	Vector	Linear (0.0001 m)	Adindan / UTM Zone 37N
Towns	Vector	Point (0.0001 m)	Adindan / UTM Zone 37N
MG_Boundary	Vector	Polygon (0.0001 m)	WGS 1984 UTM Zone 37N
MG_Kebeles	Vector	Polygon (0.0001 m)	WGS 1984 UTM Zone 37N

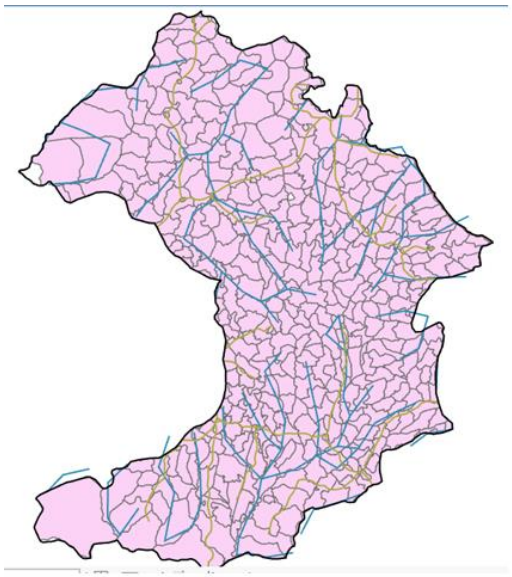


Figure 1: Study Area with factor datasets overlay

3. Irrigation Potential Suitability Methods and Criteria Mapping

While several multi-criteria evaluation methodologies exist for modeling agricultural land capability—such as the vector-based Analytical Hierarchy Process (AHP)—this study implements a raster-based Weighted Overlay technique. This spatial approach is highly effective for surface irrigation modeling because it allows continuous environmental factor surfaces to be evaluated concurrently on a pixel-by-pixel basis.

Multi-criteria spatial overlay requires all participating datasets to be reclassified from their native, disparate measurement units (such as degrees of slope, millimeters of rainfall, or soil mass fractions) into a common, standardized ordinal integer scale. For this project, a

standardized scale of 1 to 3 was applied, where 1 signifies Unsuitable (severe development constraints), 2 signifies Moderately Suitable (minor limitations requiring management), and 3 signifies Highly Suitable (optimal biophysical or infrastructural conditions).

To preserve spatial data integrity during execution, the Reclassify geoprocessing tools were configured to map missing or unclassified boundary attributes strictly to an official NoData destination. This prevents the spatial model from misinterpreting boundary edges or empty spatial cells as low-quality real land, which would mathematically corrupt downstream cell calculations. The reclassification boundaries and relative percentage weights utilized for the baseline irrigation potential model are structured in Table 2.

Table 2:: Irrigation Potential modeling Criteria

Data/Factors	Scientific Criteria (Reclassification Breaks)	Weight (%)	Scientific Reference
DEM (slope)	• **3 (Suitable)**: 0° – 5° (Flat to gentle slope) • **2 (Moderate)**: 5° – 8° (Medium tilt • **1 (Unsuitable)**: > 15° (Steep terrain, high erosion risk)	25%	[1][Lab Guideline]
Streams	• • **3 (Suitable)**: < 2,000 meters (Low pumping cost) • **2 (Moderate)**: 2,000 – 5,000 meters • **1 (Unsuitable)**: > 5,000 meters (Infeasible transport)	20%	[2] [Lab Guideline]
Land use	• • **3 (Suitable)**: Existing agricultural crops, bare ground • **2 (Moderate)**: Shrub land, open grassland • **1 (Unsuitable)**: Natural forests, wetlands, built urban zones	15%	[3] [Lab Guideline]
Rainfall	• • **3 (Suitable)**: 1,000 – 1,500 mm (Optimal supplement) • **2 (Moderate)**: 800 – 1,000 mm or > 1,500 mm • **1 (Unsuitable)**: < 600 mm (Severe moisture deficit)	15%	[4] [Lab Guideline]
Soil type	• • **3 (Suitable)**: Deep, well-drained profiles (Fluvisols, Luvisols) • **2 (Moderate)**: Heavy drainage constraints (Vertisols) • **1 (Unsuitable)**: Shallow, rocky horizons (Leptosols)	15%	[1] [Lab Guideline]
Soil Organic Carbon (SOC)	• • **3 (Suitable)**: > 1.5% (>600)carbon mass (Highly fertile topsoils) • **2 (Moderate)**: 0.5% – 1.5% (400 – 600) carbon content • **1 (Unsuitable)**: < 0.5% (<400) carbon (Highly degraded land)	10%	[5] [Lab Guideline]

4. Parameter Calibration and Optimization Logic

To establish a reliable bridge between generalized global frameworks and localized agrarian conditions, the spatial model parameters were systematically calibrated to reflect the environmental and socioeconomic realities of the West Gojjam Zone. While international land assessment guidelines, such as the Food and Agriculture Organization (FAO) frameworks, provide valuable global baselines, they often assume highly mechanized, large-scale irrigation infrastructure. This study optimizes reclassification breaks to align with smallholder farming practices and regional agricultural policies.

A comparative review reveals critical variations between localized academic parameters and global FAO guidelines regarding topographic slope thresholds. International frameworks often classify land with slopes up to 8 or 15 degrees as irrigable, primarily under the assumption that modern pressurized drip or center-pivot systems are deployed. However, because smallholder farming cooperatives in northwestern Ethiopia rely almost exclusively on traditional gravity furrow irrigation, steep gradients pose severe risks of localized field erosion and rapid canal degradation. Consequently, local slope suitability thresholds were strictly restricted to a tight 0-to-5-degree range for optimal classification, ensuring the model's outputs remain realistic and low-risk for local engineering interventions.

Similarly, proximity thresholds to perennial stream networks were calibrated based on economic and infrastructural constraints rather than purely hydrological availability. While global sub-Saharan multi-criteria evaluations frequently extend water proximity zones up to 5,000 meters based on mechanized high-pressure pumping assumptions, this analysis restricts the highly suitable zone to a tight 2,000-meter buffer. This localized adjustment directly accounts for the financial realities faced by smallholder farmers regarding the capital cost of diesel fuel, water-lifting pumps, and long-distance canal construction.

Finally, specific adjustments were made regarding land use types and Soil Organic Carbon (SOC) measurements. To balance agricultural expansion with environmental sustainability, the overlay model was calibrated to heavily constrain ecologically sensitive areas—such as communal wetlands, steep mountain rims, and high-altitude forest fragments—mapping them directly as Unsuitable. Furthermore, because the raw SOC input raster stores data as scaled integer mass fractions rather than direct topsoil percentages, scientific thresholds were calibrated to match the dataset's native attributes. In this scale, raw values under 400 indicate highly degraded zones with less than 0.5% organic carbon, values between 400 and 600 represent moderate horizons, and values exceeding 600 reflect optimal, highly fertile agricultural topsoils exceeding 1.5% organic carbon content, allowing for precise raster reclassification without data corruption.

5. Automated Geoprocessing Workflow Using Model Builder

To optimize efficiency, minimize human error, and ensure complete reproducibility, the entire spatial multi-criteria evaluation workflow was automated using ArcGIS Pro Model Builder. Developing a visual geoprocessing model allowed for the simultaneous execution of all six environmental and socioeconomic factor streams, seamlessly transforming disparate raw spatial datasets into a finalized irrigation potential map within a single, unified execution environment.

The structural architecture of the automated workflow model follows a rigorous, four-stage sequential geoprocessing pipeline.

- The first stage involves data standardization and variable preparation. In this phase, vector linear layers—such as the perennial stream network—are converted into continuous raster surfaces using the Euclidean Distance tool, while layers with mismatching resolutions are systematically adjusted using the Resample tool to establish a uniform 90-meter base pixel grid across the processing canvas.
- The second stage enforces strict spatial environment constraints. Global model environments are configured to anchor a matching grid alignment and geographic mask based on the official administrative boundary layer. This step eliminates pixel shifting and guarantees that all input factor grids overlap perfectly across matching cell borders.
- The third stage handles value normalization through parallel reclassification branches. Six individual Reclassify tool sequences execute concurrently to transform highly varied data measurements—such as topographic slope degrees, hydrological proximity metrics, and soil organic carbon fractions—into the uniform ordinal suitability scale of 1, 2, and 3.
- The fourth and final stage executes the multi-criteria evaluation. Here, the six normalized raster streams are funneled directly into the Weighted Overlay tool. By applying the calibrated percentage weights derived from regional agronomic baselines, the tool computes a composite cell-by-cell score to generate the definitive spatial output layer: the Primary Irrigation Potential Map. By structuring the analysis as a self-contained geoprocessing tool, the entire workflow becomes fully reusable. If updated environmental grids or infrastructure layers are provided in the future, regional planners can re-run the entire model instantly without manual reconstruction.

Figure 2:Model built for Irrigation Potential Suitability mapping

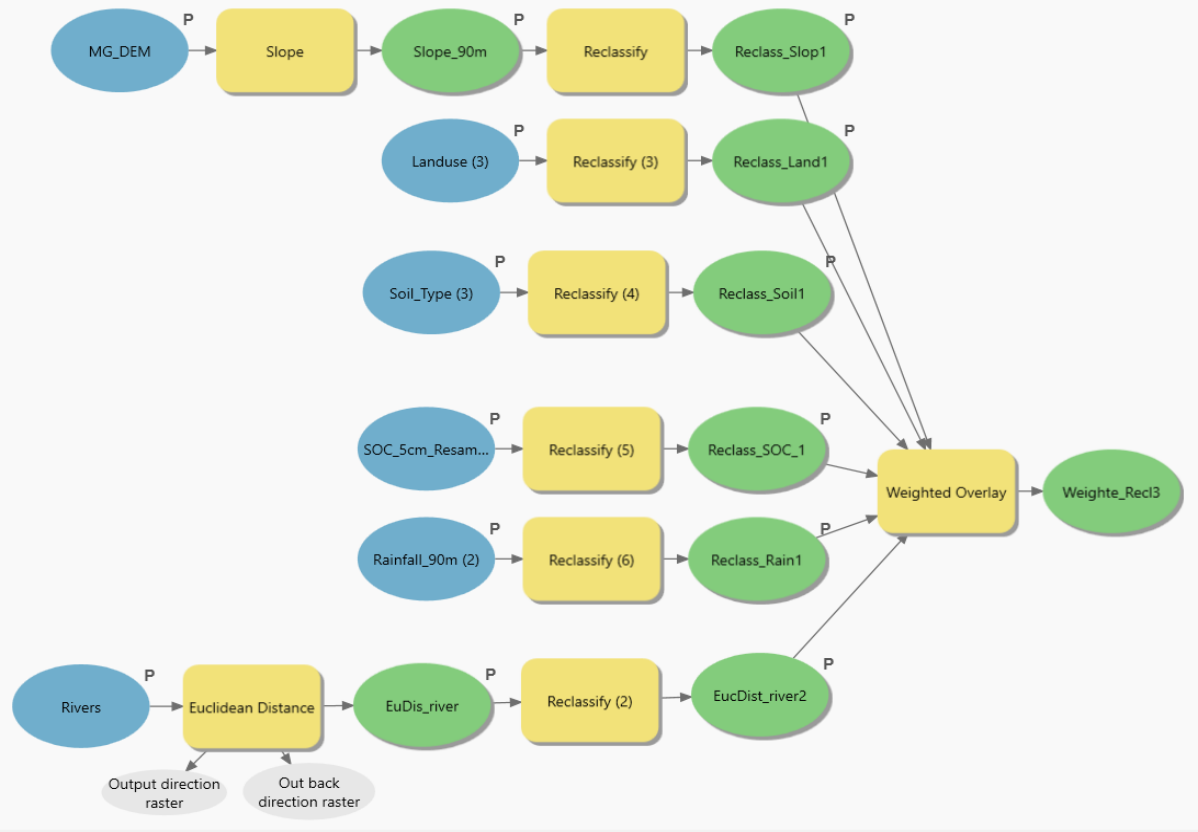
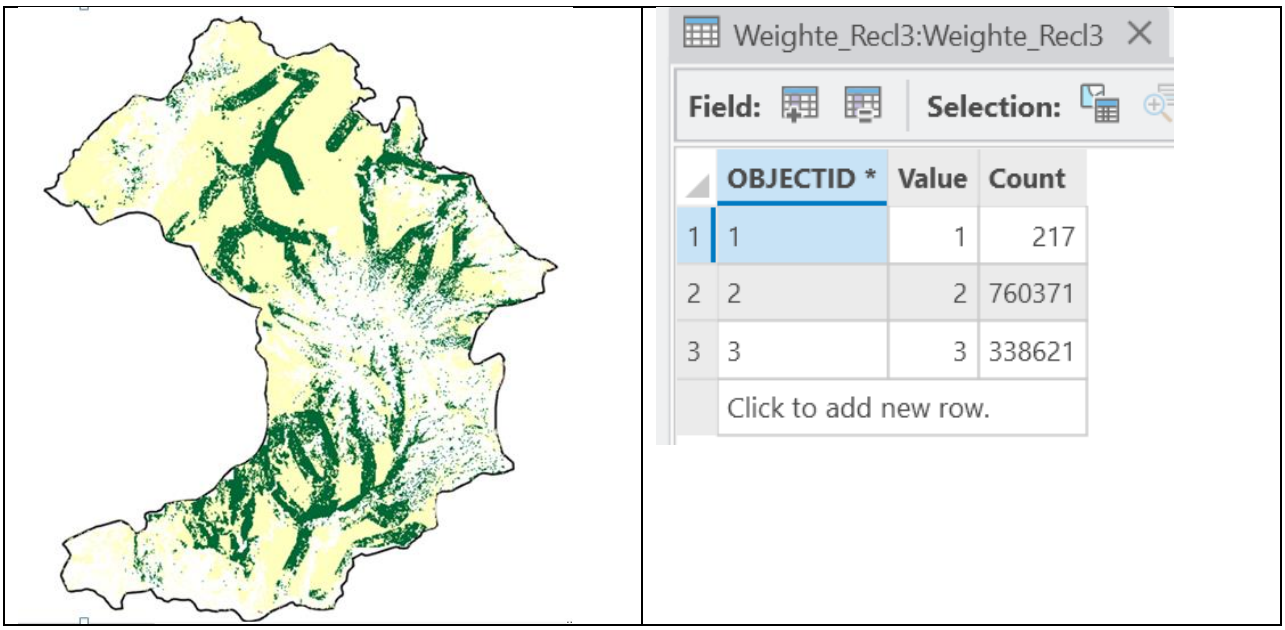


Figure 3: Primary Irrigation Potential Map (Top) and attribute table(below)



6. Spatial Interpretation and Suitability Distribution

Following the successful execution of the Weighted Overlay model, the resulting primary irrigation potential map was classified into three explicit land capability zones. A spatial calculation of the final output raster grid reveals that land suitability is highly variable across the West Gojjam administrative zone.

This spatial distribution is directly driven by the intense interplay between rugged highland topography and hydrological proximity to perennial stream corridors.

The spatial extent of the Unsuitable Zone (Class 1) is predominantly concentrated across the steep, high-altitude mountain massifs and severely dissected volcanic plateaus of the region. In these zones, surface irrigation is biophysically prohibited by extreme topographic slopes exceeding 15 degrees, which would cause immediate, catastrophic topsoil erosion under gravity-fed furrow systems. Furthermore, these unviable landscapes correlate with highly weathered, shallow Leptosols and ecologically sensitive mountain forest remnants that were strictly isolated during the model's environment mask configuration.

Conversely, the Moderately Suitable Zone (Class 2) forms a widespread, continuous matrix across the transitional rolling plains and mid-altitude hills of West Gojjam. These areas possess favorable organic soil carbon profiles and receive adequate seasonal rainfall, yet they are constrained by moderate slope tilts ranging from 5 to 8 degrees or are located at expanding distances (between 2,000 and 5,000 meters) from stable surface water networks. While these lands represent a highly valuable agricultural reserve, cultivating them requires targeted soil conservation investments, terracing, or the introduction of low-pressure mechanical pumping infrastructure.

The Highly Suitable Zone (Class 3) represents the premium, high-value target for immediate irrigation development. These optimal zones are strategically clustered along the wide, flat alluvial floodplains and low-lying valleys directly adjacent to major perennial river channels. Because these flat expanses feature slope gradients under 5 degrees, they are perfectly suited for low-cost, gravity-driven surface water distribution networks. Furthermore, these zones are underlain by highly fertile, deep Fluvisols and Luvisols with optimal Soil Organic Carbon index ratings exceeding 600. By prioritizing these specific spatial clusters, regional planning authorities can maximize dry-season crop yields while minimizing initial public capital expenditures on water-lifting machinery or extended transport canals.

7. Agribusiness Investment Site Selection (Vector Pipeline)

While isolating optimal biophysical conditions (slope, water, soil fertility, and rainfall) is foundational for mapping raw agricultural potential, commercial agribusiness ventures cannot

succeed in a geographical vacuum. To ensure long-term commercial viability, high-potential irrigation zones must be cross-referenced with regional logistical infrastructure to minimize transport overheads, ensure rapid market access for perishable cash crops, and guarantee an available labor pool.

To achieve this, a secondary automated vector processing pipeline was constructed in Model Builder to refine the raster overlay outputs into highly targeted, strategic investment zones.

The vector optimization pipeline begins by ingesting the irrigation potential map and extracting the highest-tier cells (Class 3 - Highly Suitable) from the primary irrigation potential raster using Con operator; and converting them into a discrete polygon feature layer using the Raster to Polygon tool and then selecting those polygons with area attribute greater than $20000m^2$.

Concurrently, proximity buffers are generated around the region's core logistical networks. Using the Buffer tool, a 10-kilometer economic access corridor is established around primary highway vectors to model rapid supply-chain transport, while a 25-kilometer municipal trade buffer is generated around primary town centroids to represent immediate access to regional urban markets and agricultural labor pools.

The final phase of the model pairs biophysical suitability with these logistical corridors. The extraction polygons and the logistical intersection layers are funneled directly into a final Intersect geoprocessing operation. This step isolates only the high-potential irrigable lands that lie completely within optimal proximity to both roads and urban markets. To eliminate fragmented, micro-scale parcels that are too small for commercial tractor operations or large-scale private investment, an attribute selection query blocks any polygon with a spatial footprint under 20 hectares. The visual architecture of this automated vector intersection sequence is illustrated in Figure 4. The vectored irrigation potential map is shown in figure 5 and the final spatial distribution of the filtered, high-yield strategic agribusiness investment sites across West Gojjam is presented in Figure 6.

Figure 4: Model for Investment Site Selection

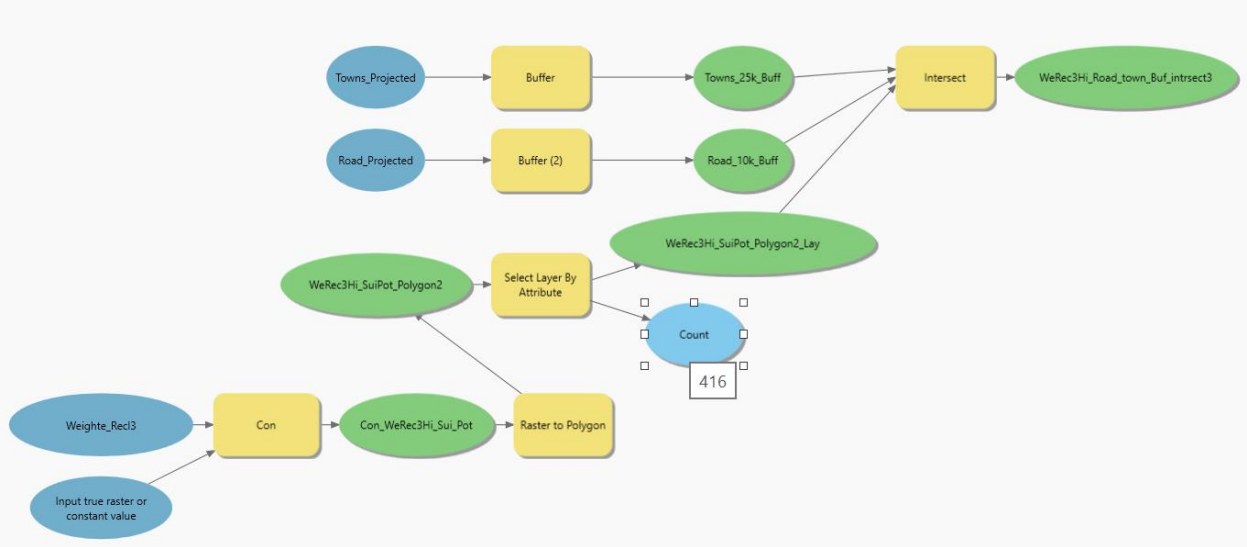


Figure 5: Irrigation Potential Vector Map

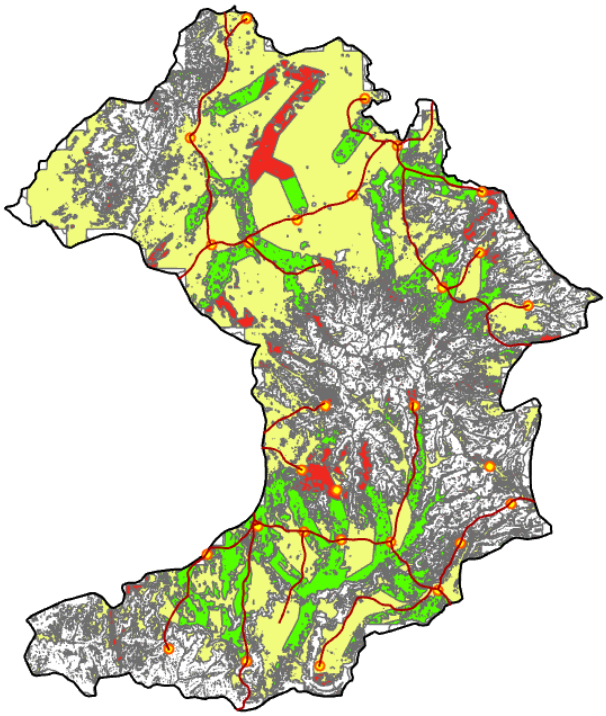
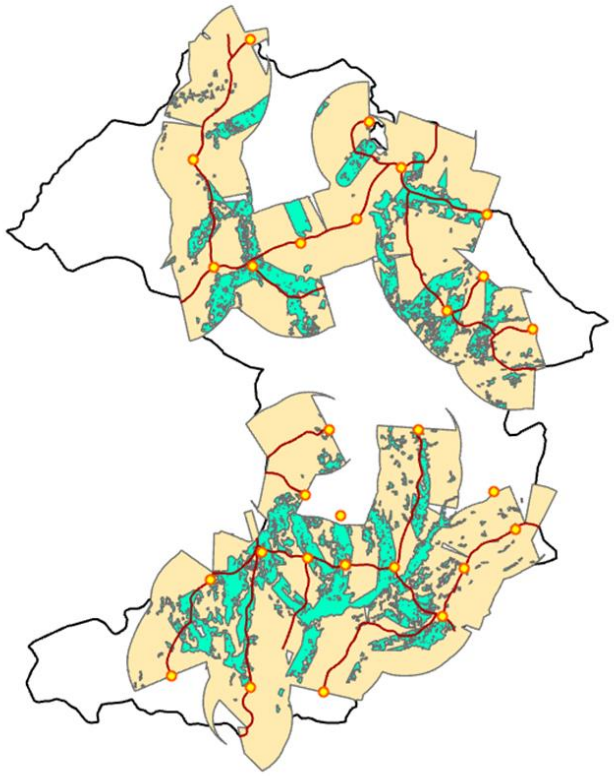


Figure 6:Final Filtered Strategic Agribusiness Investment Sites Map



8. Technical Portfolio Reflection & Analytical Responses

Question 1: List the main geoproccessing tools you used in this lab exercise and explain their functions

The multi-criteria raster overlay and subsequent socio-economic vector optimization pipelines were driven by a strategically linked sequence of core geoprocessing tools within the ArcGIS Pro environment. Rather than relying on separate manual executions, these tools were compiled into a continuous data engine using the model builder. The operational roles of the foundational tools are organized in Table below.

Table 3:Core Geoprocessing Tools and Spatial Logic Operations

Tool Name	Data Domain	Operational Geoprocessing Architecture
Euclidean Distance	Spatial Analyst Vector / Raster	Calculated the straight-line distance from critical source features like rivers (water access), roads (transport), and urban centers (markets).
Slope	Spatial Analyst Raster	Derived from the Digital Elevation Model (DEM) to evaluate land steepness, as flat or gently sloping terrain is critical for gravity-based surface irrigation.
Reclassify	Spatial Analyst	Standardized various input layers (slope, distances, etc.)

	Raster	with different scales and units into a uniform suitability scale (e.g., 1 = Unsuitable, 2 = Moderately Suitable, 3 = Highly Suitable) based on local agronomic criteria.
Weighted Overlay/Raster Calculator	Spatial Analyst Raster	Combined all standardized factor maps by assigning specific percentage weights based on their relative importance, computing values pixel-by-pixel to generate the final suitability map
Raster to Polygon	Conversion Pipeline	Converts the high-potential raster cells (Class 3) into an optimized vector polygon layer to facilitate spatial intersection and geometric area pruning.
Buffer	Vector Geoprocessing	Generates definitive proximity boundaries around critical infrastructure vectors and points, enforcing a 10-kilometer corridor for roads and a 25-kilometer radius for town hubs.
Intersect	Vector Geoprocessing	Performs geometric overlays on multiple vector features, isolating only the premium agricultural polygons that lie completely within overlapping infrastructural zones.
Select Layer By Attribute/calculate Geometry	Data Management	Executes an SQL expression query ("Shape_Area >= 200000") to automatically isolate and preserve contiguous investment blocks equal to or greater than 20 hectares; and to calculate area in hectare.
Zonal Statistics as Table/Spatial Join	Spatial Analyst Raster/vector	Extracted the mean suitability values and elevation statistics across individual administrative boundaries (Kebeles), to join tables and create an integrated vector layer which contains all the attributes needed for our analysis.
Microsoft Excel	Geometric analysis	Used to do selected calculations(area, percentage) using tables and attributes exported from the integrated vector layer

Question 2: What will be the effect in your analysis if you use different resolution and different coordinate system for your factors input data?

A primary challenge in using different coordinate system is geometric misalignment of baseline data layers. While the environmental rasters natively utilized the WGS 1984 UTM Zone 37N projection, the socioeconomic infrastructural vectors provided were anchored to the Adindan datum. Directly executing overlay operations on these unaligned layers could result in major pixel shifts and spatial displacement along river corridors. This required an immediate stabilization phase, utilizing the Project tool to enforce absolute datum transformation uniformity.

A secondary challenge involves the huge resolution gap between input factor grids, notably between the 20m land use, Soil Type, 30mDEM and 5cm SOC layers and the coarse 5,000-meter rainfall grid. Running a cell calculation directly on these mixed boundaries would cause ArcGIS

Pro to default to the coarsest common cell size(maximum of input cell size), destroying the fine topographic variations. This was optimized by manually establishing a uniform 90-meter cell processing environment, striking an ideal computational balance between preserving spatial land detail and maintaining rapid model processing speeds.

Question 3: Characterize irrigation potential factors based on the six criteria by area and spatial distribution in the study area.

Question 4: What is the irrigation suitability composition area in square kilometers and percentage? Analyze the irrigation potential sites based on the six criteria we used in this exercise (total area in percent, most suitable Kebeles and their mean altitude, etc.). Based on the altitude values of the selected Kebeles, for which crop type do you recommend and why?

A rigorous quantitative analysis of the final primary irrigation potential output including the raster, the derived vector equivalent and attribute table reveals that land capability is highly stratified across West Gojjam. An integrated layer and attribute table was obtained after performing joining zonal statistics and spatial join on different output layers:

Figure 7: Irrigation Potential Raster Map

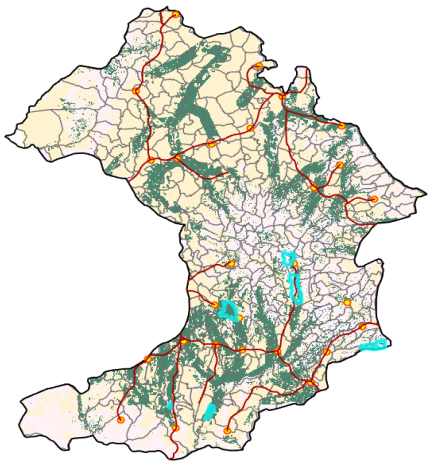


Figure 8: Attribute table of Irrigation Potential Raster Map

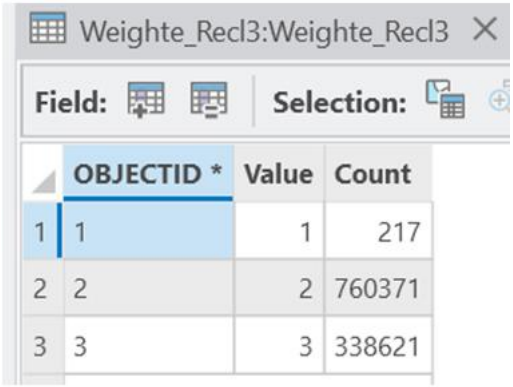
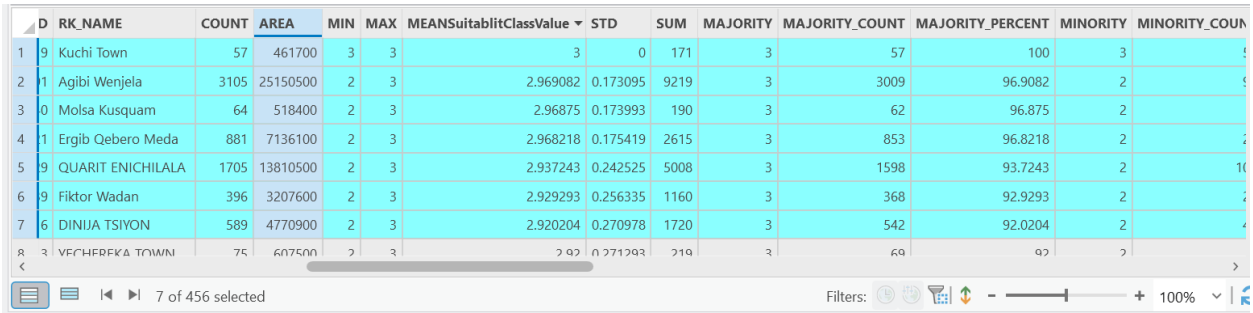


Figure 9:Attribute table of Integrated vector Layer



D	RK_NAME	COUNT	AREA	MIN	MAX	MEANSuitablitClassValue	STD	SUM	MAJORITY	MAJORITY_COUNT	MAJORITY_PERCENT	MINORITY	MINORITY_COUN
9	Kuchi Town	57	461700	3	3	3	0	171	3	57	100	3	
1	Agibi Wenjela	3105	25150500	2	3	2.969082	0.173095	9219	3	3009	96.9082	2	
0	Molsa Kusquam	64	518400	2	3	2.96875	0.173993	190	3	62	96.875	2	
1	Ergib Qebero Meda	881	7136100	2	3	2.968218	0.175419	2615	3	853	96.8218	2	
9	QUARIT ENICHILALA	1705	13810500	2	3	2.937243	0.242525	5008	3	1598	93.7243	2	
9	Fiktor Wadan	396	3207600	2	3	2.929293	0.256335	1160	3	368	92.9293	2	
6	DINIJA TSIYON	589	4770900	2	3	2.920204	0.270978	1720	3	542	92.0204	2	
3	YECHEREKA TOWN	75	607500	2	3	2.92	0.271293	219	3	69	92	2	

7 of 456 selected Filters: 100%

Statistical Summary and Spatial Interpretation

Table 4: Definitive Quantitative Composition of Irrigation Suitability Zones

Suitability Value	Formal Land Classification	Total Cell Count	Total Area (Square Kilometers)	Percentage of Total Landmass (%)
Class 1	Unsuitable Zone	217	1.7577	0.012841009
Class 2	Moderately Suitable Zone	760,371	6159.0051	44.99507354
Class 3	Highly Suitable Zone	338,621	2742.8301	20.03795094

Highly and Moderately Suitable irrigation zones collectively make up over 65.03% of the analyzed regional territory, indicating massive irrigation viability across the region. The total administrative boundary envelope contains a definitive landscape footprint of 13,688.18 square kilometers, which serves as the geographic baseline for all spatial ratio calculations.

The integrated attribute table demonstrates that the overwhelming majority of the territory occupies Moderately Suitable pixels (Class 2) spanning 760,371 active cells, which translates to a continuous land matrix of 6,159.0051 square kilometers, or exactly 44.9951% of the total regional area. These lands possess strong soil organic carbon content but are constrained by moderate slope tilts (5 to 8 degrees) or expanding distances from water networks.

The premium development zone, classified as Highly Suitable (Class 3), encompasses 338,621 active pixel cells. This isolates a high-value spatial footprint of 2,742.8301 square kilometers, representing 20.0380% of the total West Gojjam administrative landmass. This land is highly concentrated along flat, low-lying alluvial plains where slope gradients remain under 5 degrees and topsoil fertility indices are optimal.

Conversely, the Unsuitable Zone (Class 1) is restricted to a minor fragment of 217 pixels, accounting for a negligible 1.7577 square kilometers (0.0128% of the territory). This minimal footprint proves that the spatial model successfully isolated and excluded rugged mountain massifs, high-altitude forest patches, and steep slopes prone to severe erosion from the irrigation pipeline.

The total physical area and percentage were derived by multiplying the cell count of each suitability class by the active pixel dimensions (90 m × 90 m = 8,100 m^2 per cell) , multiply by the total cell count for Class and converting the product to square kilometers (1 km^2 = 1,000,000 m^2).

Figure 10: Excel calculations

OBJECTID	Value suitability Class	label suitability Class	Count	pixelSize	pixelArea 90*90	AreaMsq (Count*PixeArea)	AreaKMsq	MG boundary TotArea_	percentage
1	1	1 unsuitable	217	90	8100	1757700	1.7577	13688.18	0.012841009
2	2	2 moderately suitable	760371	90	8100	6159005100	6159.0051	13688.18	44.99507354
3	3	3 Highly suitable	338621	90	8100	2742830100	2742.8301	13688.18	20.03795094

Most Suitable Kebeles, Mean Altitude, and Crop Recommendations

Based on the zonal statistics in **joined tables** the top most suitable Kebeles (approaching a perfect mean suitability score of 3.00), their altitude metrics, and recommended crops are:

Table 5: Investment sites and Kebeles Characterization

Kebele Name	Woreda	Zone	Mean Suitability Score	Mean Elevation	Recommended Crop Type
Kuchi Town	Bure	West Gojjam	3.00 / 3	2,030 m	**High-Value Vegetables** (Onions, Garlic, Irish Potato) & **Teff**
Agibi Wenjela	Jebitenan	West Gojjam	2.97 / 3	2,243 m	**High-Value Vegetables** (Onions, Cabbage) & **Highland Wheat**
Molsa Kusquam	Bibugn	East Gojjam	2.97 / 3	2,584 m	**Cool-season Crops** (Barley, Irish Potato, Highland Pulses)
Ergib Qebero Meda	Jebitenan	West Gojjam	2.97 / 3	1,460 m	**Warm-season Crops / Grains** (Maize, Peppers, Teff)
QUARIT ENICHILALA	Quarit	West Gojjam	2.94 / 3	2,124 m	**Highland Wheat**, **Teff**, and **Dry-season Onion**
Fiktor Wadan	Bibugn	East Gojjam	2.93 / 3	2,624 m	**Cool-season Grains** (Barley, Wheat) & **Irish Potato**
DINIJA TSIYON	Quarit	West Gojjam	2.92 / 3	2,424 m	**Barley**, **Highland Wheat**, and **Cool-season Vegetables**

Following figures Overlay of multiple maps showing various aspects of the irrigation suitability and investment maps.

Figure 11: Multi-Overlay of Investment map Most Suitable Kebeles with Suitability >2.92

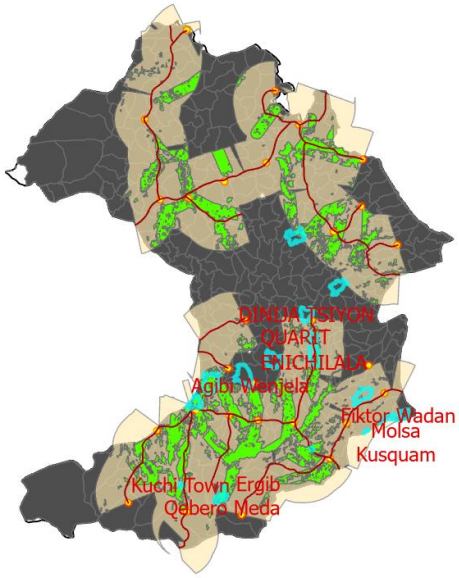


Figure 12:Elevation and Selected Kebeles Overlay

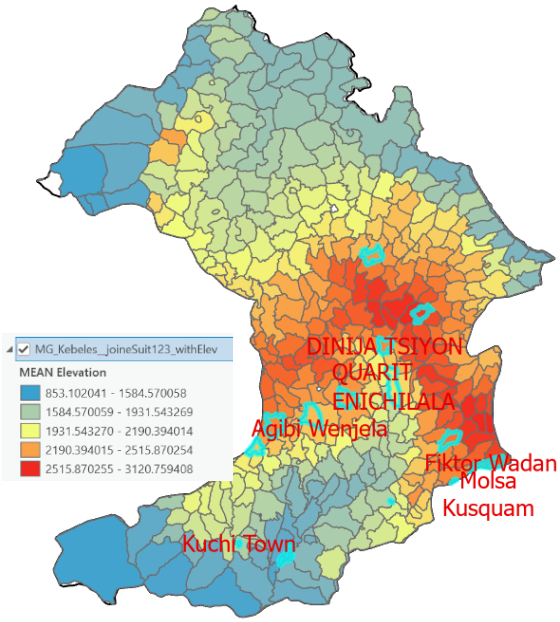
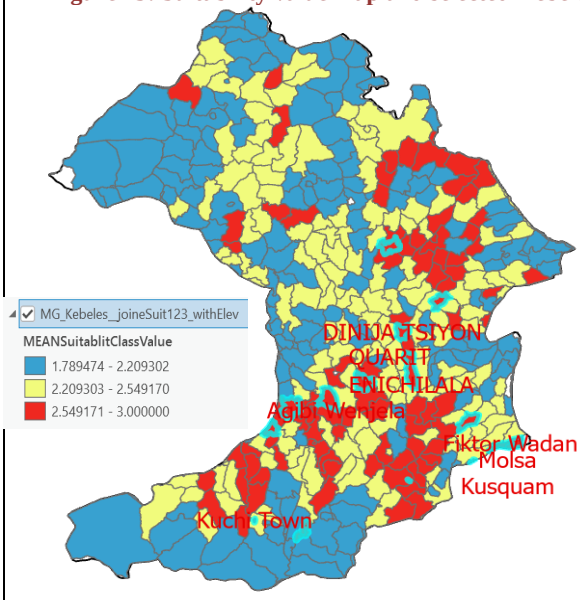


Figure 13: Suitability value map and selected Kebeles



The selected high-suitability Kebeles sit predominantly between **2,000m and 2,600m**, placing them within the **Weina Dega** (cool sub-humid highland) and **Dega** (cool/cold highland)agro ecological zones of Ethiopia.

- Cereals (Highland Wheat, Barley, Teff): The temperate climate provides the ideal diurnal temperature range and chilling hours for grain filling. Dry-season irrigation bypasses rainy-season fungal blights.
- Vegetables (Irish Potatoes, Onions, Cabbages): These crops thrive without heat stress in cooler climates. Utilizing irrigation guarantees reliable yields and high market returns for regional urban centers.

Conclusion and Recommendations

In conclusion, the integration of multi-criteria raster evaluation with automated vector routing pipelines in Model Builder provides an exceptionally objective, repeatable framework for regional agricultural planning. The empirical results demonstrate that while half of the West Gojjam Zone requires targeted investment or mechanical pumping due to moderate terrain and logistical constraints, over 20 percent of the landmass represents highly viable, high-fertility, low-slope terrain perfectly situated for low-cost, gravity-fed furrow surface irrigation development.

Based on these spatial findings, it is highly recommended that the Amhara Regional Agricultural Bureau prioritize public capital infrastructure investments strictly within the high-suitability pockets identified along the flat river valleys. Furthermore, the final strategic agribusiness investment sites—which filter these fertile pockets to ensure they lie within a 10-kilometer highway shipping corridor and a 25-kilometer municipal workforce radius—should be adopted as the official blueprint for zoning private commercial concessions. This targeted approach guarantees that incoming agricultural investments maximize production efficiency, minimize environmental degradation, and maintain seamless access to domestic and export market distribution networks.

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