North-South Slopes - Converting Semiarid Dryland into Cultivable Land- International Collaboration

Preproposal For Parallel Academic Program

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In parallel with our ongoing pilot development, this pre-proposal outlines a framework for our international collaborators. It is designed to assist them in addressing their unique research agendas funded by governments and specific implementation needs within their respective countries.

Pre-Proposal: Phase I

Phase I of the ReSlope Research Program focuses on modifying the topography of semiarid land. By utilizing engineered North-South slopes, we aim to alter local thermodynamics and moisture retention to render previously marginal land cultivable.

This initial phase will specifically address the agrophysics and topographic geometry of the sloping terrain. Phase I is structured as a foundational entry point, intended to secure the initial, smaller-scale funding necessary to prove the concept before advancing to more complex developmental stages.

1. Theoretical Foundation & Modeling

This phase focuses on the "why" and "how" of the math behind water loss.

- **The Concept:** Defining how narrow sloping terrains alter standard agricultural expectations.
- **The Penman Equation:** Estimating Evapotranspiration (ET) by balancing energy (radiation) and aerodynamics (wind/humidity).

Sub-variables include: Net radiation, air temperature, wind speed, and vapor pressure deficit.

Sensitivity Analysis: Identifying which specific variable (e.g., wind speed vs. solar radiation) has the greatest impact on water loss when the slope angle changes.

Aridity Index, Seasonal Variability, and Its Relevance to ReSlope Global

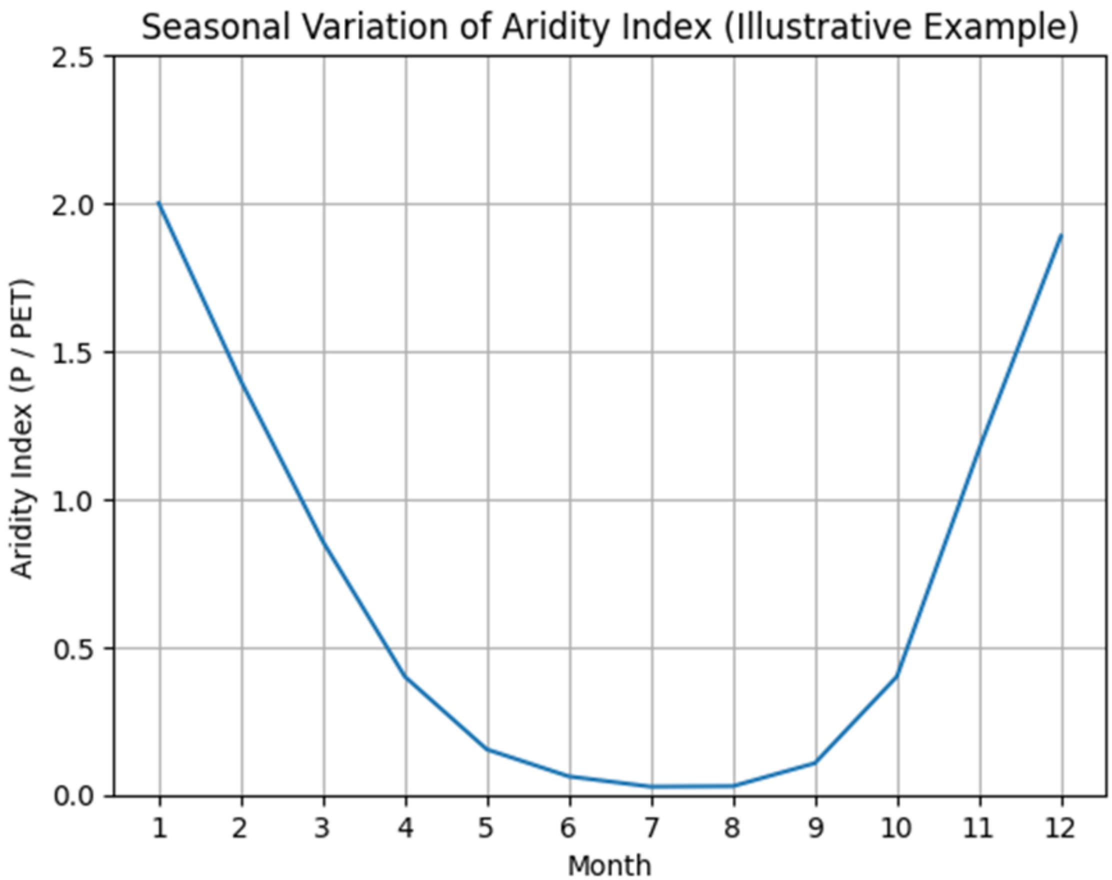
The aridity index (AI), commonly defined as the ratio of precipitation (P) to potential evapotranspiration (PET), is a fundamental indicator of climatic water balance. It expresses the relationship between water supply (rainfall) and atmospheric water demand (evaporation and plant transpiration). When precipitation is small relative to evapotranspiration, the AI is low and the climate is classified as arid or semi-arid. When precipitation more closely matches or exceeds evaporative demand, the AI is higher, indicating more favorable moisture conditions.

In most climatological analyses, the aridity index is presented as an annual average. While this approach is useful for global classification and long-term comparisons, it may conceal important intra-annual variability. In many semi-arid regions, rainfall is highly seasonal, concentrated in a defined wet period, while evapotranspiration peaks during a hot, dry season. Consequently, the aridity index is not constant throughout the year. It may be relatively high during a cooler, wetter season and extremely low during the hotter months.

This seasonal fluctuation is critical when evaluating land-use potential. A region classified as semi-arid based on its annual AI may still experience one or more months during which precipitation approaches or exceeds evapotranspiration. During this window, soil moisture can accumulate, plant water stress is reduced, and cultivation becomes feasible with minimal supplemental irrigation. Thus, even where the annual aridity index suggests marginal agricultural viability, seasonal analysis may reveal a viable cultivation period.

This perspective is particularly relevant to the implementation of ReSlope Global’s concept. By engineering artificial north–south-oriented slopes, the system modifies solar exposure, microclimate, and surface hydrology. Such terrain alteration can influence local energy balance, reduce peak soil temperatures on selected slope aspects, and improve effective moisture retention during the favorable season. When combined with careful timing of planting to coincide with periods of higher seasonal AI, the approach leverages both macroclimatic seasonality and microclimatic optimization.

In other words, ReSlope Global's strategy does not rely solely on increasing total annual rainfall. Rather, it seeks to optimize the existing climatic envelope. Even in regions where the annual aridity index remains low, seasonal windows of higher moisture availability can be amplified through terrain orientation and microclimate



Seasonal variation of the aridity index. Although the annual average value is less than one, indicating semi-arid conditions overall, certain seasons may exhibit significantly higher values that are favorable for cultivation. When combined with the expected microclimatic enhancement on the cooler north-facing slope, these seasonal windows may provide suitable conditions for crop growth despite the low annual average.

management. Crops can be cultivated during the season when atmospheric demand is lower and water availability is relatively higher, while slope design mitigates thermal and evaporative stress.

Therefore, the aridity index should not be interpreted as a fixed annual constraint but as a dynamic parameter that varies through time and space. Seasonal analysis, combined with engineered terrain modifications, can transform land that appears marginal under annual metrics into land that is seasonally productive. In this context, understanding and exploiting intra-annual variations in the aridity index becomes a key scientific foundation for the ReSlope Global implementation strategy.

2. Environmental & Physical Dynamics

How the physical shape of the land dictates the "behavior" of the crops and water.

Geometry: Defining slope shapes and dimensions.

Microclimate: Analyzing how heat and airflow behave differently on a narrow incline compared to flat land.

Hydrology: Addressing the risks of soil erosion and water runoff that naturally occur on altered gradients.

3. Applied Engineering & Optimization

The "action" phase where you design the solution.

Angle Optimization: Calculating the specific slope degree needed to minimize ET based on your local latitude and growing season.

Lab Testing: Building a physical slope platform to validate your mathematical models in a controlled environment.

4. Implementation & Logistics

Moving from the lab to the real world.

Regional Survey: Identifying high-potential areas for implementation (e.g., arid regions or hilly terrains).

Project Management: Finalizing the budget, securing funding, and establishing a division of labor.

Assessment of ecological and environmental impacts.

Public perceptions and economic impact.

Introduction: The North-South Slopes Concept

The North-South (N-S) Slopes concept is a biomimetic approach to land restoration, designed to replicate the vegetation patterns found in natural hilly terrains of

Typical natural North-South slopes in semiarid areas. The North-facing slope is lush, moist and green; the South-facing slope is dry and unusable.

Public Work in San Angelo, Texas. Grass appears spontaneously on the North-facing slope two weeks after digging.

Vegetation patterns on natural northern slope semiarid regions. In the Northern Hemisphere, northern-facing slopes receive significantly less direct solar irradiation. This natural shading reduces evapotranspiration (ET), preserving critical soil moisture that allows vegetation to thrive even when adjacent flat terrain remains barren.

The Mechanism

Our program proposes the intentional modification of topography through strategic earthmoving to create artificial N-S slopes. By concentrating cultivation on these protected northern aspects, we can establish green belts in areas where traditional flat-land agriculture is unsustainable.

While semiarid regions are defined by scarce rainfall, this method optimizes the efficiency of available water. This is particularly vital in regions where irrigation infrastructure—such as surface reservoirs or underground aquifers—is underdeveloped or entirely absent.

The concept of north south slopes

Program Roadmap

The initiative is structured into two primary phases:

Phase I: Collaborative Laboratory Development

A multinational effort bringing together specialized research groups to develop a "test lab" environment. This phase focuses on modeling and small-scale validation of soil-water dynamics.

Phase II: Full-Scale Pilot Implementation

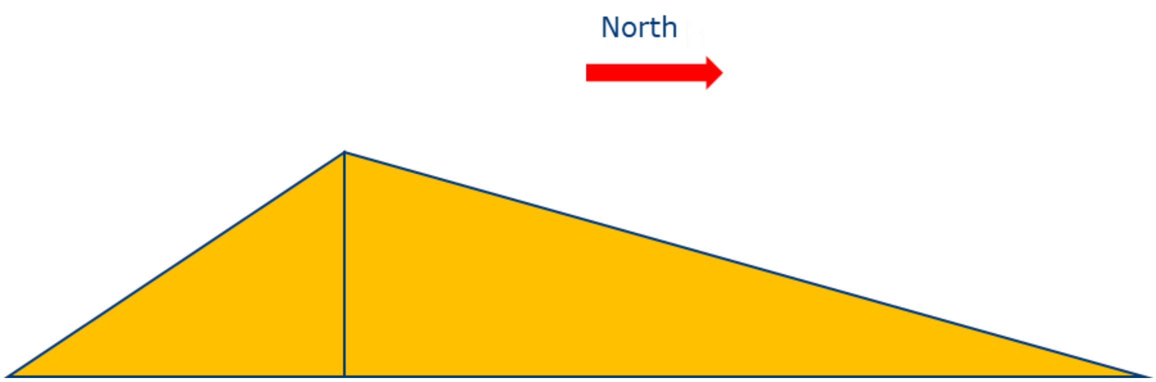
Expansion into diverse climatic zones across participating countries. These pilots will serve as proof-of-concept for regional economic and environmental scaling.

Strategic Funding and Impact

Funding for both phases will be sought from the governments of collaborating nations. By framing this as a multinational R&D program, we aim to attract international development organizations and governments dedicated to fostering sustainable economic growth and climate resilience in developing countries.

Slope Configuration and Orientation

The widths of the northern and southern slopes are distributed at a ratio of 2:1 or 3:1. This asymmetry is designed to maximize the cultivable surface area of the northern slope. To mitigate soil erosion on the steeper southern slope, protective measures such as plastic sheeting should be employed.



shape of the slopes – the width of the southern slope is smaller than the northern width to save land since the southern slope is not useable

The specific angle of the northern slope is not fixed; rather, it is calculated based on the required reduction in evapotranspiration, tailored to the specific climate and crop requirements.

Economic vs. Agronomic Optimization

The volume of earthwork required for construction is directly proportional to the cross-sectional area of the slopes, which increases quadratically relative to their dimensions. This relationship creates a primary design conflict:

Economic Constraint: Narrower slopes minimize earth-moving volume and associated labor costs.

Agronomic Benefit: Wider slopes offer superior practical utility for planting, maintenance, and harvesting.

Our program calculates the optimal dimensions to bridge these competing interests, ensuring cost-effectiveness without sacrificing agricultural productivity.

Penman Equation and its variables and sub-variables

The reduction of solar energy on a slope is expected to lower Evapotranspiration (ET). However, a shallow slope angle may not sufficiently reduce solar input to impact ET levels significantly. Conversely, an overly steep angle may excessively reduce solar radiation and photosynthesis while increasing soil erosion and water runoff. Therefore, an optimal slope angle is defined by the "necessary" reduction in ET relative to flat terrain. This required ET adjustment depends on the local climate, growing seasons, and specific crop requirements.

The Penman Equation calculates reference ET using weather variables and a standardized surface of short grass. More elaborate versions of the equation calculate an "adjusted ET" to account for taller vegetation and greater leaf area index (LAI).

The primary climate variables—solar intensity, air pressure, temperature, wind speed, and humidity—are typically measured by sensors positioned 2 meters above the surface. These primary variables are derived from several sub-variables; consequently, the equation is often simplified for specific applications. Our plan is to conduct a mathematical sensitivity analysis to determine how ET responds to perturbations in these weather variables and their respective sub-variables. To streamline the approximation, variables with negligible impact will be omitted.

Determination of Required ET Reduction for Terrain Modification

The primary objective of altering the terrain is to determine the specific reduction in Evapotranspiration (ET) necessary to minimize the gap between local precipitation and the irrigation water requirement. Ideally, the terrain should be modified so that the adjusted ET is less than or equal to local precipitation.

By calculating the "Target ET" required to achieve water neutrality, the specific slope angle can be derived. This transformation ensures that the microclimate created by the altered topography naturally sustains the crop, reducing or eliminating the need for supplemental irrigation.

Soil Stabilization & Runoff Management

One primary concern is the potential for soil erosion and water runoff on the sloping terrain, which could necessitate frequent, costly earthmoving.

The Southern Slope: Given its high susceptibility to erosion, this face may require protection. Rather than a standard plastic sheet—which can cause its own runoff issues—we might consider geotextiles or erosion control blankets. These stabilize the soil while allowing moisture to penetrate.

The Northern Slope: We can draw inspiration from agricultural engineering. Techniques used for hillside crops like grapes and winter wheat—specifically contour plowing, terracing, and the use of cover crops—can naturally anchor the soil and manage water flow.

If soil is eroded from the northern slope, it is not necessarily lost; it will accumulate in the inter-slope areas and, if needed, can be redistributed onto the slope every few years. Runoff water from the southern slope, which is covered with plastic sheeting, can be collected and reused to irrigate the northern slope.

There were numerous investigations on cultivation and

Hill-side vineyards and wheat

evapotranspiration on hilly natural slopes[4,5,6]. In none it has been suggested to alter or construct artificial slopes. Ours is a new focus – designing and constructing slopes' angle for a desired ET.

To date, only one small pilot project involving artificial north–south slopes has been developed and tested, in Israel in 1997, with promising results.

However, evapotranspiration was neither calculated nor incorporated into the design, and the slope angle was selected arbitrarily. The Israeli pilot was discontinued in the early 2000s.

Assessment of Ecological and Environmental Impacts

A comprehensive environmental assessment, including a full CO_2 footprint analysis, will be conducted. This analysis will evaluate the carbon impacts associated with cultivating cereal grains on newly created semi-arid arable land (for example, in Morocco). The assessment will also consider the potential carbon offset benefits resulting from reduced grain imports from regions where production and transport generate comparable or higher emissions. Additional carbon footprint considerations are addressed in the previous report.

Potential risks to wildlife will be carefully evaluated. Wildlife corridors will be incorporated at regular intervals between slope sections to allow safe and unobstructed passage for desert fauna. Furthermore, agronomists and soil scientists participating in the program will conduct detailed assessments of impacts on local biota, soil health, and ecosystem dynamics.

Public Perceptions and Economic Impact

Environmental organizations may oppose the implementation of the N–S slopes and could generate negative publicity. However, environmental policy decisions should be determined by the appropriate regulatory authorities and policymakers in the countries where implementation occurs.

Approximately 15% of the world's land surface is classified as semi-arid. The N–S slopes have the potential to generate employment, stimulate regional economic development, and strengthen food security in developing nations. In certain contexts, agribusiness companies may invest in land acquisition, rehabilitation, and large-scale cultivation, including production for export markets.

All are interested in joining an international collaboration that is expected to be funded by their respective government

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pilot for North-South slopes was tested on a ¼ acre plot. The pilot showed promising results but was abandoned.