

Key Economic variables of ReSlope Land Transformation

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Introduction

This document outlines key variables for a cost-benefit analysis regarding the proposed north-south (N-S) slope program. Please note that site-specific analyses—accounting for unique geographic locations and crop varieties—are outside the scope of this preliminary overview and will be delegated to local agricultural economists in a later phase.

Cultivation Modalities

Agricultural production is generally categorized into two primary modes:

Intensive Agriculture: Characterized by high-input cultivation on smaller plots. This method utilizes significant labor, fertilizers, and water per unit area to maximize yield, commonly seen in greenhouse operations focused on fresh produce for local markets.

Extensive Agriculture: Utilizes large land areas with lower input density per unit area, often relying primarily on natural rainfall. Extensive agriculture accounts for the majority of global human food and animal feed production.

ReSlope Global Strategic Focus

ReSlope Global's primary objective is to implement terrain alteration techniques to enable extensive agriculture across vast semiarid regions, specifically targeting commodity crops. While these slopes remain viable for intensive agricultural applications, the broader economic impact is projected to be greatest through large-scale extensive cultivation.

The ReSlope concept is designed to convert vast areas of underutilized semi-arid land—terrain that currently has little or no economic value—into productive agricultural land. The core principle is to capture and retain rainfall that would otherwise be lost. This is achieved by reshaping the terrain to reduce evaporation from the soil and transpiration through plants, a combined process known as evapotranspiration (ET).

By significantly reducing evapotranspiration losses, a larger fraction of natural rainfall is retained in the soil and becomes available for plant growth. In effect, ReSlope increases the productivity of rainfall itself, transforming marginal land into viable farmland without reliance on external irrigation.

The primary variables influencing the cost–benefit analysis include:

- the cost of earthmoving required to construct the optimized slopes;
- the market value of the newly created arable land; and
- the economic value of the water conserved through reduced evapotranspiration.

Earthmoving projects benefit strongly from economies of scale. Accordingly, this analysis assumes a representative project covering **10 square miles (approximately 25.9 square kilometers)**. At this scale, modern earthmoving

equipment can operate efficiently, allowing large tracts of currently unproductive land to be converted into valuable agricultural assets.



Fig. 1: Earthmoving by graders for slope construction

Earthmoving Cost

The cost of earthmoving required to construct the north–south slopes differs fundamentally from conventional earthmoving operations. Typical projects—such as building foundations or road construction—are carried out on relatively small areas. In these cases, soil is excavated by bulldozers or excavators and then transported over significant distances by trucks, which greatly increases both operational complexity and cost.

By contrast, the terrain modification required for the ReSlope Global system involves no long-distance transport of earth. The overall average elevation of the terrain remains essentially unchanged after the operation. Instead, the process consists of relatively shallow cutting and redistribution of soil to reshape the landscape into the required slope pattern, all performed locally without hauling material away from the site.

This type of operation can be carried out efficiently using motor graders—similar to those commonly used for road leveling or snow removal. Because the machinery can operate in long, uninterrupted passes without frequent turning, stopping, or reversing, the equipment can move at relatively high speeds in straight lines. As a result, large areas of terrain can be reshaped quickly, significantly reducing both time and cost.

Before any terrain alteration begins, the project site must undergo thorough surveys and analysis, including soil composition, geomorphology, climate conditions, and rainfall patterns. These studies ensure that the slope design is optimized for effective rainwater capture and agricultural productivity.

A summary is the following: 1/3 of the area is sacrificed for the unutilized southern slopes and for roads, so the obtained cultivable arable area is 6.66 square mile. The initial operation for N-S construction is scarifying, which tears the top soil with a grader equipped with scarifying blades. The cost depends on the number of hours of the grade operation, which in turn depends on the width of the grader's blade and the speed of the grader.

The fundamental equation^{A1} for a Caterpillar 24M is:

$$\text{Production (sy/hr)} = \frac{5280 \times S \times W \times E}{9} \times \frac{1}{N}$$

where sy/hr. = square yard per hour, 5,280 = number of feet per mile, S = grader motion speed MPH, W = blade width (24 ft), and E = efficiency factor or 0.9.

For scarifying the grader's speed is low, 3 MPH. For shaping, the speed is 6 MPH. The blade width is 24 feet. The number of passes for initial construction is 2 for scarifying and 2 for shaping. We also assume 2 shaping passes each 5 years to correct for soil erosion. For the total project of 10 years, 3 additional shaping operations are required for erosion corrections.

The cost of land rental in the U.S. Southwest is \$130/acre/year. In Italy the cost is \$110 per acre or \$247 per hectare. In other countries, however, the cost of rental land might differ; in some there may exist no land rental market at all.

Cost of water

The economics of water is complicated since it depends on the level of subsidies, the availability of underground and surface water and the energy and capital cost of pumping and piping water to the fields. Using our concept, however, retained rain falls **exactly** where the water is needed without pumping and piping.

Before assigning numbers, let's quantify the amount of water saved by rainfall retention. Assume for the sake of analysis that the site is the Dallas region, Texas, where the annual rainfall is 34 inch or 860 mm, but the area is still semiarid due to intense solar radiation and evapotranspiration.

Barley, oats and wheat each require 450-650 mm, and beans require 300-500 mm. This would mean that even a fraction of the rainfall is enough to replace the necessary 600-mm water requirements. One acre = 4,000 sq. meters. This annual amount of water is equivalent to 2,400 cubic meters per acre which is 5,900 cubic meter per hectare.

The subsidized cost of farming water in California, for example, is ~ \$100 per acre-foot while 1 acre-foot =1,200 cubic meters. This means that the cost of farming water is ~\$0.05 per cubic meter. The worldwide cost of water is in the range of \$0.05-0.10 per cubic meter (Bierkens et al., 2019).

Case in central Italy: We consider an agricultural district of central Italy (the Upper Tiber valley, Umbria region) with an area of about 77 sq. km, where a large part (about 70%) of the crops (mainly tobacco, maize, cereals, vineyards and olive groves) are irrigated (Dari et al., 2022). The annual mean rainfall is about 800 mm.

One of the most water-demanding crops in the area requires ~ 3200 m³/ha, i.e., 320 mm. The experimental evaluation of the actual ET is not straightforward. We can assume, on the basis of satellite estimates (MODIS), a mean annual value of ET and PET (potential ET) of ~ 500 mm and 1400 mm, respectively. Hence, it would seem that the annual rainfall could cover the water required, but the temporal distribution of rainfall, together with the high ET rates and the economic implications of the production of tobacco, necessitate irrigation practices. In fact, as shown in Figure 2, rainfall precipitation is lower during the summer months,

i.e., from June to August, when crops require more water. Hence, the ET reduction induced by N-S slopes could also save irrigation water amounts over intensively cultivated areas. In Italy the cost of the water for agricultural purposes ranges between 0.02 and 0.05 €/m³, which is also \$0.05/m³.

Therefore, in Italy, the reduction of ET might be enough to replace a portion, but not all, of the water for the required irrigation. Therefore, a farmer in Italy should decide if the reduction of ET is worth the reduction of arable land due to the need to sacrifice 33% of the arable land required for southern slopes.

This observation is correct in general even if we consider an average annual rainfall of 800 mm because of the seasonal distribution of the rainfall amounts. In any case, a reduction of ET in the summer surely would reduce the demand for irrigation. The costs-benefits analysis must obviously be done and depends on the expected percentage of reduced ET.

Coming back to Texas, the sloping terrain saves 2,400 cubic meters per year and per acre, so the additional water cost avoidance is $2,400 \times 0.05 = \$120$ per year per acre, which is **comparable** to the annual cost of land rental in Texas.

Even in California and Italy, for example, where existing semiarid arable cultivable land uses irrigation water, this concept makes sense even if it does not produce additional arable land. A farmer in California should decide whether to sacrifice 33% of her land for the southern slopes in order to avoid water costs via rainfall retention on the northern slopes.

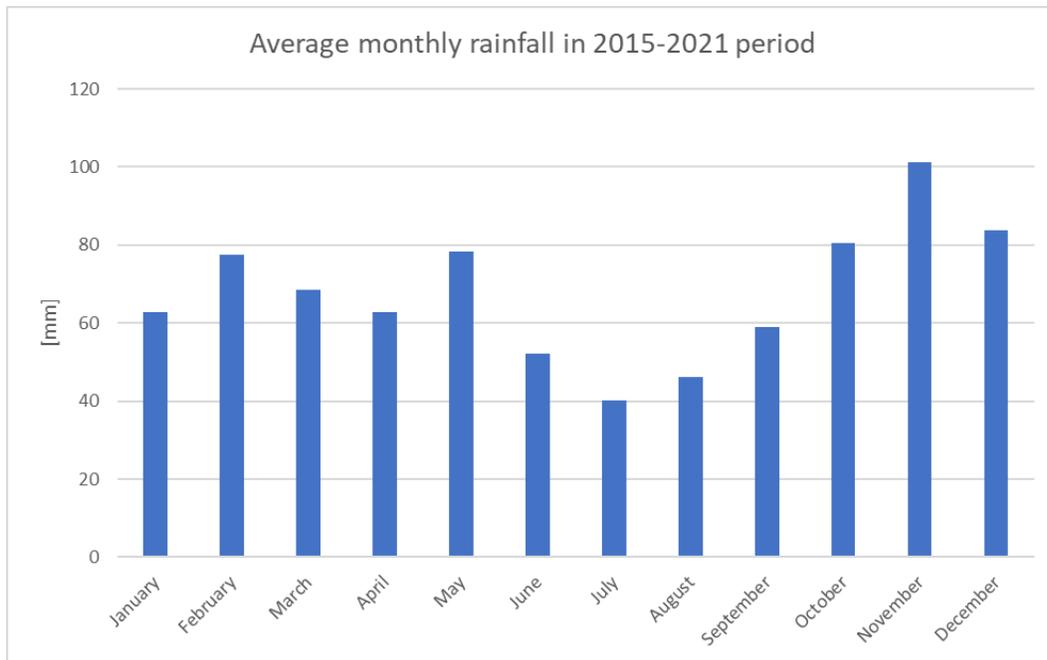


Figure 2: Average monthly rainfall over the Upper Tiber, Italy in 2015-2021. The mean value for the June-August trimester is ~140 mm.

Due to climate change, dire predictions exist for the availability of farming water in semiarid countries in the future, and it is more than likely that subsidies for water will be curtailed. This curtailment would mean that the water cost avoidance by the slopes will be even greater, providing further economic viability for the concept.

Intangible Considerations

Many developing countries rely heavily on imported food, which exposes them to volatile global prices and contributes to food insecurity. Converting semi-arid land into productive agricultural land therefore offers additional, non-quantified benefits by reducing dependence on food imports and strengthening domestic food security.

Semi-arid soils often contain very low levels of organic matter. As a result, they present an opportunity to function as significant carbon sinks. ReSlope Global plans to develop and deploy technologies for carbon sequestration—such as the

use of biochar and finely ground rock dust—to increase soil organic content. These practices may also generate additional revenue through carbon credits.

This writeup shows four key benefits of the enterprise:

- a. Formation of arable land;
- b. Avoidance of water costs;
- c. Food security; and
- d. Carbon sequestration by the combination of using dust rock and biochar production systems, which could provide credit revenue.

This write-up presents a methodology and a preliminary framework for a more detailed analysis to be conducted by earthmoving experts, hydrologists, and water economists engaged by ReSlope Global. Their work will refine these assumptions and produce a rigorous evaluation demonstrating the economic viability of the enterprise.

References

1. The Shadow Price of Irrigation Water in Major Groundwater-Depleting Countries, Marc F. P. Bierkens, Stijn Reinhard, Jens A. de Bruijn, Willeke Veninga, Yoshihide Wada, *Water Resources Research*, Volume 55, Issue 5, pp. 4266-4287, 18 April 2019, <https://doi.org/10.1029/2018WR023086>.
2. Dari, J., Brocca, L., Quintana-Seguí, P., Casadei, S., Escorihuela, M.J., Stefan, V., Morbidelli, R., 2022. Double-scale analysis on the detectability of irrigation signals from remote sensing soil moisture over an area with complex topography in central Italy. *Adv. Water Res.*, in press, 104130. <https://doi.org/10.1016/j.advwatres.2022.104130>.