

# Soil Bioengineering to Deal with Soil Erosion and Landslides in Developing Nations

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## Abstract

The study has focused on the impacts of bioengineering on soil erosion prevention along with lower the risk of landslides that can accelerate the probability of nation progression considering financial benefits of using this technology. Agriculture field of different developed countries are the mostly influenced by the implication of bioengineering. On the other hand, GREEN infrastructure development through the application of bioengineering also has been focused here. Advantages and disadvantages of this technology also have been discussed over here to depict the importance of bioengineering for the development of nations. Road management also has been highlighted in this study to understand the unique characteristic of bioengineering. Basic principles of bioengineering technology have been prioritized here to measure the strength of this technology. Bioengineering practices considering the prevention of soil erosion and landslides also has been described here following the particular steps. Cost effectiveness and long term impact also has been discussed over here to highlight the beneficial aspect of country development including economic strengthening.

## Keywords

Agriculture, Bioengineering, Soil erosion.

## INTRODUCTION

Diverse engineering measures are the trending path to prevent **soil erosion considering bunding, contour trenching, terracing and grassed waterways**. Bioengineering is the highest applicable technique in the agriculture field to maintain the progression of nations. **Palisades, brush layering, bamboo fencing and wattle fencing** are the progressive initiatives taken by many countries to strengthen the economic background of the nations. Advanced agricultural insight of a nation symbolizes the national development of the country including less poverty, employment opportunities and competitive advantage of economic sustainability. Implication of **soil bioengineering** to some extent ensures the use of plant material, elimination of environmental problems, reducing rapid landslides, eroding slopes. **Plants are the main component of implicating bioengineering** in preventing soil erosion and landslides [1]. Bioengineering has prioritized perennial plant cover, crop cover planting, mulching to prevent landslides and providing assurance for growth of agriculture plants.

**Earth walls** are the innovative initiatives of bioengineering that determined the reduction of soil erosion by using slopes. **Controlling runoff is an extra advantage of bioengineering technology** that can prevent the erosive force of soil [2]. Considering all the consequences, bioengineering can be defined as a biological system that helps to create products or control or modify the products according to the requirements of biological structures including agriculture, medical, construction and many other fields. Bioengineering accelerates the natural way of preventing landslides and soil erosion by prioritizing the plant vegetation. Implication of

bioengineering improves the drainage systems of lands to prevent landslides along with creation of angles in slopes and can also excavate the slopes from overload. In bioengineering there are different positive aspects to prevent soil erosion and create revolutionary enactment, especially in the agriculture perspective of developed countries. Slowing and trapping of runoff are the main aim of bioengineering technology that helps to achieve the progression goal of nations.

## MATERIALS AND METHODS

Particular techniques are used in this study to execute the study properly with informative justification, the techniques are

### Research design

The study has been used in qualitative research design to execute the study to reach the goal of the study. Qualitative research design helps to establish justified answers on the basis of phenomenon queries relevant to the subject of the study. Obtaining data considering communicational approach and existing information are the basic criterion of the qualitative research design. The subject of the study has highlighted the impact of bioengineering on the preventing soil erosion and landslides that reflects on the progression of nations. General perspectives of the realistic world can justify the subject of the study and the writer of this study has selected the qualitative research design to justify the significance of the study.

### Research type

Research types indicate the techniques that have been used by the writer to conduct the research depending on the data information. There are two types of research, one is

quantitative and another one is qualitative. In this study a secondary research type has been used to meet the objectives of the study. Already existing data information is mostly used in secondary research that has more authentication and reliability [3]. Considering the intensity of the study the writer of the study has selected the secondary research type to meet the purpose of the study. Reliable information regarding the evaluation of bioengineering in nation development considering the soil erosion and landslides has been prioritized by the writer of the study; hence secondary research type has been used in this study.

**Inclusion and exclusion criterion**

**Table 1:** Inclusion and exclusion criterion

Inclusion criterion	Exclusion criterion
<ul style="list-style-type: none"> <li>Secondary data collection procedure has been included in this study.</li> <li>Peer reviewed journals are used in this study.</li> <li>Qualitative research type has been included.</li> <li>Secondary data collection method has been used.</li> </ul>	<ul style="list-style-type: none"> <li>Primary data collection method has been excluded in this study.</li> <li>Survey and interview are excluded in this study.</li> <li>Quantitative research type has been excluded.</li> <li>Primary data collection method has been excluded.</li> </ul>

**Data collection techniques and analysis**

Secondary data collection procedure and thematic data analysis technique have been used in this study. Peer reviewed journals are used in this study as data sources from where secondary data has been collected. Already existing information can be retrieved from peer reviewed journals that make the study more reliable and trustworthy for the readers. Time and cost effective approach of secondary data collection procedure helps to meet the goal of the study with proper informative justification. Relevant to the subject of the study, secondary data information collected from peer reviewed journals enhances the quality of the study. Depending on the secondary collected data thematic analysis of data has been done in this study to signify the study. In thematic data analysis the writer has the scope to interpret the data with a combination of realistic observations relevant to the subject of the study including a flexible and independent approach [4]. Interpretation of secondary data through developing themes is a time saving and cost effective approach that meets the study goal with informative justification. Subject of the study has focused on the impact of bioengineering on countries' development that can be justified with thematic interpretation of secondary collected data.

**Choice of subject**

Economical development of a nation to some extent depending on the agriculture perspectives considering the implication of advanced technology. Bioengineering can be

defined as an advanced initiative of developed countries and the study has focused on this topic prioritizing the progression of nations. Importance of preventing soil erosion and landslides to grow the agriculture field also has been focused in this study. Competitive advantage of bioengineering also has been prioritized by the writer of the study to depict the needs of nation's progression.

**RESULTS**

**Soil bioengineering application and practices in agriculture field**

Soil bioengineering is the most effective approach used by different countries to fertilize the soil enough to grow crops considering the agricultural development. Stream banks are the most soil erosion prone areas that have to be prevented and the application of bioengineering techniques helps to prevent the soil erosion and enhances the soil fertility. Vegetation on slopes is the most useful technique of bioengineering that stabilizes the stream bank soil erosion. Brush layering, palisades, live checking dams, fascines and vegetative stone pitching are the best soil erosion preventing features of bioengineering that ensures the agriculture development of different countries [5]. Cost Effectiveness of bioengineering enhances the use of these techniques and ensures the accessibility along with availability of these techniques. Bioengineering applications are focused on the locally available raw material that reduces the operational cost of this application.

Economic benefits of these techniques also have been prioritized considering the strengthening criteria of the global economy along with nation's progression. Low cost labour also decreases the initial installation cost of bioengineering in the agriculture field that can be afforded by all economic groups of farmers. Smart firming also has considered the application of bioengineering to increase the progression of the agriculture field. Continuous growing of crops has been determined by the application of bioengineering that ensures the economic growth of the agriculture field. Scientific implication in biological systems using bioengineering is a revolutionary enactment of nation's progression [6]. Implication of advanced technology indicates the progression of a country and establishing GREEN infrastructure in the yield to prevent soil erosion and landslides is a progressive example of different countries. Biodiversity conservation considering the GREEN infrastructure has been influenced by the bioengineering technology that ensures the vegetation procedure in soil.

Improving soil stabilization, soil surface protection and enhanced drainage functions has been prioritized in the GREEN infrastructure to maintain the ecological balance of the environment. The main purpose of bioengineering is to meet the requirement of plants that includes strong and flexible stems needs, recovering criterion, low canopy, fibrous roots and many more needs of plants. There are different functions of bioengineering that enhance the probability of plants growth, such as catching, armouring,

reinforcing, anchoring, supporting, reducing and draining capacity [7]. Growing productivity of crops increases the economic growth of the agricultural aspect of nations that reflects on the financial sustainability of the developed countries. Most effective techniques of bioengineering are grass planting, direct seeding, brush layers and fascines, truncheon cuttings, tree planting, large bamboo planting, vegetated stone pitching, geo-textile covering, wattle fences and hydro seeding that are used by developed countries. Southwest Asian Countries are influenced by this bioengineering technology that enhances the sustainability of the nation.

This particular technology passively encourages the different business perspectives by providing raw materials in a cost effective way. Long bamboos are the example of raw materials that have been grown in large quantities with the help of bioengineering techniques [8]. Environment sustainability and economic strength both have benefited with the implication of bioengineering prioritizing the Green infrastructure in the agriculture field of developed countries. Considering the environmental and social benefits, bioengineering has several financial impacts that help to lead

the progress of a nation. Implication of bioengineering enhances the road infrastructure and reduces the road maintenance cost that influences the economy of nations.

Preventing soil erosion and landslides decreases the loss of agricultural productivity that determines financial growth of developed countries. On the other hand, employment opportunities have been prioritized with the implication of bioengineering considering low cost labour charges and prioritizing women empowerment. Economy and environment both are the measuring criteria of a developed country and implementation of bioengineering ensures the progression of the nation [9]. Bioengineering practices follow some planning, designs and procedural steps that accelerate the efficiency of bioengineering techniques in a country's development. The practices of bioengineering have four phases that include planning, designing, implementation and monitoring along with maintaining the overall techniques. The further outcomes have a positive impact on managing the environmental and agricultural consequences that ensure the progression of a nation considering financial aspects.

PHASE	STEP	ACTION TO BE TAKEN	RESULT/OUTPUT EXPECTED	LOCATION
Planning	1	Make an initial plan of the year's works	List of sites requiring treatment	Office
	2	Prioritize the work	List of sites in priority order	Roadline
	3	Initial site appraisal	Divide the sites into segments for assessment	Sites
	4	Assess the site	Detailed plan of site with problems identified	Sites
	5	Determine combination of works required	Initial plan of civil and bioengineering techniques	Sites
	6	Choose the optimal techniques for the site	List of techniques to be designed in detail, with measurements	Sites
Design	7	Design the civil and bioengineering works	Detailed designs for all required works	Office
	8	Select the species to use	List of actual species of plants to be used	Office
	9	Calculate the required quantities and rates	Table of quantities, rates, and costs for all required works	Office
	10	Finalize priority against available budget	Finalization of site works to be completed within available budget	Office
	11	Plan plant needs	Determination of the actual sources of bioengineering plants	Office
	12	Prepare documents and arrange implementation	Draft contract documents and arrange procurement	Office
PHASE	STEP	ACTION TO BE TAKEN	RESULT/OUTPUT EXPECTED	LOCATION
Implementation	13	Prepare for plant propagation or procurement	Arrangements made for provision of all required plants	Nursery/Source
	14	Make the necessary site arrangements	Contracts and other procurement and logistical arrangements	Office/Sites
	15	Prepare the site for work	Site access and safety provisions completed	Sites
	16	Implement the civil engineering works	All earthworks and hard engineering completed	Sites
	17	Implement the bioengineering works	All bioengineering works completed	Sites
	18	Monitor the works	Regular inspections undertaken to ensure works are functioning	Sites
Maintenance	19	Maintain the works	Repairs, cleaning, and refinement undertaken, as necessary	Roadline/Sites

**Figure 1: Bioengineering practices**

Implication of bioengineering in preventing soil erosion and practices of this particular technique in agriculture development encourages the GREEN infrastructure in the agriculture field of developed countries that focuses on the progression of nations. Planned and designed execution of bioengineering techniques determines the cost effective and positive outcomes from the implicated area that ensures the management of ecological balance along with economic benefits [10]. Restoring, improving and maintaining characteristics of bioengineering have successfully established the quality infrastructure in fields considering soil stabilization using different strategies. Soil erosion prevention has passively affected the economy of developed countries and bioengineering mitigates the risk factors of soil erosion to develop the economical aspect of different developed countries.

#### **Advantage and disadvantage of bioengineering considering development of nations**

Adoption of bioengineering in road maintenance and agriculture infrastructure has been influenced by its impacts on preventing soil erosion and landslides in the agriculture field. Implementation of bioengineering in different fields strengthens the economic aspects of nations and leads the nation to progress. Most influential impact of bioengineering technology is the low cost of installation and long term low maintenance cost compared to traditional methods [11]. This feature of bioengineering accelerates the profitability rate in the agriculture field by increasing productivity of agriculture crops. Road maintenance cost also has been reduced by the application of bioengineering that reflects on financial improvement of nations. Live plants maintaining cost also can be controlled by the implication of bioengineering in agriculture fields and ensure the increased productivity of the crops. Balance of biodiversity is impacted with the effectiveness of bioengineering. Reduction of water pollution and improving the quality of water is another beneficial aspect of bioengineering technology.

Aesthetical improvement of water also can be controlled by bioengineering technology that increases the sustainability of the environment to move ahead on the progression of nations. Structural stability of different fields has been transformed with the implication of bioengineering as the root systems of different project execution has been strengthened by this technological support. Comprehensive compatibility of environments is impacted with the effective implication of bioengineering [12]. In sensitive sites and limited accessible areas, bioengineering can be easily available and applied. Ecological development also has been enhanced by this unique characteristic of bioengineering.

Considering the positive aspects of bioengineering technology, there are some limitations that can create barriers for beneficial implication of this application such as this process is to some extent dependent on the plant's dormant seasons that limits the site's availability. The results reflect on difficulties of installation of this technology in improving soil stabilization and also decrease the ability of slope based

landslides. Lack of knowledgeable and experienced skilled labor delays the process of execution of bioengineering technology [13]. Skilled training programmes are required for the installation of bioengineering technology to maintain the basic principles of bioengineering to maintain the quality of bioengineering technological application. Alternative practices are also creating a threat to the bioengineering technology as considering the challenges of bioengineering society and environment adopt the alternative substitute of bioengineering.

Manufacturing and installation delay of bioengineering technology in different fields according to the service demand affects the different projects and slows the development of nation progression. Lack of reluctant parts of bioengineering technology creates difficulties for labourers for proper installation of bioengineering technology. Some technological equipment of bioengineering needs frequent modification and servicing along with preventive maintenance that can increase the expenditure cost of bioengineering technological application execution [14]. This feature of bioengineering technology discourages different fields to adopt the technology considering the progression of nations. Prioritization of the national progression has increased the requirement of bioengineering applications to install in different fields that enhance productivity along with maintaining the environmental balance.

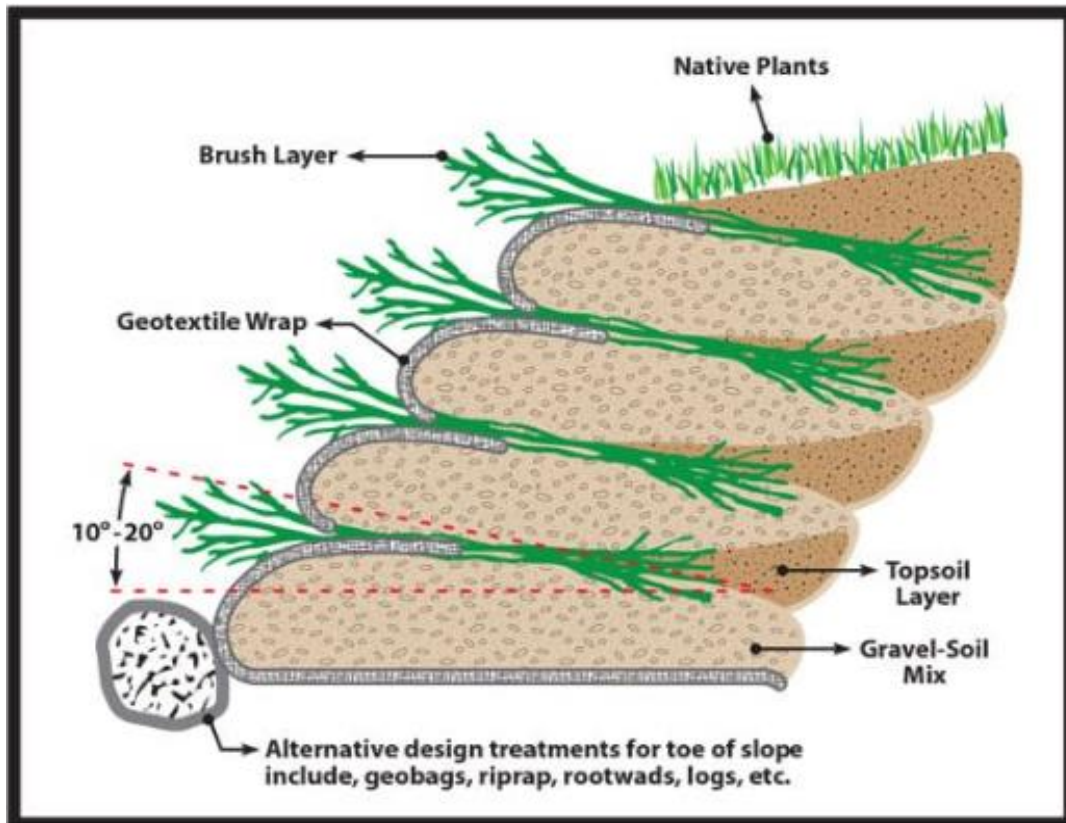
#### **Effects of bioengineering in roadside management**

Soil bioengineering can be considered as the instant solution for small site problems that also ensure the economic savings and potentially impact the road maintenance. Soil erosion can cause big damage to roads that increase the cost of repairing the road. On the other hand, bioengineering prevents soil erosion and increases the soil stabilization that ensures the long term effects on road maintenance. Soil bioengineering also requires less heavy equipment excavation that lowers the soil disturbance and determines the strength of roads along with preventing landslides [15]. Native plants materials and seeds accessibility helps to prevent landslides as slopes are used in planting the trees and crops that increase the soil quality. Enhancing the strength of the slopes through using soil bioengineering ensures lower landslides and decreases the effects on roads. Installation timing of bioengineering is the preferable feature for the road construction as other construction projects are slower than peak time. This feature helps to reduce the high pressure on roads and ensure the stabilization of road strength.

Erosion control covers under the bioengineering technology also has been a unique characteristic that prevents the roads from the climate uncertainties, animal interruptions that lower the damaging risk of the roads. Live crib walls are another preventing measure of bioengineering that prevents the effect of unnecessary interference on roads along with strengthening the roads capacity. Live gully repair also determines the land and slopes loading capacities [16]. Log terracing and vegetated geo-textile also has increased the

proficiency of road construction that increases the economic strength of different countries considering the implication of bioengineering. Limited accessible sensitive area's roads also

can be maintained by the implication of bioengineering for its easy accessibility nature.



**Figure 2:** Soil bioengineering

The process of bioengineering has been considered the evaluation of sites and design checklists that determines the strengthening construction of the roads and maintaining roads construction for a long term aspect with a cost effective approach. Topographical analysis capability of bioengineering also increases the project success rate that symbolizes progression of nations [17]. Climate conditions have also been considered by bioengineering technology to prevent landslides and slope stabilization disturbance. Vegetation and soil skills are checked before the project work is started under the application of bioengineering. Avoiding earthwork based on structural soil conditions also has enhanced the quality of roads.

Planting trees on the basis of bioengineering technology has considered the site characteristics, existing vegetation aspects, rooting features of vegetation, ecological relationship of plants relevant to growing nature, availability of resources and logistical structure along with economic constraints that determines the development of the progressive countries. A nation's progression to some extent depends on the environmental infrastructure, social overview and economic independence of that particular country and bioengineering accelerates the development of nations with the implication of advanced technological comprehension to the country profile [18]. Competitive advantages of bioengineering in different effective areas considering global

aspects enhance the progression of countries that strengthen the sustainable position of nations in the overall world.

### DISCUSSION

The study has focused on the evaluation of bioengineering impacts on preventing soil erosion and landslides that reflects on the development of different countries. Different methods of bioengineering have been interpreted here with its effectiveness in the agriculture field along with road maintenance. Basic principles of bioengineering have been discussed in this study to highlight the unique characteristics of bioengineering. Plants have been considered as the main components of bioengineering. Palisades, brush layering, bamboo fencing and wattle fencing, trenching, terracing, brush layering, grassed waterways are the most influential methods of bioengineering that confirms the prevention of soil erosion and landslides. Cost effectiveness of bioengineering and its impacts on nations' progression also have been focused in this study to justify the subject of the study.

The result showcases the practices of bioengineering in the agriculture field that enhance the soil stabilization factors along with increasing the quality of soil. Stream bank soil erosion has been prioritized by bioengineering technology to prevent the soil erosion and lower the risk of landslides.

Slope based planting also has been considered in the application of bioengineering techniques. Green implication including bioengineering technology also has been considered in this study to depict the importance of bioengineering as a competitive advantage of the nation. Advantages and disadvantages of bioengineering have been briefly discussed in this study to analyze the adoption probability of bioengineering methods. Considering the advantages, certain limitations of bioengineering can slow the development of a country. Less knowledgeable and inexperienced labourers hampers the quality of bioengineering impacts. Seasonable implications of bioengineering technologies is depending on dormant trees has limited the site's accessibility.

Alternative practices also decrease the demand of bioengineering technology on the basis of its limitations. Lack of skilled training programs is another barrier for adoption of this technology by the progressive fields of countries. Manufacturing and servicing delay also decrease the efficiency of bioengineering application. Despite this, the cost saving approach and long term effectiveness of bioengineering technology influences the adoption of bioengineering technology in different working fields of a nation. Environmental engagement of bioengineering applications enhances the quality of water, prevents soil erosion and landslides that helps to maintain the ecological balance of nature. Development of root systems of structural projects is another positive aspect of bioengineering that accelerates the progression of a country. Compatibility relationship of bioengineering with the environment considering limited accessible sites also added an extra advantage to a nation's progression.

Development of roads and agriculture productivity explore the beneficial consequences of economic growth of a country considering the implication of bioengineering technology. Prevention of landslides and long term effective road management also increases the probability of country developments. Increasing soil stabilization by preventing soil erosion strengthens the road capacity that controls maintenance cost for a long term aspect. Unique features of bioengineering techniques such as erosion control covers, using native plants materials, live gully repairing, installing crib walls are helping to enhance the road capacity and also lower the risk of landslides. Slope based planting also has been prioritized by the bioengineering technology that increases the road management capability of bioengineering technology that ensures economic benefits of nations. The overall results of evaluation of impact of bioengineering in preventing soil erosion and landslides has highlighted nations progression can be accelerated with the implication of bioengineering in a cost effective manner.

### CONCLUSION

Bioengineering techniques have an influential impact on preventing soil erosion and landslides that enhances the probability of development of countries. Different techniques

such as palisades, brush layering, bamboo fencing, and grass planting are considered as revolutionary implications of bioengineering techniques as it has an effective perspective on economic strengthening of developed countries. Secondary data collection procedure and thematic data analysis on the basis of peer reviewed journals have been followed in this study to justify the subject of the study. Evaluation of the impact of bioengineering in prevention of soil erosion and landslides considering nations progression has been highlighted in this study. Implication of bioengineering and its practices in the agriculture field including establishment of GREEN infrastructure also has been depicted in this study. On the other hand, risk reduction of landslides also has been focused in this study to analyse the advanced technological implication of bioengineering application in development of a nation.

Depending on the subject consistency of this study pros and cons also have been considered to measure the strength of bioengineering technology. Road management in a long term aspect and cost effective approach considering bioengineering technology also has been discussed in this study to analyse the economic benefits of this particular application that enhances a nation's progression. Environmental and economic benefits of bioengineering techniques have been discussed over here that reflect on the sustainable development of countries considering different aspects of nations. Functions and characteristics of this particular technique also have been depicted here highlighting the cost effectiveness of this technique. Prioritizing the plant's components and vegetation procedure has been utilized by these techniques focusing on preventing soil erosion and landslides. Agriculture productivity has been increased by the implication of bioengineering techniques that has an influential impact on business progression.

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