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Cost-Benefit Analysis of the Billion Tree Tsunami Afforestation Project: Insights from Hazara Region, Khyber Pakhtunkhwa

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Abstract
An innovative project called the Billion Tree Tsunami Afforestation Project (BTTAP) was started in Khyber Pakhtunkhwa, Pakistan, with the goals of improving carbon sequestration, restoring damaged ecosystems, and offering financial and environmental advantages. With an emphasis on the Hazara region, this report critically evaluates the project's environmental effect, economic viability, and benefit to local life. The cost-benefit analysis of the study indicates that BTTAP has an internal rate of return (IRR) of 6% and a benefit-cost ratio (BCR) of 1.7, which means that investors will get back 70% of their money. Despite the project's successful eight-year cost recovery, issues including fire hazards, inadequate post-project monitoring, and lost chances to plant fruit-bearing plants on shared lands continue to exist. The findings emphasize afforestation's transformational potential for ecological restoration and economic viability, as well as the importance of governmental interventions to improve community involvement and project sustainability.

Keywords: Billion Tree Tsunami Afforestation Project, Cost-Benefit Analysis, Carbon Sequestration, Economic Viability

Background of the Study

Climate change is a major problem for the world and a threat to the global economy. CO_2 is a significant component of greenhouse gases, which are a key contributor to climate change. In 2005, forests covered 30% of the world's territory, or about 3.8 billion hectares. By 2015, the percentage of forest cover had slightly climbed to 31%, or 3.9 billion hectares. Approximately 1.6 billion people worldwide rely on trees for their livelihood (FAO, 2020). While the natural forest area has decreased over the past 20 years, the planted forest is trending upward (Reams et al., 2015). Rapid economic and agricultural growth put enormous strain on forest cover, yet forest resources continue to play an important role in providing food security for rural household populations in developing countries (Jagger et al., 2014).
Pakistan is one of Asia's most populous countries, but it only has around 2.5

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DIALOGUE SOCIAL SCIENCE REVIEW

Vol. 3 No. 3 (March) (2025)

percent of its territory covered by forest (Erbaugh and Oldekop, 2018). According to Ahmed and Long (2013), natural gas accounts for over half of Pakistan's CO2 emissions. There are several strategies for mitigating CO2 emissions, and the cost of sequestration through forest or other land management is substantially cheaper than other methods of CO2 emission reduction. According to several scientific investigations, CO2 emissions have a favorable influence on forest production (Keutgen & Chen, 2001). The United Nations provides a framework under the Kyoto Protocol (1997) with the primary goal of reducing climate change by controlling the carbon market and investing in emissions. One of the Kyoto Protocol's provisions is the Clean Development Mechanism. Following the agreement, numerous national utilities and private enterprises invested in the forestry sector. In Pakistan, population growth, weak governance, and economic instability have all played a role in frantically supporting the earth's ecology, which has suffered massive harm in recent decades (Zhang et al., 2012). A billion-tree tsunami afforestation project (BTTAP) was started in 2014 in the Pakistani province of Khyber Pakhtunkhwa. It was completed in August 2017 in accordance with the forest policy and the Khyber Pakhtunkhwa Forest Ordinance 2002. The goal of this project was to push the green growth initiative, livelihood, and livestock in the rural area and mitigate the impact of climate change.

Forest plantation and new tree planting are well established in both the public and commercial sectors. According to the FAO (2016), planted areas accounted for only 7% of worldwide forest cover in 2010. To meet the demand for timber products while mitigating the effects of climate change, new plantation projects are being built in various places and regions that were previously unforested (Marchi et al., 2020). The growing trend of tree planting has significantly contributed to forested farmland, and plantation forests have been constructed to meet rising worldwide demand for wood products (FAO, 2016).

Under certain conditions, expanding plantations are predicted to have a higher potential for CO2 sequestration than current wild forests. Regenerating forests or newly planted trees can continue to store carbon for 20 to 50 years or more in an undisturbed environment. Tree planting has yet to make a significant impact on lowering CO2 levels in the atmosphere when compared to preventing the loss of natural forests. Planting a tree may remove around 101 to 106 giga tons of CO2 per year, which is similar to the entire world GHG emissions of 50 GT in 2004 (Yingjie et al., 2019).

The development of REDD+ (Reducing emissions from deforestation, degradation, sustainable forest management, conservation, and enhancement of carbon stocks in forests) as a critical tool for forest-based climate change mitigation in developing countries necessitates a reliable assessment of the total biomass of standup plants in the jungle (Agrawal et al., 2011). Accurate biomass evaluations need reliable algometric models to extract oven-dry biomass from forest catalogue data (Chave et al., 2014). Regression is used to estimate the biomass of standup trees based on a variety of characteristics such as diameter at breast height (DBH), total tree height (ht), crown diameter, and wood density at a specific site. Furthermore, the participation of these factors in above-ground biomass (AGB) varies by location, stand structure, disorder degree, and species structure (Whitmore, 1984). Although much research has been conducted to produce the (Brown, 1997; Chave et al., 2005; Litton & Boone, 2008), little work has been done for tree species of temperate mountains.

ISSN Online: 3007-3154
ISSN Print: 3007-3146

DIALOGUE SOCIAL SCIENCE REVIEW

Vol. 3 No. 3 (March) (2025)

Several countries throughout the world recently started forest tree planting in their own regions, with the goal of mitigating the impact of climate change. For example, the Chinese government reassigned about sixty thousand soldiers allegedly to plant trees and expand the nation's forests, with the goal of covering over eighty-four thousand square kilometers with trees by the end of 2018. The campaign's major goal is to raise the nation's forest cover from 21 percent to 23 percent of its total area by 2020. According to a China Forestry Administration officer, the government plans to grow its forest acreage by up to 26% by 2035 (Campbell, 2014). In India, volunteers planted 66 million trees in 12 hours in 2017 and made a proposal to the Paris Agreement to increase forest area by five million hectares by 2030 to offset the effects of climate change (Baynes, 2017). Bangladesh recently announced a giant tree planting operation in an effort to alleviate regional environmental concerns. During the National Tree Plantation Campaign and Tree Fair event, the government claimed that three million trees were planted around the country in 2018 (Xinhua, 2018).
The Pakistani province of Khyber Pakhtunkhwa is situated near the Afghan border in the northwest. Under the guidance of the Khyber Pakhtunkhwa forest policy and ordinance 2002, the province of Khyber Pakhtunkhwa in Pakistan initiated the billion-tree tsunami afforestation project (BTTAP) in 2014, which was finished in November 2017. The purpose of this project was to support KPK Province's forestry efforts and advance the green growth program (WWF, 2017). The primary goal of BTTAP was to help Pakistan, the seventh most climate-vulnerable nation in the world, mitigate the main consequences of climate change (WWF 2016). With a growth rate of around 5.7%, Pakistan is the sixth most populated country in the world. Nearly 2.2% of its land is covered by forests. However, under international standards, any nation must have around 25% of its land covered by forests. BTAAP's primary goal is to promote green growth. Afforestation is 40% of the project, with the remaining 60% being regenerated. There are over 27 different species planted. The government has invested 126 million dollars on this project and has set aside 100 million dollars to keep it going till 2020. The battle against climate change is greatly aided by this effort. There are undoubtedly some social and economic advantages to these initiatives, such as better health, the generation of jobs, and environmental preservation. The BTTAP covered an area of about 150 million hectares of degraded land and deforested into new forest and restoration by 2020 and 350 million hectares by 2030 (Kamal et al., 2019).
The objective of this study is to evaluate the Hazara region's freshly planted trees' potential to sequester carbon and the monetary worth of their carbon stock. It also does a cost-benefit analysis of the BTTAP to assess its economic feasibility and aims to provide answers to important concerns, such as the amount of carbon sequestration capability of the trees planted under the BTTAP. How much is the carbon stock worth in terms of money? What are the possible advantages of this endeavor, and what expenses does society bear? The study intends to provide insights into the economic and environmental effects of extensive afforestation projects such as BTTAP by answering these questions.

Review of Literature

National accounting systems in many countries lump forestry under agriculture in their national income calculations (FAO, 2008), while other—perhaps most—

environmental income may not be counted at all. In most household surveys representing the population, such as Living Standards Measurement Surveys (LSMS), material on forestry and environmental revenue is often very narrow, at best containing only questions on fodder, fuel, or building materials. Giving limited attention to, or ignoring, environmental income in such surveys may lead to the underestimation of total household incomes by understating the value of the environment to rural households (PROFOR, 2008; Vedeld et al., 2004), thus also skewing our understanding of the generation and distribution of wealth within the rural economy (Fisher, 2004).

Verkerk et al. (2014) developed various schemes to identify the use of biomass and for increasing forest protection. The European forest information scenario model was applied in the study for 26 countries. The impact was assessed by analyzing the impact on provisioning and other services for the period 2010 to 2030. The study found that round wood, residue, and stump biomass production could be strengthened, but there are trade-offs with non-marketed ecosystem services. Growing biomass production could lead to a net societal benefit in 2030. However, larger benefits would be attained within Europe if forest biodiversity protection is improved.

The potential of China's forests to sequester carbon is examined in Yao, Piao, and Wang (2018). The study's key conclusions are that, due to the selection of beneficial tree species, increasing forest age, climatic change, and CO_2 concentration, there is a favorable influence on forest biomass. According to Siraj (2017), the Arsi Nagelle forest's tree species' capacity to sequester carbon affects Gambo district's biodiversity. Grevillea Robusta was found to have the best survival capacity and the greatest ability for sequestering carbon. Therefore, the author suggests Grevillea robusta as a carbon sink.

Richards and Stokes (2004) examined the cost of carbon sequestration over the course of many decades that assessed the financial viability of forestry alternatives. According to the results, forest interventions may lower US emissions by 40% in 1990 at marginal costs of less than $60 per ton. Albrecht and Kandji (2003) look into how well agroforestry systems store carbon and how they might help lower CO_2. Additionally, show that agroforestry may play a significant role in carbon sequestration. The soil sequesters carbon through agroforestry.

The cost of providing farmers with incentives for sequestering carbon through agroforestry is estimated by Jong, Tipper, and Montoya-go (2000). Therefore, the most crucial component of any extensive carbon sequestration effort in Chiapas would be the management of natural forests and secondary vegetation. The study of Suryawanshi, Patil, and Sciences (2014) looks into how much carbon can be sequestered by the university's reliance on the chosen trees. According to the IPCC, tropical rainforests have the largest potential for sequestering carbon from above-ground biomass (Lemma, Kleja, Nilsson, & Olsson, 2006). In a nutshell, forest vegetation is a major ecosystem and provides low-cost options to mitigate climate change (Zhou et al., 2018).

Material and Methods

Study area and data collection

The study area consists of the Hazara division's common forest and grazing land, where the forest service has established plantations using woodlots, dibbling, and

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Vol. 3 No. 3 (March) (2025)

seed planting. The Khyber Pakhtunkhwa Forest Department is responsible for implementing the BTTAP throughout the province. Three forest zones—the Southern and Central regions, the Malakand region, and the Hazara region—are included in this initiative. The Watershed Management Circle is also a part of the Hazara area (WWF, 2016). Following each phase, the provincial forest division's consolidated physical and financial reports were used to compile the planting records by region. The Hazara region and the Hazarara watershed areas as a whole rank highest where planting work has been completed under this initiative, according to the WWF assessment from 2016.
Goats and cows are typically kept as pets in the mountainous Hazara region for milking and other nutritional purposes. Snow falls on the mountains during the cold winter months. The summer months are still mild, and the monsoon season brings with it a lot of rain. For food and fodder, people rely heavily on forest resources. In the majority of Hazara Division, people utilize wood for heating and cooking. The availability of pasture grounds for grazing in the area is strongly correlated with livestock productivity, and forests are utilized as pastoral areas. Both primary and secondary data form the basis of our investigation. A questionnaire was used to gather primary data from the research region. This study's data is cross-sectional. The primary objective of the study is to determine the project's expenses. In order to determine various expenses, we gathered primary data from this study region.

Sampling Technique

We use a multistage sampling technique. At the first stage, we purposely selected three districts, i.e., Abbottabad, Mansehra, and Haripur, with a major population share in the Hazara Division. The BTTAP project is implemented through village development committees (VDC), which were formulated based on the size of the population. Higher VDCs mean a higher rural population. So, at the second stage, we selected VDCs randomly from each district. The number of VDCs in each district was selected based on the total population. The higher the VDCs in a district, the larger the number of negheban (caretakers) for grazing restrictions. The population data is taken from the census report 2017 (PBS, 2017), and VDC stats are taken from the official website of the KPK government (Khyber Pakhtunkhwa, 2017). We selected a total of 150 respondents from 10 VDCs. Finally, we randomly selected 15 respondents from each VDC.

Table 1: Data Sampling

District	Population as per 2017 Census	Village Council (VDCs)/ Selected VDCs	Number of respondents
Abbottabad	1332912	209/3	45
Mansehra	1556460	194/4	60
Haripur	1003031	180/3	45

Cost and benefit analysis

Additionally, we assess the BTTAP project's economic viability in the Hazara region. The project's whole costs and benefits were translated into current value for this purpose, using hectares as the unit of analysis and millions of Pakistani rupees as the monetary unit. Environmental issues were also taken into consideration. The project's economic viability is evaluated by estimating the

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Vol. 3 No. 3 (March) (2025)

benefit-cost ratio (BCR) and internal rate of return (IRR). Every cost incurred throughout the project's execution is taken into account. People chose to sell their livestock when grazing limitations were implemented, and there was an excess of supply. As a result, market prices decreased. The cost of the plantation, the opportunity cost of not having grazing animals, the loss from a drop in prices, the cost of the caretakers' salaries, the opportunity cost of selling an animal (forgoing income because of selling animals), and the opportunity cost of land are some of the various costs that we took into account in the analysis.
Below is a description of each cost. These costs have been calculated in monetary terms. The unit of the costs is million PKR. A total of six types of costs are discussed in detail as:

Cost of plantation

It includes the fixed costs such as the cost of seeds, the cost of sowing seed and dibbling (woodlots), and the cost of rehabilitation of degraded watersheds in all three phases. The project is executed in three phases. Phase 1 during 2014-2015, Phase 2 during 2015-2016, and Phase 3 during 2017-2020 were implemented, respectively. Operational costs and maintenance costs (watering costs and watch and ward costs) remained continuous up to five years after the plantation. However, seedling cost and plantation cost occurred only once at the time of plantation. The detail about different costs has been well documented by the KPK government (KPK 2014-15, KPK 2015-16, KPK 2017). The costs in monetary terms are estimated in million PKR.

Opportunity cost of not grazing animals on communal based forest

Grazing restrictions increased the fodder cost. The opportunity cost of not grazing is measured by multiplying the average fodder cost per animal with the number of animals dependent on per hectare and the area eligible for grazing in hectares. We got average fodder cost by collecting the data through a questionnaire.

$$OCNG = AYFC * NAGH * GAH$$

Where,

$OCNG$: Per year opportunity cost of not grazing the animals in million PKR.
$APYFC$: Fodder cost per animal.
$NAGH$: Number of animals that can be grazed on one hectare.
GAH: Area eligible for grazing in hectares

The eligible area for grazing is the percentage of the total grazing area where animals can climb and return back. The total opportunity cost of not grazing is different for each phase due to variation in the area of plantation in each phase.

Total loss in the form of decrease in the price of animal at the time of sale

When all people decided to sell the animals due to restrictions, then there was a surplus of supply. It leads to a significant decline in prices. If the people sold their animals in a normal situation, then they would have gotten higher prices that could lead to higher profits. The loss per hectare is estimated by multiplying the number of animals depending on one hectare for grazing with the total number of hectares eligible for grazing in each phase. The estimation process has further elaborated as below.

ISSN Online: 3007-3154
ISSN Print: 3007-3146

DIALOGUE SOCIAL SCIENCE REVIEW

Vol. 3 No. 3 (March) (2025)

$$TLSA = ATLF * ADH * AHG$$

Where,
TLSA is the total loss on sale of animals in million PKR.
ATLF: Average total loss of a family on sale of animal/animals.
ADH: Animal dependent on one hectare of grazing land.
AHG: Eligible area in hectares on which grazing can be done. The total area of plantation varies for each phase.
The total average loss on the sale of animals is not the same for every year because plantations have been made over the years, and the numbers of hectares for each year are different.

Cost on negheban salary

Neghebans, or watchmen, were appointed by the government to execute the BTTAP efficiently on each enclosure. The neghebans received a monthly salary from the government for their services. The caretaker was responsible for watering the plants and watching the plants. Neghebans were also responsible for the protection of plants from the animals, and they did not allow people to graze animals where plantation has been carried out. So strict restriction policy executed through neighbors.

$$CNS = NE * PYS$$

Where,
CNS is total cost on neghebans' salary
NE: Number of enclosures established by the forest department.
PYS: Per year salary of each negheban.

Opportunity cost of sold animals

Opportunity cost of the sold animals is measured to assess the forgone benefit that could be attained if animals had not been sold due to the restriction. Opportunity cost of sold goats and cows measured in million PKR separately, as milk yields of goats and cows are not the same.

$$OCSA = ADH * VMY * TMY * AHG$$

Where,
$OCSA$: Opportunity cost of sold animals.
ADH: Number of animals dependent on one hectare. We estimated the ratio of milking animals in our sample and used the same ratio for the study area i.e. average number of milking animals from total sold animals.
VMY: Value of milk lost (yearly)
AHG: Eligible area in hectares on which grazing can be done.
The average number of sold animals was gathered from the primary data collected through the questionnaire, while other components were taken from secondary data.

Opportunity cost of land

The opportunity cost of land is calculated by multiplying the land rent (Rs.12355/hectare) with the total number of hectares under plantation. The land rent continues to enter into the analysis for the total years of the project, and it is considered a fixed cost. The yearly land per hectare rent of the non-agriculture in the Hazara region is Rs.12355.

Present value of total cost
The present value of total cost has been calculated by the formula

$$Present\ Value\ of\ total\ cost \sum_{t=0}^{20} = TC_{20}/(1+r)^{20}$$

Where t= 0…………….20
"0" is the initial year and "20" will be the last year for which a cost incurred.

Benefits
There are several benefits of afforestation, like carbon sequestration, economic value of trees, timber that can be used for furniture, and use of wood for fire. We calculated just the carbon sequestration capacity and economic value of trees, as wood cutting is not allowed in the communal-based forest area. So the benefits of BTTAP are listed below.

1. Per tree carbon sequestration capability
2. Economic value of standing trees

The benefit calculated in monetary term and the unit of the benefit is millions PKR.

Benefit from carbon sequestration
The carbon sequestration capacity of a tree is calculated by the weight of dry biomass in it. Each tree carried almost 47% of carbon of its total biomass (Ali 2020). Major tree species planted during BTTAP in communal lands are Pinus Roxburghii (Chirpine), Eucalyptus, Cedrus Deodara (Deodar), Pinus Wallichiana (Kail), Acacia Modesta (Phulai), Acacia Nilotica (Kikar), and Robinea. Sequestration rate in tons for each species in each year was calculated by Ali in his study (Ali 2020). A regression model is selected for each species depending upon its nature, whether it's a conifer or broadleaf. According to the study, all tree species were measured by the identical method. Diameter at breast height (DBH) and total tree height of the sample tree were measured before flooring. Age of tree calculated through counting of annual rings on stump. Moreover, stand form, stand density, altitude, aspect, and coordinates were also documented with the help of GPS. Different models were tested to calculate the biomass of all species listed above; the best-yielding model (power law combined) used by the author for the estimation of all species is given below:

$$M = a(D^2H)^b$$

Where
M = Dry biomass of a tree in Kg.
D = Diameter at Breast height in cm.
H = Total height of tree in meter.
a = Regression constant.
b = Regression coefficient.
We calculated the carbon stock for each species in every year separately and added the carbon stock of each species to get the total carbon stock in each phase. The monetary value of per ton carbon stock is $36.4 for Asian countries. The dollar value is converted into PKR. The number of trees planted and area in hectares in each phase are different, so we calculated the carbon stock for each

ISSN Online: 3007-3154
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DIALOGUE SOCIAL SCIENCE REVIEW

Vol. 3 No. 3 (March) (2025)

phase separately according to the survival rate of plantation for that phase. The value of carbon stock for each phase will be in million PKR.

Economic value of standing trees

The economic value of trees is calculated for each species. To calculate the economic volume of a tree in cubic feet, we converted the DBH in cm and height in meters to feet. The economic value or price of wood of a standing tree in cubic feet for each species was taken from the DFO Kunhar and Unhar (Hazara Region) office. The formula used to find out the volume of a tree is given below:

$$V = \pi R^2 H$$

Where
V = Volume of tree
π = 3.14
R = Radius of the tree in foot. Radius obtained by dividing diameter in feet with 2.
H = Height in feet. Height in feet obtained by converting height in meter to height in foot.
The volume of a tree increased with the growth of the tree after every year. The economic value of a tree is the product of the volume and price of a stand-up tree for a particular species in cubic feet.
.

$$EV = V * P$$

Where
EV = Economic value
V = Volume of tree in cubic feet
P = Price of standing tree given by forest department.
We calculated the economic value of a tree for each species separately. The total economic value of trees in every phase is obtained by adding the values of all species in that particular phase and converting it into million PKR. The price of a cubic foot standing tree for different species is given below:
Deodar = Rs 650 cubic foot
Chirpine = Rs 350 cubic foot
Kail = Rs 450 cubic foot
Eucalyptus, Kikar, Robinia etc = Rs 300 cubic foot.

Present value of total benefit

The present value of total benefit has been calculated by the formula:

$$Present\ Value\ of\ total\ benefit \sum_{t=0}^{20} = TB_{20}/(1+r)^{20}$$

Where t= 0……………..20
"0" is the initial year and "20" will be the last year from which a will be attained.

Benefit- Cost Ratio

$$Benefit\ to\ Cost\ Ratio = \ ^{PVTBn}/_{PVTCn}$$

PVTBn is the present value of total benefits over the years.
PVTCn is the present value of total costs in over of years.

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DIALOGUE SOCIAL SCIENCE REVIEW

Vol. 3 No. 3 (March) (2025)

Divide the estimated benefit by the estimated cost, which will give a benefit-to-cost ratio. If this ratio is greater than 1, it means that the choice is profitable. If the ratio is less than 1, it means that the choice will not be profitable.

Internal Rate of Return (IRR)
The internal rate of return is the rate of return on a project. If the value of IRR is greater than the present interest rate, it endorses that we should have to invest in that project instead of keeping money in the bank. If the IRR value of a project is less than the interest rate, then saving money is a better option than investing in that project. The present interest rate is 7% per annum.

Cut-off point
The cut-off point in cost-benefit analysis is that year in which total benefit becomes greater than total cost. This study estimated the cut-off point of BTTAP.

Results and Discussion
Cost benefit analysis
Any public sector strategy needs to undergo an economic evaluation before it can be endorsed or funded, providing a signal to the government and decision-makers. The internal rate of return, net present value, and cost-benefit analysis are only a few of the numerous economic evaluation indicators. We engaged in a cost-benefit study to analyze the carbon sequestration capability and economic worth of the billion tree tsunami afforestation initiative. We take into account the overall expenses spent in each of the three stages as well as the potential advantages of BTTAP. Table 2's results show the project's expenses and advantages. In this study, the monetary unit is the million PKR. Due to space limitations, we only offer analysis for the last eight years in Table 2.

Table 2: Cost and Benefit Analysis of BTTAP

Cost Benefit Analysis	0	1	2	3	4	5	6	7
Costs in Millions PKR:								
Cost on Plantation	111	1763	803					
Cost on Rehabilitation of degraded watershed	12	40						
Cost on Watch & ward, Maintenance & watering		19	395	395	376			
Opportunity cost of not grazing	321	3326	4622	4622	4622	4300	1296	
Cost on Neghebans' Salary	209	209	209	209	209			
Opportunity cost of sold cows	97	1006	1398	1398	1398	1301	392	
Opportunity cost of sold goats	79	1109	1553	1553	1553	1474	444	
Loss of families on sale of animals	37	515	757					
Opportunity cost of land	51	730	1022	1022	1022	1022	1022	1022

Total Cost in millions	919	8717	10760	9200	9181	8098	3154	1022
Present value of total Costs	919	8147	9399	7510	7004	5773	2102	637
Adding each year Costs	919	9066	18464	25974	32978	38752	40854	41490
Benefits in Million PKR:								
Benefits from carbon's sequestration in Phase 1		10	14	18	26	36	43	63
Benefits from carbon's sequestration in Phase 2			186	267	346	498	674	762
Benefits from carbon's sequestration in Phase 3				59	82	105	154	207
Benefits from Economic value of trees in Phase 1		38	16	30	60	81	86	109
Benefits from Economic value of trees in Phase 2			289	185	431	940	1424	1827
Benefits from Economic value of trees in Phase 3				176	87	166	327	458
Total benefits in Million	0	48	505	87	1033	1826	2707	3425
Present value of total	0	45	441	166	788	1302	1804	2133
Adding each year Benefits	0	45	485	651	1439	2741	4545	6678
Net profit in Millions PKR	-919	-8102	-8958	-7344	-6216	-4471	-298	1497
Benefit Cost Ratio (BCR)	1.7							
Internal Rate of Return (IRR)	6%							

Our results demonstrate all costs and benefits of the BTTAP. The cost of the plantation is recorded as Rs. 111 million, Rs. 1763 million, and Rs. 803 million, respectively, for Phase 1, Phase 2, and Phase 3. The cost of rehabilitation of watersheds and the maintenance cost varies from each phase, as the area and number of trees are not the same in three phases. The cost of rehabilitation of the degraded watershed is reported as Rs. 12 million and Rs. 40 million for Phase 1 and Phase 2, respectively. On average, 1075 trees were planted on one hectare during each phase. Cost on watch and ward, maintenance, and watering of plantation for year 1, year 2, year 3, and year 4 recorded as Rs.19 million, Rs.395 million, Rs.395 million, and Rs.376 million, respectively.

The opportunity cost of not grazing animals on communal-based forests is calculated. The cost borne by the society for not grazing is recorded as Rs.322 million for the first year and Rs.1296 million for the seventh year after the execution of the project. The average cost on Negheban's salary is Rs. 209.4 million, and it is carried for all five years. Forgo cost of sold animals is also included in our analysis. The opportunity cost of sold cows and goats is calculated separately as the yield of both types of animals is not the same. The opportunity cost of sold cows is recorded as Rs.97 million in the first year and Rs.392 million for the seventh year. Similarly, the opportunity cost of sold goats is Rs.79 million and Rs.444 million for the first year and seventh year for the project, respectively. Loss of families on sale of animals is calculated as Rs.37 million, Rs.515 million, and Rs.757 million, respectively, for all three phases. The rent of non-agricultural is considered the opportunity cost of land. The opportunity cost of land continues for the last year of the project. The opportunity cost of land is recorded as Rs.52 million in the first year, and it increases as the area under plantation increases in each phase. The opportunity cost of land approaches the maximum value at the 3rd year (Rs. 730 million) and remains for all 20 years. The total cost of the project is calculated by summing the cost of each year. The net present value (NPV) of the cost is calculated by applying the NPV formula.

Similarly, we calculate the benefits of the project as we calculated the cost. The total benefit from the carbon stock and economic value of trees in all three phases is calculated separately. The benefits from carbon stock and economic value started after the one year of plantation for each phase. The value of carbon stock after one year of plantation is recorded as Rs.10 million, Rs.186 million, and Rs.59 million for Phase 1, Phase 2, and Phase 3, respectively. The value of carbon stock for the last (20th) year of analysis is recorded as Rs.620 million, Rs.10716 million, and Rs.2916, recorded for Phase 1, Phase 2, and Phase 3, respectively. The economic values of trees after one year of plantation in each phase are recorded as Rs.38 million, Rs.289 million, and Rs.176 million, respectively, for phase 1, phase 2, and phase 3. In the 20th year, the economic values of trees for phase 1, phase 2, and phase 3 are Rs.681 million, Rs.11368 million, and Rs.3706 million, respectively. The value of benefits is added, and we get the total value of the benefits in each year.

Our results disclose that the billion-tree tsunami afforestation project recovers its cost in the 8th year after the execution of the project. The average age of conifer tree species is more than 100 years, and for broad leaves, it's more than 50 years. The benefit-cost ratio represents that if we spent Rs.1 on BTTAP, it would generate Rs.1.7 in return. The internal rate of return (IRR) for the billion tree afforestation project is 6 percent. The value of IRR is relatively low from the current interest rate. The benefit-cost ratio indicates that investment in BTAAP generates greater profit, indicating the viability of the investment.

Conclusion and Recommendations

Conclusion

The Hazara region, home to a predominantly rural population of 5.3 million, relies heavily on tourism, agriculture, livestock, and mineral resources for its livelihood. Communal grazing lands and pastures are critical for sustaining dairy and livestock needs, with the size of herds closely linked to the availability of grazing areas. The Billion Tree Tsunami Afforestation Project (BTTAP) was a ground breaking initiative aimed at ecological restoration, improving forest ecosystems, and creating sustainable livelihood opportunities for rural communities in Khyber Pakhtunkhwa. By targeting degraded forests and private lands for afforestation, the project significantly enhanced the region’s ecological and economic resilience.

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DIALOGUE SOCIAL SCIENCE REVIEW

Vol. 3 No. 3 (March) (2025)

Economic evaluation of BTTAP reveals its viability, with a benefit-cost ratio (BCR) of 1.7, indicating that every rupee invested generates 70% more in return. Although the internal rate of return (IRR) of 6% is modest, it confirms the project's capacity to recover costs and deliver long-term economic and environmental benefits. These findings underscore the project's potential to attract further investment in afforestation initiatives. While BTTAP has made remarkable strides, challenges remain. Lack of post-project monitoring has exposed young plantations to risks such as wildfires, and the preference for non-fruit-bearing species on communal lands has led to missed opportunities for direct community benefits. These aspects highlight the need for ongoing policy support, enhanced community awareness, and strategic interventions to maximize the project's impact and ensure its sustainability.

Policy recommendation

Community awareness management

The government should initiate widespread awareness campaigns to educate local communities about the economic opportunities linked to BTTAP. This includes promoting the sustainable use of forest products such as beekeeping, chilghoza harvesting, and mushroom collection, which can provide supplementary income to rural households.

Enhanced post-project monitoring

The absence of surveillance after the project completion poses significant risks, particularly from wildfires. It is crucial to deploy dedicated forest guards (neghebans) to safeguard young plantations and ensure the long-term success of afforestation efforts.

Strategic selection of tree species

The project has primarily focused on planting non-fruit-bearing species on communal and private lands. Planting fruit-bearing species could reduce communal losses and provide an additional source of income for local communities. Future afforestation initiatives should prioritize species that balance ecological restoration with economic benefits.

Strengthening livelihood integration

Efforts should be made to integrate BTTAP with broader rural development plans. Providing training in forest-based entrepreneurship and value-added products can amplify the socioeconomic impact of the project.

Policy and funding support

Continuous policy attention and financial backing are essential to maintain and expand the impact of BTTAP. Establishing a dedicated fund for afforestation projects and fostering public-private partnerships can enhance sustainability and scale up the program's success.

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