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A Financial Cost-benefit Analysis of Pure Teak Plantation for Restoration Program in Shan State of Myanmar

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Abstract

Knowledge on costs and benefits of restoration interventions can provide an insight for better allocation of resources within a restoration program. This paper presents financial analysis of pure teak plantations established at 1996-1997 fiscal year in three districts of Shan State, Myanmar. The objectives are to evaluate and determine which region is financially viable and more feasible. The time frame is set at 30 years to make easy comparisons among the plantations. The costs and benefits are estimated using an annual discount rate of 10% based on current year values. This analysis calculates three financial indicators, namely Net Present Value (NPV), Internal Rate of Return (IRR) and Benefit Cost Ratio (BCR). The results indicate positive NPVs in all the plantations, ranging from MMK 8,125,533 per acre to MMK 116,196 per acre over a 30-year period. The range of IRR varies from 22% in plantation of Kyaukme District to 11% in plantations of Taunggyi District. Additionally, all these plantations attain a BCR of greater than 1, with the smallest value (1.2) in Taunggyi District and the largest value (11.8) in Kyaukme District. Pure teak plantation in Kyaukme Dirstrict would attain the highest BCR, the acceptable NPV and IRR due to the growth rate of teak in the region. In conclusion, pure teak plantation in Taunggyi District is found to be least profitable following by Lashio District and Kyaukme District. The results provide valuable information for plantation policy for the government.

Key words: Plantation, Cost-benefit analysis, Net present value, IRR, Shan State, Myanmar

သစ်တောများပြန်လည်တည်ထောင်ခြင်းအစီအစဉ်တွင် ပါဝင်သော ရှမ်းပြည်နယ်ရှိ စီးပွားရေး ကျွန်းစိုက်ခင်းများ၏ အကျိုးအမြတ် လေ့လာဆန်းစစ်ခြင်း

ဒေါက်တာအေးချမ်းကိုကို၊ လက်ထောက်ညွှန်ကြားရေးမှူး
သစ်တောဦးစီးဌာန

စာတမ်းအကျဉ်း

သစ်တောများပြန်လည်တည်ထောင်ခြင်း လုပ်ငန်းများနှင့်စပ်လျဉ်း၍ စီးပွားရေးအကျိုးအမြတ်ဖော်ဆောင်နိုင်ခြင်းရှိမရှိ လေ့လာသိရှိခြင်းသည် သစ်တောပြန်လည်တည်ထောင်ခြင်း စီမံကိန်း ဆောင်ရွက်ရာတွင် ရန်ပုံငွေအရင်းအမြစ်များ ခွဲဝေချထားရန် စဉ်းစားချင့်ချိန်ရာ၌ အထောက်အကူ ပြုနိုင်မည်ဖြစ်ပါသည်။ ဤစာတမ်းသည် မြန်မာနိုင်ငံ၊ ရှမ်းပြည်နယ် အတွင်းရှိ ၁၉၉၆-၉၇ဘဏ္ဍာနှစ်တွင် တည်ထောင်ဆောင်ရွက်သော သစ်တော ပြန်လည်တည်ထောင်ရေးလုပ်ငန်း (ကျွန်း စိုက်ခင်း တည်ထောင်ခြင်း)အပေါ် စီးပွားရေး အကျိုးအမြတ်ဆိုင်ရာ လေ့လာဆန်းစစ် တွက်ချက်ထားပါသည်။ သစ်တောပြန်လည် တည်ထောင်ခြင်း လုပ်ငန်းများသည်စီးပွားရေး အကျိုးအမြတ် ဖော်ဆောင် နိုင်ခြင်းရှိမရှိနှင့် စီးပွားရေး တွက်ခြေကိုက်မှုရှိမရှိ သိရှိလာနိုင်စေရန်ရည်ရွယ်ပါသည်။ စီးပွားရေး အကျိုးအမြတ်လေ့လာ ဆန်းစစ်ရာတွင် လုပ်ငန်း အမျိုးအစားအားလုံးအတွက် တပြေးညီ ဖြစ်စေရန် အချိန်ကာလသတ်မှတ်ချက်ကို နှစ်(၃၀)အဖြစ် သတ်မှတ်၍ ဆောင်ရွက်ခဲ့ပါသည်။ လုပ်ငန်းအမျိုးအစားတစ်ခုချင်း အလိုက် အနာဂတ်တွင်ကုန်ကျမည့် ကုန်ကျစရိတ်များနှင့် ရရှိမည့် အကျိုးအမြတ် များကိုမူ လက်ရှိ နှစ်ကာလ နှုန်းထားများအပေါ် နှစ်စဉ်ငွေတန်ဖိုးကျဆင်းနှုန်း (Discount Rate)ကို (၁၀%)ဖြင့် ယူဆ၍ ခန့်မှန်းတွက်ချက်ထားခြင်းဖြစ်ပါသည်။ စီးပွားရေး အကျိုးအမြတ် လေ့လာဆန်းစစ်မှုများကို ဆောင်ရွက်ရာတွင် အသားတင်လက်ရှိအမြတ်တန်ဖိုး(Net Present Value –NPV)၊ အကျိုးအမြတ်ပြန်လည်ရရှိမှုနှုန်း (Internal Rate of Return– IRR)နှင့် အမြတ် ကုန်ကျစရိတ်အချိုး(Benefit Cost Ratio-BCR)စသည့်အခြေခံညွှန်ကိန်း(၃)ခုဖြင့်အကဲဖြတ် ဆန်းစစ်ထားပါသည်။အကဲဖြတ်မှုရလဒ်များ အနေဖြင့် နှစ်(၃၀)ကာလအတွင်း ကျွန်း စိုက်ခင်း တည်ထောင်ခြင်းလုပ်ငန်း(ကျောက်မဲခရိုင်) (၁)ဧကသည် NPVတန်ဖိုး ၈,၁၂၅,၅၃၃ကျပ်ဖြင့် အများဆုံး အကျိုး အမြတ်ရရှိပြီး တောင်ကြီးခရိုင်တွင် ၂,၁၃၅,၆၁၂ ကျပ်ဖြင့် အကျိုးအမြတ် အနည်းဆုံးရရှိကြပါသည်။ အကျိုးအမြတ် ပြန်လည်ရရှိမှုနှုန်း (IRR) အနေဖြင့် ကျွန်း စိုက်ခင်း တည်ထောင်ခြင်း လုပ်ငန်းသည် (၂၂%)မှသည်၁၁%အထိ ရရှိနိုင်သည်ကို တွေ့ရှိ ရပါသည်။ ထို့ပြင် အမြတ်ကုန်ကျစရိတ်အချိုး (BCR)သည်ကျွန်းစိုက်ခင်း တည်ထောင်ခြင်း (တောင်ကြီးခရိုင်)သည် အချိုး(၁.၂)ဖြင့် အနည်းဆုံးဖြစ်ပြီး (ကျောက်မဲခရိုင်)သည် (၁၁.၈) ဖြင့် အများဆုံး

ရရှိသည်ကို တွေ့ရှိရပါသည်။ ကျွန်းစိုက်ခင်းတည်ထောင်ခြင်း လုပ်ငန်း(ကျောက်မဲခရိုင်) သည် (NPV နှင့် BCR)တို့တွင် အမြင့်ဆုံးရရှိခြင်းသည် မြေနေရာ ရွေးချယ်မှုမှန်ကန်မှုကြောင့် ဖြစ်ပါသည်။ အချုပ်အားဖြင့် ဆိုသော် ကျွန်းစိုက်ခင်း တည်ထောင်ခြင်းသည် စီးပွားရေး တွက်ခြေကိုက်မှုအရ တောင်ကြီးခရိုင်တွင် အနည်းဆုံးဖြစ်ပြီး ကျောက်မဲခရိုင်သည် အများဆုံး ဖြစ်ပါသည်။ ဤစာတမ်းပါ လေ့လာတွေ့ရှိချက်များသည် စိုက်ခင်း မူဝါဒရေးဆွဲရာတွင် လိုအပ်သော သတင်းအချက် အလက်များကို ထောက်ပံ့ပေးနိုင်မည်ဖြစ်ပါသည်။

A Financial Cost-benefit Analysis of Pure Teak Plantation for Restoration Program in Shan State of Myanmar

1. Introduction

Forests cover 31 percent of the global land area [1]. The global forest area decreased by 178 million hectares between 1990 and 2020, but the demand for timber and forest products is expected to have more than triple by 2050 due to the growing world population and changing patterns of consumption. [1]–[3] Between 2015 and 2020, the rate of deforestation was estimated at 10 million hectares per year, down from 16 million hectares per year in the 1990s. In 2020, the planted forest area in the world was about 294 million hectares, accounting for about 7% of the global forest area and the rate of increase has slowed since 2010. [4]. Forest plantations are mainly used in combating desertification, absorbing carbon to offset carbon emissions, protecting soil and water, maintaining biodiversity and providing rural employment. The potential for forest plantations to partially meet demand for wood and fibre for industrial uses is increasing. In several countries, a significant portion of the wood supply for industrial uses comes from plantations, rather than natural forest resources. Nowadays, forest plantations are mainly distributed in tropical and temperate zones especially in Southeast Asia.

In Myanmar, forest plantations were established and managed by the Government for various purposes. The Forest Policy of Myanmar (1995) stipulated that plantation forestry has always been the supplementary and the existing natural forests will not be substituted with forest plantations. Myanmar initiated the establishment of Teak plantation as early as 1856 on a small scale using Taungya method. In 1941, the area of forest plantations reached 47,167 ha. Large scale plantation forestry began in 1980 and about 30,000 ha of forest plantations have annually been established since 1984. In 1998, the Government began to encourage special teak plantation program to increase timber production.

According to the Forest Resources Assessment (FRA), about 42.19% of the Myanmar's land area is still covered by forest resources, accounting for 28.5 million hectares [5]. Myanmar possesses great variation in topography and climatic conditions, and six major forest types can be in the country. Of these, mixed deciduous forests and hill and temperate evergreen forests are the major forest types, covering an area of 38.20% and 26.92%, respectively(Forest Department, 2020). In Myanmar's NDC, forestry is a main sector to contribute to climate change mitigation and adaptation. Myanmar's NDC targeted to extend RF and PPF up to 30 % and PA up to 10 % of the total country's area. To fulfil this target and diminish its deforestation rate, Ministry of Natural Resources and Environmental Conservation (MONREC) has developed a 10-year restoration program (2017-18 to 2026-27) called Myanmar Reforestation and Rehabilitation Program (MRRP). The program is being mainly implemented by the Forest Department with its own national budget. The MRRP includes a wide range of restoration activities such as establishing commercial plantations, restoring old commercial plantations, upscaling community forestry, promoting agroforestry, etc. Under the MRRP, commercial forest plantations with valuable species like teak (*Tectona grandis*), pyinkado (*Xylia xylocarpa*) and padauk (*Pterocarpus macrocarpus*) are being established by the Forest Department to decrease timber demand pressure on natural forests and to assure sustainable supply of teak and other hardwoods to international and domestic markets.

To promote forest development and improve management, the economic benefits are the powerful driver [7]. In most cases, plantations consist of only one tree species, and if a

suitable species is chosen a high volume per unit can be yield, which reduces the harvesting costs (Evans 2004). Still, the profitability of a forest plantation depends on various factors, including chosen species, land characteristics, labour costs and local as well as global wood prices (Niskanen et al. 1993). Forest plantations established are not only to increase forest cover but also to store potential carbon sink adding to their production value. Forest plantations will not end its role of carbon sequester after being harvested. In Myanmar, it is still needed to determine if restoration programs are financially feasible.

2. Objectives

This study attempts to analyse the cost and benefit of forest plantation in Myanmar. This study was designed to compare the economic performances of pure teak plantations in three districts in a single rotation. We used three financial indicators, namely Net Present Value (NPV), Internal Rate of Return (IRR) and Benefit Cost Ratio (BCR). The study could help the state and local governments to evaluate and formulate policies that would encourage more ecological forest plantations.

3. Materials and Methods

3.1. Study Area

The Shan Plateau is situated in north-eastern side of Myanmar is extended with mountainous upland ranging from 1000 m to 2300 m in height (Fig.1). It covers an area of 155,800 km^2 with a population of 5.8 million. Shan State takes a significant place amongst the fourteen Regions and States in the country, in terms of the biggest area of all, covering almost 25% of the whole nation, and in terms of population by far the biggest of the country (GAD 2020). The weather is a humid subtropical, dry winter climate in Shan State. The annual average temperature is at 17-29°C and the annual rainfall is 1000-1500 mm. The area is undulating with stripped of natural forests which are subject to severe erosion. The forest area of Shan state occupies 7.5 million ha, accounting for 25.19% of Myanmar forest area.

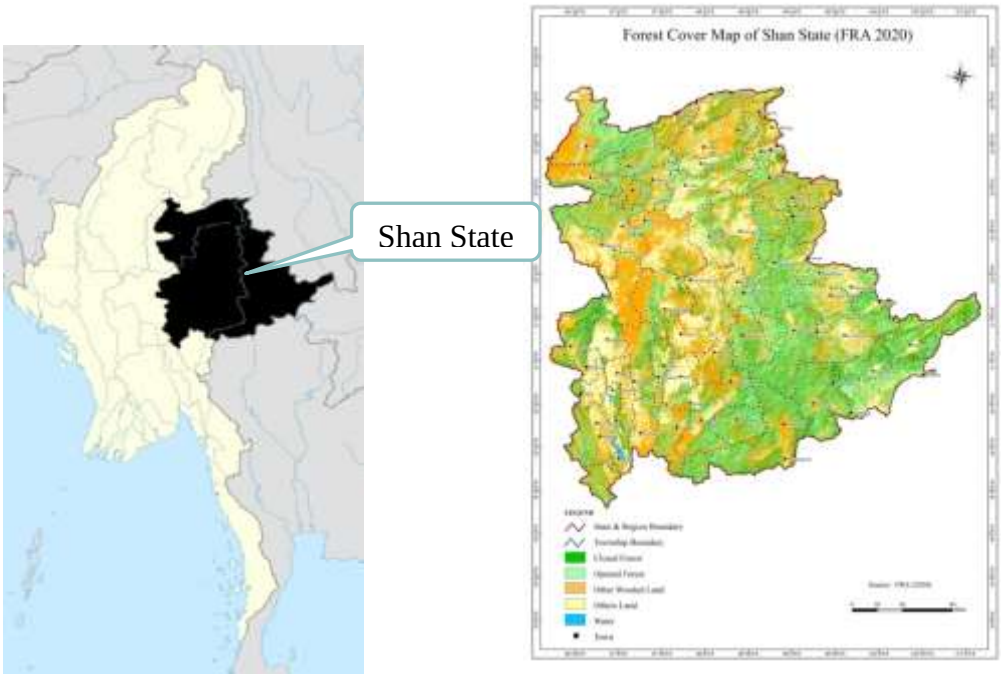


Fig.1. The location of Shan State in Myanmar

3.2. Method of data collection

The study considers planted species (teak). To examine the financial and economic feasibility of teak species, the Forest Department (FD) norms were taken for assessing the costs of establishment and maintenance of forest plantations. Myanmar Timer Enterprise prices were used for valuing the final timber harvest. Since different species have different growth cycles, the years of economic benefit and harvesting are also different according to the different rotations in calculations of net present value (NPV). In the study, each of plantations in district is chosen 1996-97 fiscal year established plantations to have a time frame of 30 years for easy comparisons. The second-hand information survey method is to collect the data through the existing resource inventory data and research reports, such as analysis of the yearbook and data from District Forest Management Plan which contains the information of forest species, total forest area, forest standing volume, areas of natural forests and plantations.

3.3. Material studied

According to the data that were collected from the Forest Department of Shan State, there are four main plantation types in Shan State, namely commercial plantation, watershed plantation, industrial plantation and village-used plantation. According to statistics, the following table represents the area of forest plantation established by the Forest Department from1981-2024. The study considers commercial plantations of mostly planted species.

Plantation types	Area (acre)
Commercial plantation	1329325 ac
Watershed plantation	354034 ac
Industrial plantation	181246 ac
Village owned plantation	480148.31 ac

In order to determine financial viability of plantations, this analysis uses three indicators: (i) Net Present Value (NPV) which is calculated by subtracting the summation of discounted costs from the summation of discounted benefits; (ii) Internal Rate of Return (IRR) which is calculated using the Excel built-in function upon the annual net cash flow of the intervention; (iii) Benefit Cost Ratio (BCR) which is simply calculated as the ratio of total discounted benefit to total discounted cost over a 30-year time frame. Regarding the indicators, the decision rules are as follows: if NPV is positive, the plantation is profitable; if IRR is greater than the cost of capital (10%), it is feasible; and the restoration program is said to be financially viable if BCR is greater than 1.

4. Results

According to economic principles, if a forest management is wise investment, NPV of forest plantations should be positive. To better understand the management situation in Shan State, the NPVs are calculated as Table 1-3 and the calculation formula is shown as follows:

$$\text{NPV} = \sum_{y=0}^{n} \left[\frac{R_y}{(1+r)^y} - \frac{C_y}{(1+r)^y}\right]$$

Where NPV = the sum of revenues in each year
y = discounted to year 0 minus the sum of costs in each year discounted to year 0
R and C = revenues and costs in the subscripted years
r = is annual interest rate/100 (here r = 10 %).

4.1. Teak Plantation

Teak is one of the commercial species that are commonly planted species in the townships to restore those forested areas where they had once existed. Pure teak plantations have been established by the FD and private firms in Shan State. The study presents cost-benefit analysis of pure teak plantation established by FD. In this analysis, it is assumed that teak plantation is established with a spacing of $8\frac{1}{2}$ ft $\times$ $8\frac{1}{2}$ ft and hence there are 600 trees/ acre. Teak has by far the longest rotation of those considered here about 30 years. According to MRRP work schedule, planting is done in rainy season and weeding operations are carried out three times, two times, two times and one time in 1st, 2nd, 3rd and 4th years respectively. Fertilizer is applied in the first year and fire protection is carried out until four years from establishment. Thinning operations are assumed to be conducted at 5-year intervals, at the ages of 6, 11 and 16 years.

Some maintenance activities such as camp, sign posts, survival counting, etc., are carried out in the 1st year. The costs included in this intervention are: initial year costs for survey, land preparation, seeds and nursery practices, planting and maintenance activities; costs for weeding operations and fire protection in the first four consecutive years; thinning operation costs in 6th, 11th and 16th years; and labour cost for final harvest of teak posts. All costs other than labour costs for the final harvest were valued based on the norms that are determined by the FD for the larger-scaled teak plantation (i.e., > 50 acres) under MRRP. The unit acre cost is scale-dependent and could increase in smaller-scaled teak plantations. Although the plantation is expected to attain 80% survival at the end of the first year, there will be 300 stems left after the first thinning at the age of 6. Thinning poles from 1st thinning at the age of 6 are not valued as they are small in size. The benefits are revenue from sales of 150 poles from 2nd thinning at age of 11 with stumpage value of MMK 7,000/pole, 75 posts from 3rd thinning at the age of 16 with stumpage value of MMK 15,000/post and final harvest of ton from the plantation at age of 30 with stumpage value of MMK 2,065,900/cubic ton.

Although the amount of pole and post from thinning are the same, the final harvest of ton from the plantations is different because the growth rate of teak is varied with the different regions. Therefore, total costs from one acre of land are expected to be MMK 753,290 over 30 years and total costs of all three plantations are the same. But total benefits from one acre of land are different and expected to be MMK 2,139,259 in teak plantation of Lashio district (Table 1), MMK 869,486 in teak plantation of Taunggyi district (Table 2) and MMK 8,125,533 in teak plantation of Kyaukme district (Table 3) over 30 years. The NPV of all the plantations are positive (per acre) indicates that the entire plantation is profitable. The entire plantation will generate a BCR of above 1 indicating financial viability of teak plantation. The IRR of all the plantation is estimated to be 16% in Lashio District, 11% in Taunggyi District and 22% in Kyaukme District which is greater than the cost of capital (10%), suggesting a feasible investment. On the other hand, the entire plantation bears a long payback period which is 16 years.

Table 1: Teak cash flow of Plantation in Lashio District

No	Item	Total	Year																
			0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16-28	29
1	**Discounted Costs**																			
	Survey	2,500	2500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Land preparation	80,000	80000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Seeds and nursery practices	41,356	86039	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Planting related costs	86,400	159550	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Fertilizers	17,400	35000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Maintenances	21,340	21340	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Weedings (3+2+2+1 times)	361,120	150000	90909	82645	37566	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Fire protection (4 years)	26,151	7500	6818	6198	5635	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Thinnings (3 times)	98,111	0	0	0	0	0	48898	0	0	0	0	30362	0	0	0	0	18852	0	0
	Final harvest (posts)	18,912	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18912
	Total cost	**753,290**	**406496**	**97727**	**88843**	**43201**	**0**	**48898**	**0**	**0**	**0**	**0**	**30362**	**0**	**0**	**0**	**0**	**18852**	**0**	**18912**
2	**Discounted Benefits**																			
	2nd Thinning poles	404820	0	0	0	0	0	0	0	0	0	0	404820	0	0	0	0	0	0	0
	Thinning posts	269316	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	269316	0	0
	Final harvest (posts)	1465123	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1465123
	Total benefit	**2139259**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	404820	**0**	**0**	**0**	**0**	**269316**	**0**	**1465123**
3	NPV	1385969																		
	BCR	2.8																		
	IRR	16 %																		

Table 2: Teak cash flow of Plantation in Taunggyi District

No	Item	Total	Year																
			0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16-28	29
1	**Discounted Costs**																			
	Survey	2,500	2500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Land preparation	80,000	80000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Seeds and nursery practices	41,356	86039	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Planting related costs	86,400	159550	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Fertilizers	17,400	35000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Maintenances	21,340	21340	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Weedings (3+2+2+1 times)	361,120	150000	90909	82645	37566	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Fire protection (4 years)	26,151	7500	6818	6198	5635	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Thinnings (3 times)	98,111	0	0	0	0	0	48898	0	0	0	0	30362	0	0	0	0	18852	0	0
	Final harvest (posts)	18,912	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18912
	Total cost	**753,290**	**406496**	**97727**	**88843**	**43201**	**0**	**48898**	**0**	**0**	**0**	**0**	**30362**	**0**	**0**	**0**	**0**	**18852**	**0**	**18912**
2	**Discounted Benefits**																			
	2nd Thinning poles	404820	0	0	0	0	0	0	0	0	0	0	404820	0	0	0	0	0	0	0
	Thinning posts	269316	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	269316	0	0
	Final harvest (posts)	195350	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	195350
	Total benefit	**869486**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	404820	**0**	**0**	**0**	**0**	**269316**	**0**	**195350**
3	NPV	116196																		
	BCR	1.2																		
	IRR	11 %																		

Table 3: Teak cash flow of Plantation in Kyaukme Township

No	Item	Total	Year																
			0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16-28	29
1	**Discounted Costs**																			
	Survey	2,500	2500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Land preparation	80,000	80000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Seeds and nursery practices	41,356	86039	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Planting related costs	86,400	159550	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Fertilizers	17,400	35000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Maintenances	21,340	21340	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Weedings (3+2+2+1 times)	361,120	150000	90909	82645	37566	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Fire protection (4 years)	26,151	7500	6818	6198	5635	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Thinnings (3 times)	98,111	0	0	0	0	0	48898	0	0	0	0	30362	0	0	0	0	18852	0	0
	Final harvest (posts)	18,912	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18912
	Total cost	**753,290**	**406496**	**97727**	**88843**	**43201**	**0**	**48898**	**0**	**0**	**0**	**0**	**30362**	**0**	**0**	**0**	**0**	**18852**	**0**	**18912**
2	**Discounted Benefits**																			
	2nd Thinning poles	404820	0	0	0	0	0	0	0	0	0	0	404820	0	0	0	0	0	0	0
	Thinning posts	269316	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	269316	0	0
	Final harvest (posts)	8204686	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8204686
	Total benefit	**8878823**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	404820	**0**	**0**	**0**	**0**	**269316**	**0**	**8204686**
3	NPV	8125533																		
	BCR	11.8																		
	IRR	22 %																		

5. Discussion

5.1. NPV and IRR of Teak Plantation in Lashio District

Table 1 shows that the NPV of Teak plantation of Lashio district in Shan State is 1,385,969 kyats per acre, given a 10% discount rate, and the internal rate of return(IRR) is 16%, greater than the 10% discount rate, which states that Teak's cost of capital should be accepted, in other words, the rate of return on Teak plantation is far greater than the return of 10% of opportunity-cost rate , and it will result in choosing the investment of Teak in Lashio District that will maximize the value added to Shan State.

5.2. NPV and IRR of Teak Plantation in Taunggyi District

As Table 2 shows, Teak plantation of Taunggyi District returns are more than total costs, and the NPV is 116,196 kyats per acre with the 10% discount rate, the IRR is 11 %, exceeding the cost of capital, and the teak plantation is also accepted in Shan State.

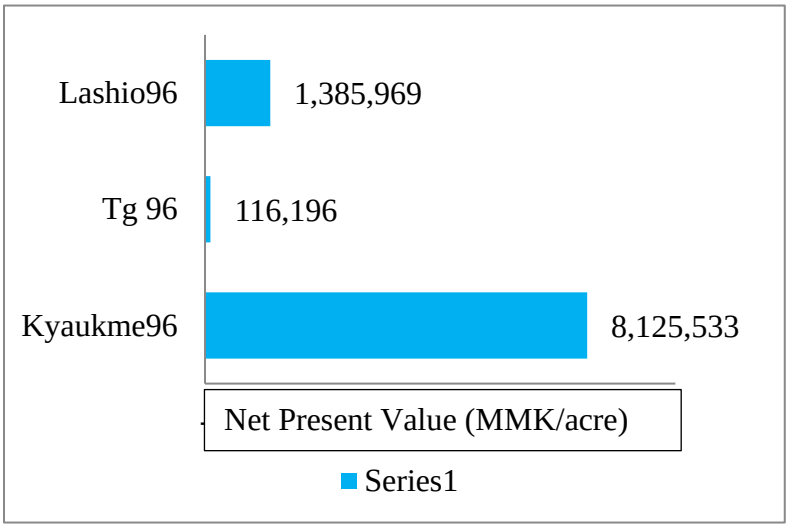
5.3. NPV and IRR of Teak Plantation in Kyaukme District

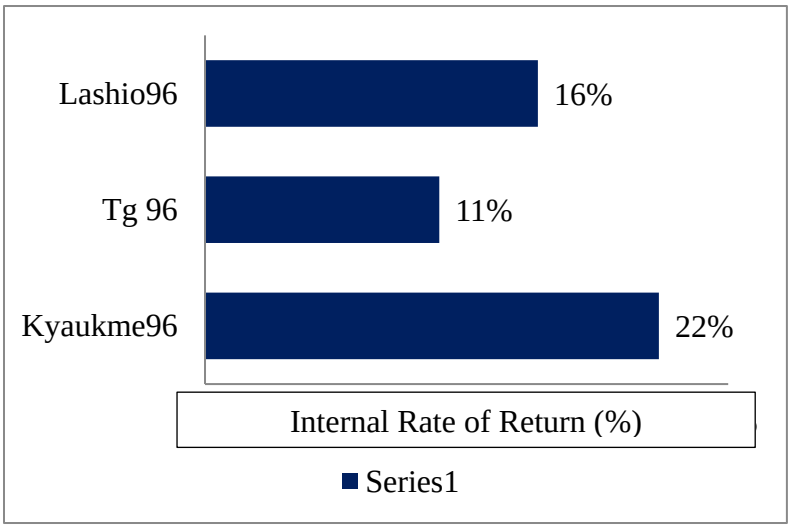
Similarly, Table 3 illustrates that the NPV of Teak Plantation in Kyaukme District in Shan State is 8,125,533 kyats per acre with an IRR of 22%, far greater than the 10% discount rate, and the result therefore is acceptance for the investment in Shan State.

The NPV, IRRs and BCRs of the plantations are shown in Table 4 and Figure 2. All the plantations reveal positive NPVs showing the profitability of them all.

Table 4. Summary of discounted costs and benefits for the following plantation over a 30-year period in Shan State of Myanmar.

Restoration Intervention	Total Cost (MMK/ acre)	Total Benefit (MMK/ acre)	NPV (MMK/ acre)	IRR (%)	BCR	Payback Period (year)	Total Cost before Payback Period (MMK/acre)
Pure teak plantation (Lashio District)	753,290	2,139,259	1,385,969	16	2.8	16	404,820
Pure teak plantation (Taunggyi District)	753,290	869,486	116,196	11	1.2	16	404,820
Pure teak plantation (Kyaukme District)	753,290	8,878,823	8,125,533	22	11.8	16	404,820





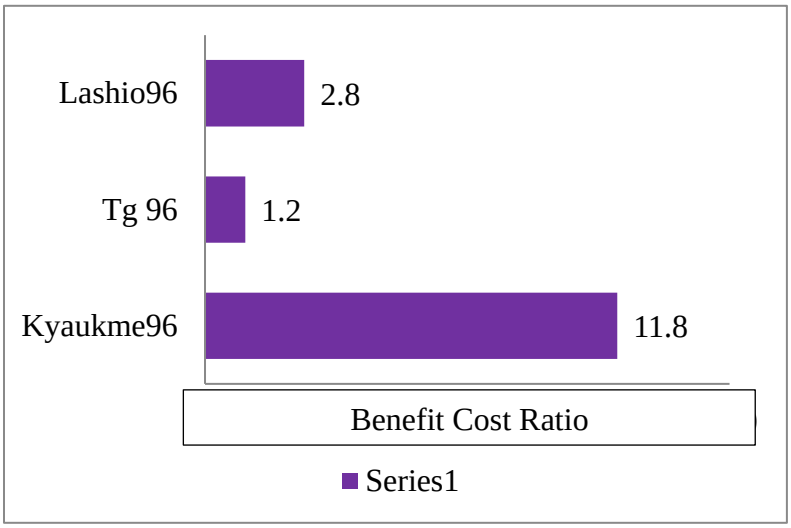


Figure 2. Comparisons of NPVs, IRRs and BCRs of three plantations in Shan State of Myanmar

6. Conclusion

This study calculates the Net Present Values (NPVs) of three prominent plantations in Shan State using the net-present-value method. The analysis, based on three financial indicators, reveals that all interventions are profitable, though with notable differences. After comparing the benefits, it is found that the Internal Rate of Return (IRR) for the teak plantation in Kyaukme District is the highest at 22%, followed by Lashio District's teak plantation at 16%, and Taunggyi District's plantation at 11%. Additionally, the Kyaukme District plantation shows the highest Benefit-Cost Ratio (BCR) of 11.8 and an NPV of MMK 8,125,533 per acre, outperforming the other regions. Consequently, establishing teak plantations presents a promising investment opportunity, which is of interest to both public and private enterprises. Developing markets for intermediate yields could further enhance the benefits from this investment. In fact, the economic potential could be greater by establishing forest-based industries, rather than simply selling raw timber from the plantations.

Financial profitability plays a more significant role in determining plantation methods than considerations related to social welfare or income distribution. From an economic standpoint, forest plantations should only be established on land with low opportunity costs. A critical challenge in many Southeast Asian countries, including Thailand, is finding a balance between the management of natural forests and the production of timber from forest plantations, in order to meet the growing demand for high-quality, fast-growing wood [8]. In conclusion, the choice of rehabilitation technique should be tailored to specific situations. While financial profitability supports the encouragement of plantations, long-term productivity and potential negative ecological impacts must be carefully considered. Zhang (2010) emphasized that successful cultivation requires stability, time, and the ability to align both human needs and nature's pace.[9] Moreover, attention should be paid to forest layout and ecological concerns in forestry development. A systematic approach is needed to calculate optimal spacing, plant numbers, and anticipated final yields in order to achieve high-quality timber and maximize economic returns.

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