IKI Trees on Farms Targets and Investment Scenarios for Rwanda

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1. Brief background

1.1. Rwanda's restoration targets under the Bonn Challenge

Rwanda has successfully achieved its targets for forest cover. The aim was to achieve 30% forest cover by 2020. Based on the recent forest cover map by the Ministry of Environment in 2019, the country has now achieved 30.4% of forest cover. The next challenge is set to improve the quality of forests and increasing tree cover on agricultural land, agroforestry. Agroforestry provides numerous means by which further expansion of tree cover can take place in managed agricultural landscapes while bringing significant benefits to farmers.

Rwanda is on a good track towards Bonn Challenge commitment to restore two million hectares of degraded land by 2030. According to the Barometer Report of 2019, Rwanda had achieved 35% of its goal. Land restoration has involved a range of different activities, but the majority has been through trees on farms initiatives.

1.2. IKI Trees on Farms Targets

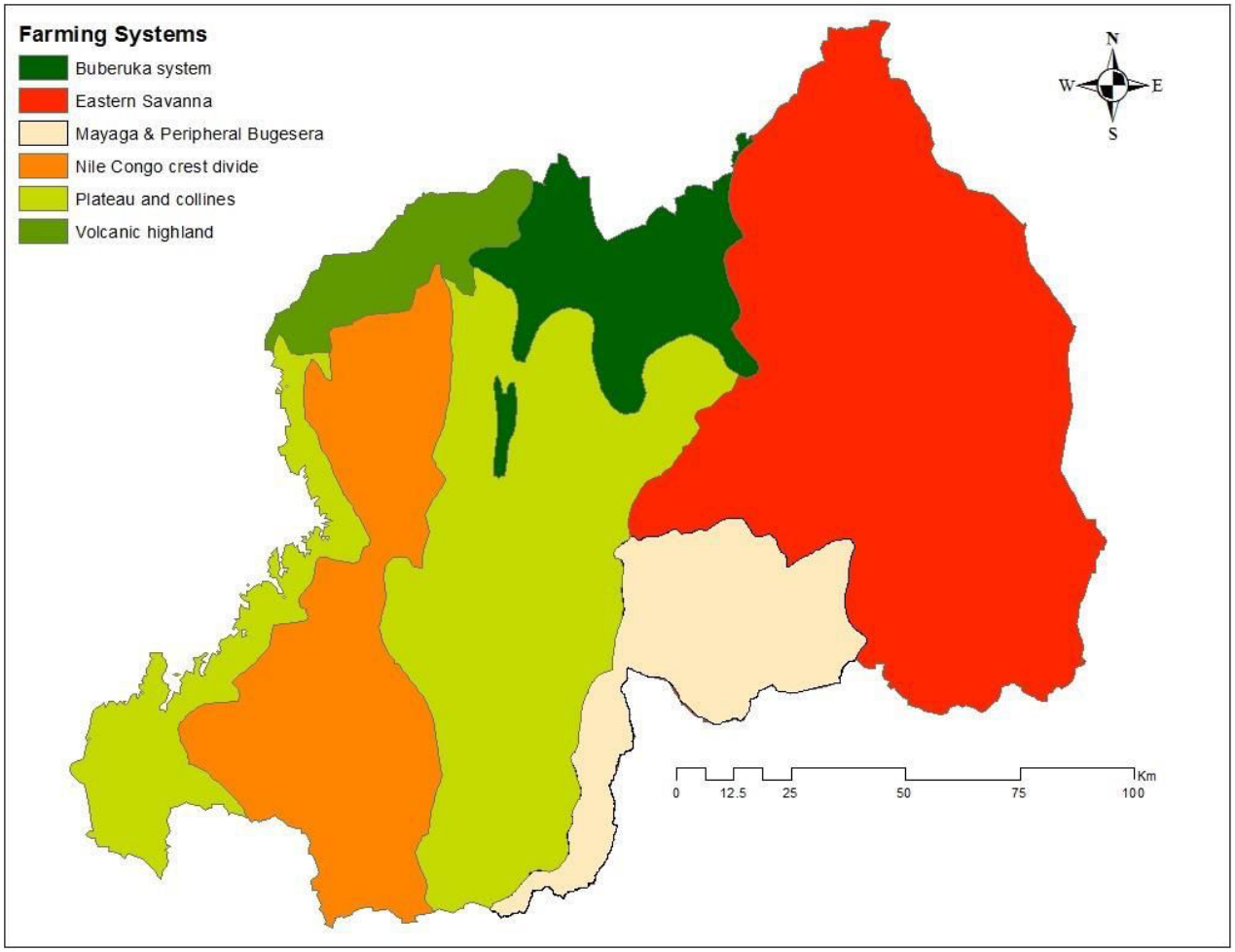
Trees on farms targets were developed to indicate how current farming systems can be improved with the incorporation of trees for food security and enhanced biodiversity conservation. The targets were developed for two contrasted sites with different land use practices. Maize-bean system in semi-arid Bugesera and Irish potato- bean system in highland Gishwati. Annual crops are grown on a rotational basis whereby an agricultural year consists of two rainy seasons in which beans are rotated with maize in Bugesera and with irish potatoes in Gishwati. Trees in Bugesera are planted on farm boundaries, the most preferred practice by residing farmers while in Gishwati trees are planted on contours, progressive and radical terraces.

There is a cost to implement these targets. Investment costs were classified into two categories: (i) the costs borne by the farmer associated with integrating trees on farms options, such as the purchase of inputs, including tree seedlings, manure and fertilizers; and (ii) the institutional costs needed for setting up an enabling environment, such as the development of infrastructure, including tree nurseries and processing factories for tree commodities. They also include trainings and capacity development. Institutional costs were set to cover 100 ha with 100 households in Bugesera and 250 households in Gishwati.

1.3. Study area for IKI Trees on Farms Project

		Volcanic highland	Nile Congo Crest Divide	Peripheral Bugesera & Amayaga
		Gishwati		
Bio-physical factors	Area (ha)	90,936	393,964	478,999
	Alt. (m)	2200-2400	1900- 2500	1200-1400
	Rainfall (mm)	1300-1500	1300-2000	800-1000
	Soil	Andosols	Luvisols Acrisol V.acidic soil	Ferrasols Regosol Vertisol Acrisol Histosol
	AF system	Contour Hedges	Contour hedges Woodlots	Boundary planting, Scattered
Socio-economic factors	Crops	Potato, Wheat, Climb. beans pyrethrum	Tea, Coffee, I potato, Wheat	Cassava, Maize, Bean, Rice
	Livestock	Sheep, Goat, Cattle (zero grazing)	Sheep, Goat, Cattle (zero grazing)	Goat, Cattle (free grazing)
	Land size (ha)	0.59	0.46	1.18
	Pop. density (inh/km2)	527	420	274
	Food secure HH (%)	8-28	33-43	03-07

Table 1: Bio-physical and socio-economic factors of semi-arid Bugesera and highland Gishwati



2. Background and context of trees on farms targets

The Trees on Farms (TonF) project in Rwanda has two broad targets i.e., Broad target 1 and Broad target 2 which are optimized for the maize-bean system in semi-arid Bugesera and irish-bean system in highland Gishwati respectively. Bugesera is a district in the Eastern Province of Rwanda (located at 1E45' 00" S latitude and 30E30' 00" E longitude), south-east of Kigali 40 km away. Bugesera has an average rainfall of 400 to 600 mm/year and barely exceeds 800 mm/year (https://bit.ly/3qoVJZS). According to (https://bit.ly/3iwwK2o) the district has a surface area of 1,334 km^2 and with an estimated population of 300,000 people. As illustrated in Table 1, the soils in the area are Ferrasols, Regosol, Vertisol, Acrisol, and Histosol. Gishwati on the other hand is a highland in the Western Province of Rwanda and in this study we focus on the Volcanic highland and the Nile Congo Crest Divide 90,936 ha and 393,964 ha respectively within the Gishwati ecosystem.

Each broad target has a sub-category(s) and for each target in the broad target subcategory i.e., Target B1, B2, and G3 has three scenarios: The baseline scenario also known as the Business as Usual (BAU) or scenario1, represents the status quo of the land use system. On the other hand, scenario 2 represents an optimized land-use system with TonF options for food security, nutrition and income whereas scenario 3 focuses on optimizing the land use system for enhanced biodiversity and ecosystem services.

- **Broad target 1: Optimized trees on farms interventions in maize/bean systems of Bugesera**

- Target B1: Broad target 1 through fruit production
- Target B2: Broad target 1 through tree products

- **Broad target 2: Optimized trees on farms interventions in irish potato/bean systems of Gishwati**
  - Target G3: Broad target 2 for soil erosion control and water management.

Each target has three scenarios:

- **Scenario 1.** Current status, the prevailing land-use practice.
- **Scenario 2.** Optimized land-use system with TonF options for food security, nutrition and income.
- **Scenario 3.** Optimized for enhanced biodiversity and ecosystem services

3. Broad target 1: Optimized trees on farms interventions in maize/bean systems of Bugesera

3.1. Target B1 - Scenario 1: The BAU scenario of maize-bean system in Bugesera

The business-as-usual scenario is constructed on a general assumption that there are no mitigation polices, measures or interventions that will be implemented beyond those that are already in operation hence no significant change in farmers' livelihoods strategies, attitudes and priorities. The BAU is an essential baseline/point of reference/counterfactual construction on which change can be measured i.e., the change in investment costs associated with integrating trees on farms under different agroforestry regimes or designs.

In the BAU of target B1, the maize and beans system consist of few scattered or no fruit trees as illustrated in figure 2. The existing fruit trees on farms are either too old or too young to produce fruits, poorly manged or affected by pests and diseases, and there are no fruit trees in farmers' homesteads. The BAU scenario is constrained by a lack of access to quality fruit planting materials (seeds, seedlings, and scions), limited skills in fruit tree management including pests and diseases management, limited knowledge on adapted fruit tree varieties in the landscape, and the lack of a reliable market for fruit production. However, there are opportunities that arise from scenario 1 which include the establishment of fruit tree nurseries in farmers' proximity, establishment of demonstration orchards where fruit tree management practices are applied, the establishment of fruit mother blocks to source fruit planting and grafting materials, training of farmers on fruit tree management and post-harvest practices, the assessment and prioritization of fruit value chains for promotion, and the development and strengthening of market linkages for fruit producers of prioritized fruit value chains.

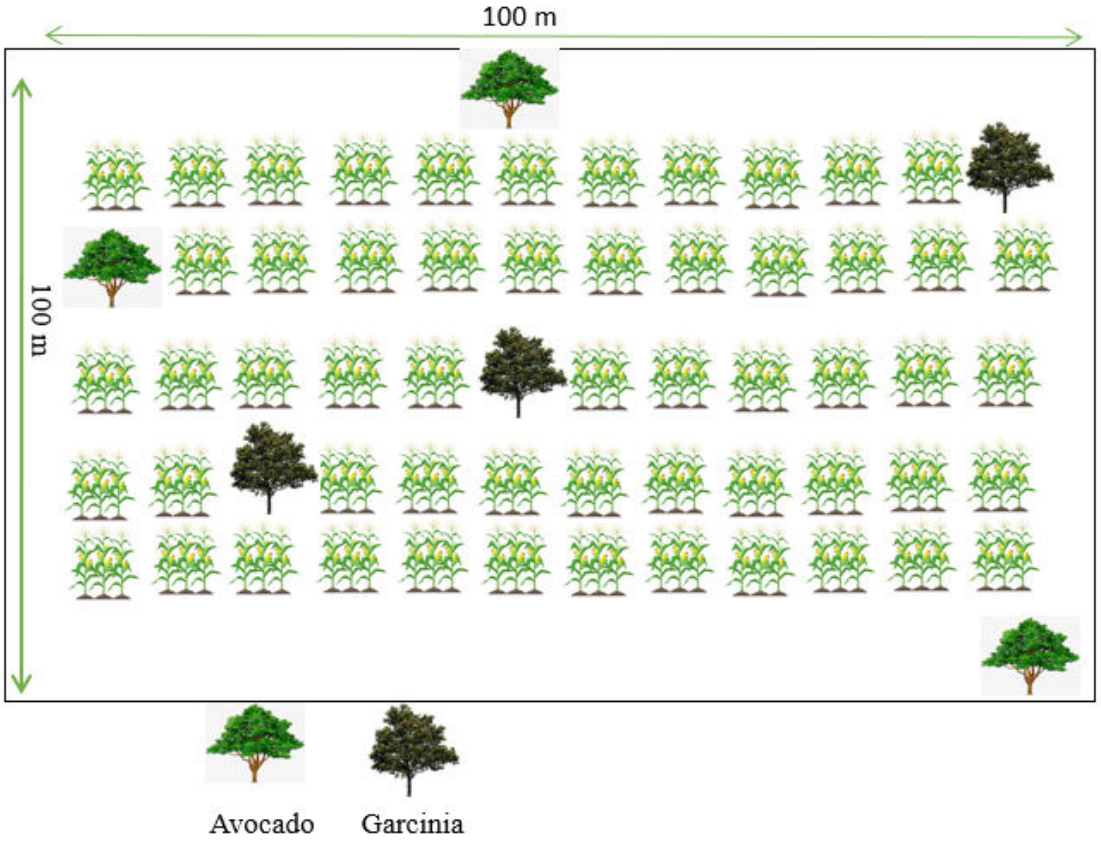


Figure 2: Target B1, BAU scenario of a typical maize-bean system in Bugesera, Rwanda.

3.2. Target B1 – Scenario 2: Mazie-bean system with optimized TonF for better livelihoods

Target B1 in the broard target 1 subcategory focuses on optimizing BAU scenario through fruit production. Therefore, scenario 2's main objective is to optimize scenario 1 through interventions that will increase the density of fruit trees such as tree totmato to provide tangible and direct benefits such as improved food security, nutrition, and income. Figure 3 illustrates a well managed maize-bean system with tree tomatos and *G. sepium* planted along the plot boundaries.

Maize and beans system with well managed fruit trees producing higher quality and quantity of fruits. Fruit tree species and varieties that are adapted to local context and resistant to pests, diseases and drought conditions. Farmers applying appropriate agronomic practices leading to optimized maize/bean and fruit production. For maximum optimization of the TonF intervention, tree species are selected based on the farmers' needs and preferences and WP1 results i.e., fast

growing, and drought and termite resistant fruit tree species/varieties. E.g., Cyphomandra *betacea,* Persea *americana,* Mangifera *indica.* Scenario 2 leads to increased profitability with fruit tree production in maize/bean system, improved nutrition and reduced child stunting, and reduced poverty.

Specific target: Increased Density of fruit trees to improve food security, nutrition and income
Tree tomato line

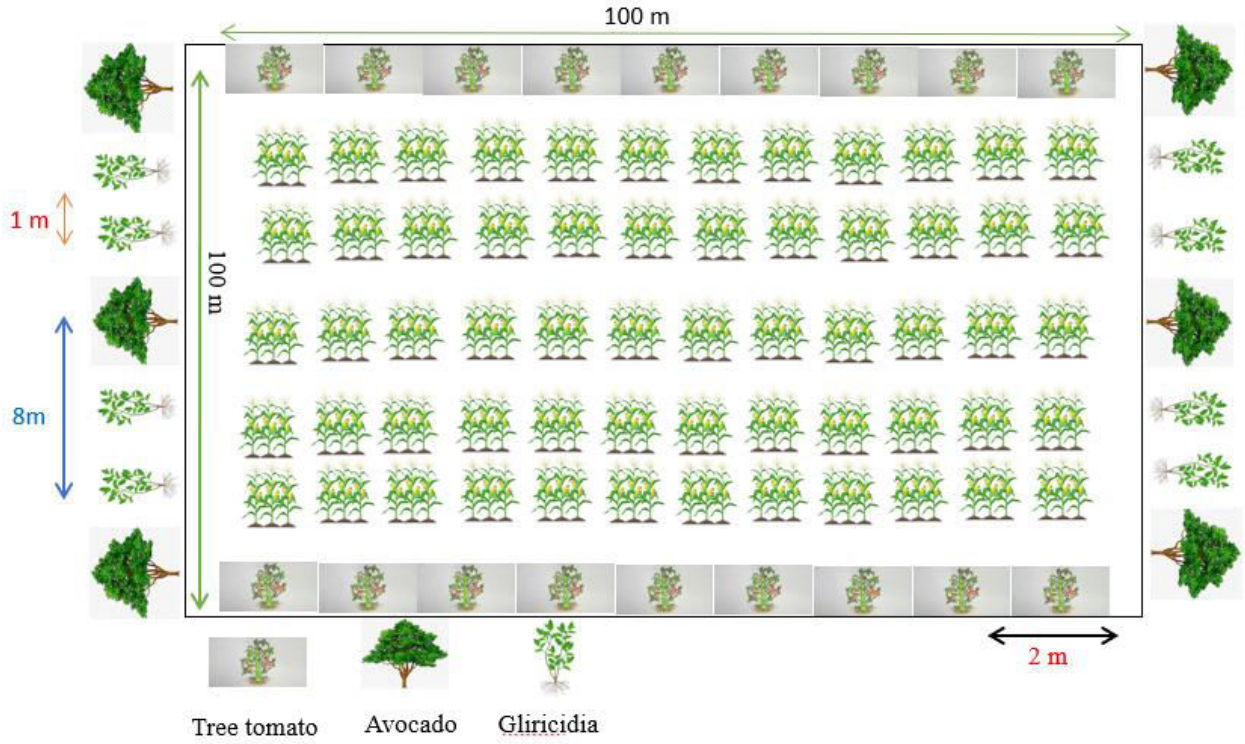


Figure 3: Target B1*, scenario 2 optimized maize-bean system for food security, nutrition, and income in Bugesera, Rwanda.*

3.3. Target B1 – Scenario 3: Mazie-bean system with optimized TonF for high biodiversity

Scenario 3's specific target involves integrating and increasing the density of trees on farms to enhance biodiversity and ecosystem services. To achieve this target, farmers need to apply the appropriate management practices that will lead to optimized ecosystem services by integrating indigenous/threatened fruit trees. Figure 4 illustrates the configurations for a well-managed

maize and bean system with indigenous/threatened fruit trees that used to be in the semi-arid landscape, i.e., adapted to local agro-ecological conditions.

Specific target: Increased density of trees on farms to enhance biodiversity and ecosystem services

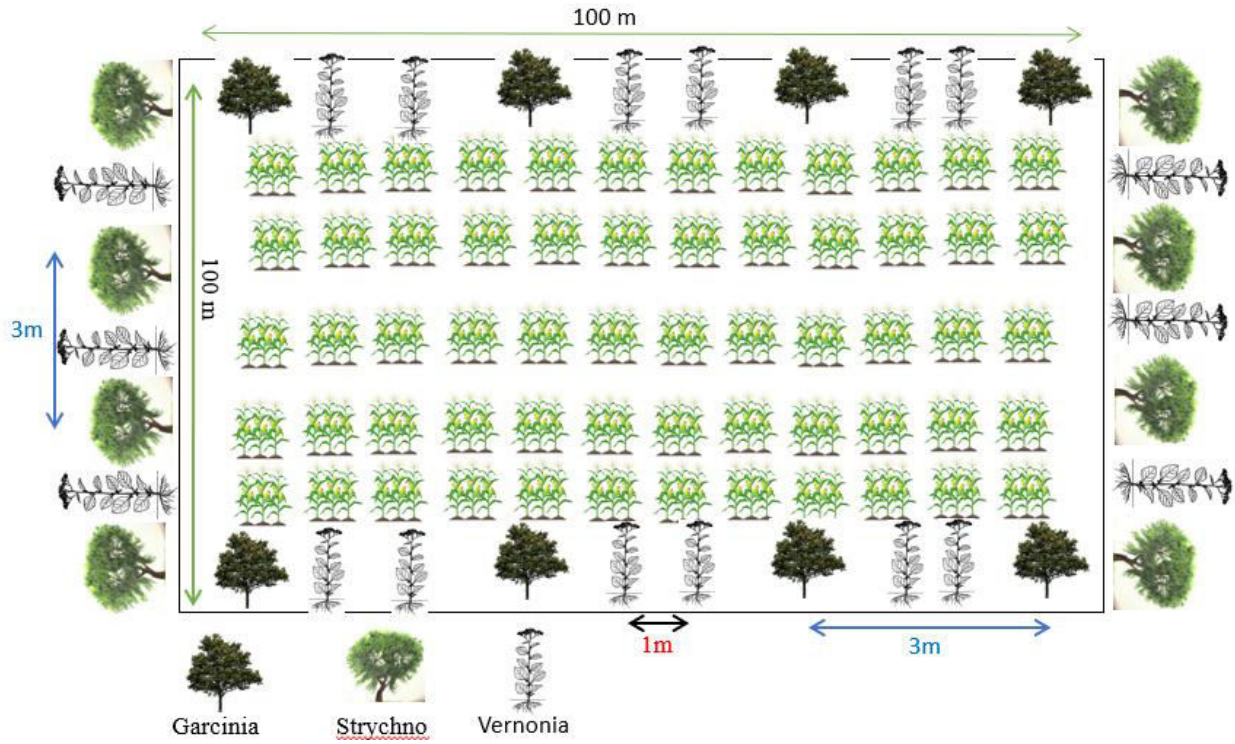


Figure 4: Target B1, scenario 2 optimized maize-bean system for high biodiversity and ecosystem services in Bugesera, Rwanda

3.3.1. Action plan of scenario 3

Scenario 3 involves integrating high biodiversity tree species from e.g., The IUCN Red List Index that is used by the Convention on Biological Diversity (CBD) to monitor progress towards achieving the Aichi Targets[1]. ed list, endangered trees, indigenous trees, trees that are important for foraging or breeding sites).

To achieve this target the following actions are to be implemented:

[1] https://www.iucnredlist.org/

- Conduct workshops with elderly community members on indigenous fruit trees that used to grow in semi-arid conditions
- Select fruit tree species from IUCN Red list of Rwanda that meet farmers' preferences
- Develop specific training manuals on propagation methods and domestication of indigenous fruit trees
- Conduct awareness raising workshops with farmers on threatened fruit tree species
- Conduct trainings of lead farmers on domestication and management of threatened fruit trees
- Establish fruit tree nurseries to produce seedlings of threatened fruit trees

3.3.2. Benefits

The additional benefits of Scenario 3 include improved soil health, enhanced biodiversity conservation, enhanced ecosystem services such as pollination, and meeting the fruit market demand.

4. Methodology and data

4.1. General assumptions for modeling scenarios

All farmers' costs are expressed on the basis of a single hectare for a single year, for all the annual crops, two planting and therefore harvesting seasons have been considered across all the targets. On the other hand, institutional costs have been expressed on the basis of single nursery bed of 1 ha capable of supplying seedlings, capacity building and related services to 100 farmers with a single hectare each. The current US $ rate (1 US $ = RWF 998) has been used in all the financial estimations whereas the prevailing local market prices have been used for estimating the values of the component crops and farm inputs in the system.

Under the baseline scenario of Target B1, annual crops are integrated; beans and maize at an average spacing of 0.5x0.2m and 0.75x0.5m hence a population density of 100,000 and 53,333 plants, respectively per hectare per season considering double spacing. Therefore, for the 2 seasons in a year the density has been multiplied by 2 after which all configurations are deduced on an annual basis. On a rational basis, there are six unmanaged *G. robusta* trees in this scenario.

In scenario 2, the configurations for the two annual crops, maize and beans are maintained. In addition to maintaining the available trees, new tree species, 25 *P. americana* (avocado), 200 *G. sepium* and 100 *C. betacea* (tree tomato) trees are introduced along the boundaries at a spacing 8m, 1m, and 2m respectively.

In addition to maintaining the configurations and the tree species in the BAU scenario, scenario 3 on the other hand has 25 *G. buchananii*, 400 *V. amygdalina*, and 67 *S. spinosa* at a spacing of 8m, 1m, and 3m being introduced along the boundaries.

4.1.1. Risks

- Many exotic species are used, some of which have negative impacts (e.g. become invasive)
- Trees on farms are sometimes thought to reduce crop yields
- Susceptibility to risks such as pests and diseases for fruit tree species
- Low acceptability of indigenous tree species due to limited knowledge of farming communities. They are perceived as slow growing and not as beneficial as exotic in terms of tree products.
- Farmers perceive complicated management as constraints
- Farmers might be reluctant in trees if they are not getting expected optimal yield in the first years
- Higher costs of investment and maintenance compared to the farmer's capacity hinder farmers to exploit established terraces.

4.2. Annual investment costs associated with different scenarios for Target B1

4.2.1. BAU scenario

Table 2 provides a picture of what the investment costs are like in the BAU with the assumption that farmers continue with their current practices as outlined in the previous section. This implies that for the 10-year period considered for this target there are no institutional costs since there are not shifts in mitigation policy or interventions. On the other hand, farmers incur recurring annual costs associated with production of the annual crops i.e., maize and beans. The total costs per hectare that farmers typical incur are around US$ 856/ha/year, with the majority of these expenses (US$435) being for the purchase of inputs such as seeds, chemical fertilizers, insecticide, and manure. A total of US$421 allocated for labor provision for various activities such as land preparation, weeding, harvesting etc. As we consider only the nominal values, investment costs are constant across the 10 years.

Table 2: Costs associated with the BAU Scenario for Target B1 in US$ per ha per year

Investment costs in the business as usual scenario		**Time horizon**			
		Year 1	Year 3	Year 6	Year 10
Institutional costs	Total costs of establishing nurseries	$0.00	$0.00	$0.00	$0.00
	Total costs for training & capacity building	$0.00	$0.00	$0.00	$0.00

	Total Institutional Costs (USD)	$0.00	$0.00	$0.00	$0.00
Costs to the farmers	Total labor costs to farmers per ha	$420.89	$420.89	$420.89	$420.89
	Total input costs to the farmer per ha	$434.67	$434.67	$434.67	$434.67
	Total variable cost to the farmer per ha	$855.56	$855.56	$855.56	$855.56

4.2.2. Scenario 2

In order to transform the BAU scenario into the alternative scenario 2, we incorporate new institutional services that create an enabling environment towards this change. In addition to the costs associate with the institutional services, there are incremental costs to the farmer on both labor costs and the costs of inputs due to the introduction of new tree species and close to US$ 100 being added for climbing beans to improve production. The total investment costs required in the first year provide sufficient institutional services for scenario 2 are just over US$ 56,000. About US$ 48,000 of the total institutional costs will be used for the establishment of a 1 ha tree nursery that supplies quality tree planting material over a 100ha radius which approximates to 100 households in Bugesera. Of the total institutional costs, a little over US$ 8,000 will be used for training and capacity development to the farmers and other stakeholders in the TonF project.

As illustrated in Table 3, in the consecutive years from year 2 to year 10, the total costs for establishing nurseries drops since some costs such as the cost of purchasing the land and installation of the irrigation systems are not incurred. On the other hand, the total costs for training and capacity development, only 70% of the total costs is incurred in the second year, which drops to 50% in year 3 and again to 30% from year 4 to year 10. There is a drop also in the total variable costs to the farmer in the years 2 to 10 due to the exclusion of costs associated with the integration of trees on farms such as the purchase of seedlings, and the labor requirement for digging planting holes. However, in odd years from the time of establishment, the costs for integrating tree tomatoes are maintained as for the first year.

Table 3: Costs associated with Scenario 2 for Target B1 in US$ per ha per year

Investment costs in Scenario 2		**Time horizon**					
		Year 1	*Year 2*	*Year 3*	*Year 4*	*Year 6*	*Year 10*
Institutional costs	Total costs of establishing nurseries	$47,917.73	$35,785.28	$35,785.28	$35,785.28	$35,785.28	$35,785.28
	Total costs for training & capacity building	$8,339.60	$5,837.72	$4,169.80	$2,501.88	$2,501.88	$2,501.88
	Total Institutional Costs (USD)	$56,257.33	$41,622.99	$39,955.07	$38,287.16	$38,287.16	$38,287.16

Costs to the farmers	Total labor costs to farmers per ha	$467.08	$434.42	$434.42	$434.42	$434.42	$434.42
	Total input costs to the farmer per ha	$527.55	$453.71	$487.87	$453.71	$487.87	$453.71
	Total variable cost to the farmer per ha	$994.63	$888.12	$922.29	$888.12	$922.29	$888.12
Overall costs of investment		$57,251.96	$42,511.12	$40,877.36	$39,175.28	$39,209.44	$39,175.28

4.2.3. Scenario 3

As it is the case in optimizing BAU to scenario 2, we look at the institutional services that enable the shift as discussed in the previous section. In scenario 3 the total investment costs required in the first year provide sufficient institutional services are just over US$ 76,000. Of the total, about US$ 63,000 will be required for the establishment of tree nurseries and about US$ 13,000 will be needed for training and capacity development. In the consecutive years 2 to year 10, the total costs for establishing nurseries drop to just under US$ 50,000. The total costs for training and capacity development on the other hand is assumed to drop to 90% of the total in year from years 2 to year 5, after which it drops again to 70% of the total in years 6 to year 10.

The total variable cost to the farmer in the first year is just over US$ 1,100, but this drops to about US$ 800 between year 2 to year 10. This is an attribute to the assumption that there are costs that do not recarry to the consecutive years after project implementation and in addition to this the total input costs to the farmer per ha between year 2 to year 5 is only 90% of the total from year 1 and 70% between year 6 and year 10. Table 4 show the costs associated with scenario 3.

Table 4: Costs associated with Scenario 3 for Target B1 in US$ per ha per year

Investment costs in Scenario3		**Time horizon**					
		Year 1	Year 2	Year 3	Year 5	Year 6	Year 10
Institutional costs	Total costs of establishing nurseries	$62,987.74	$49,831.11	$49,831.11	$49,831.11	$49,831.11	$49,831.11
	Total costs for training & capacity building	$13,381.23	$12,043.11	$12,043.11	$12,043.11	$9,366.86	$9,366.86
	Total Institutional Costs (USD)	$76,368.97	$61,874.22	$61,874.22	$61,874.22	$59,197.98	$59,197.98
Costs to the farmers	Total labor costs to farmers per ha	$476.98	$423.89	$423.89	$423.89	$423.89	$423.89
	Total input costs to the farmer per ha	$627.66	$451.80	$451.80	$451.80	$448.00	$448.00
	Total variable cost to the farmer per ha	$1,104.63	$875.70	$875.70	$875.70	$871.89	$871.89
Overall costs of investment		$77,473.61	$62,749.92	$62,749.92	$62,749.92	$60,069.87	$60,069.87

4.3. Investment costs for Institutional services

As we focus on adjusting the BAU scenario to include alternative scenarios 2 and 3 there are investment costs incurred as disscussed on previous scetions and as shown in Table 5 and Table 6. First, we look at the investment costs associated with establishing and maintaing a 1 ha tree nursery which include the purchase of the land and it's development (i.e., constrution of an office, shed, beds) plus other materials and inputs as well as the personel and adminitration costs associated with the developemt of the nursery.

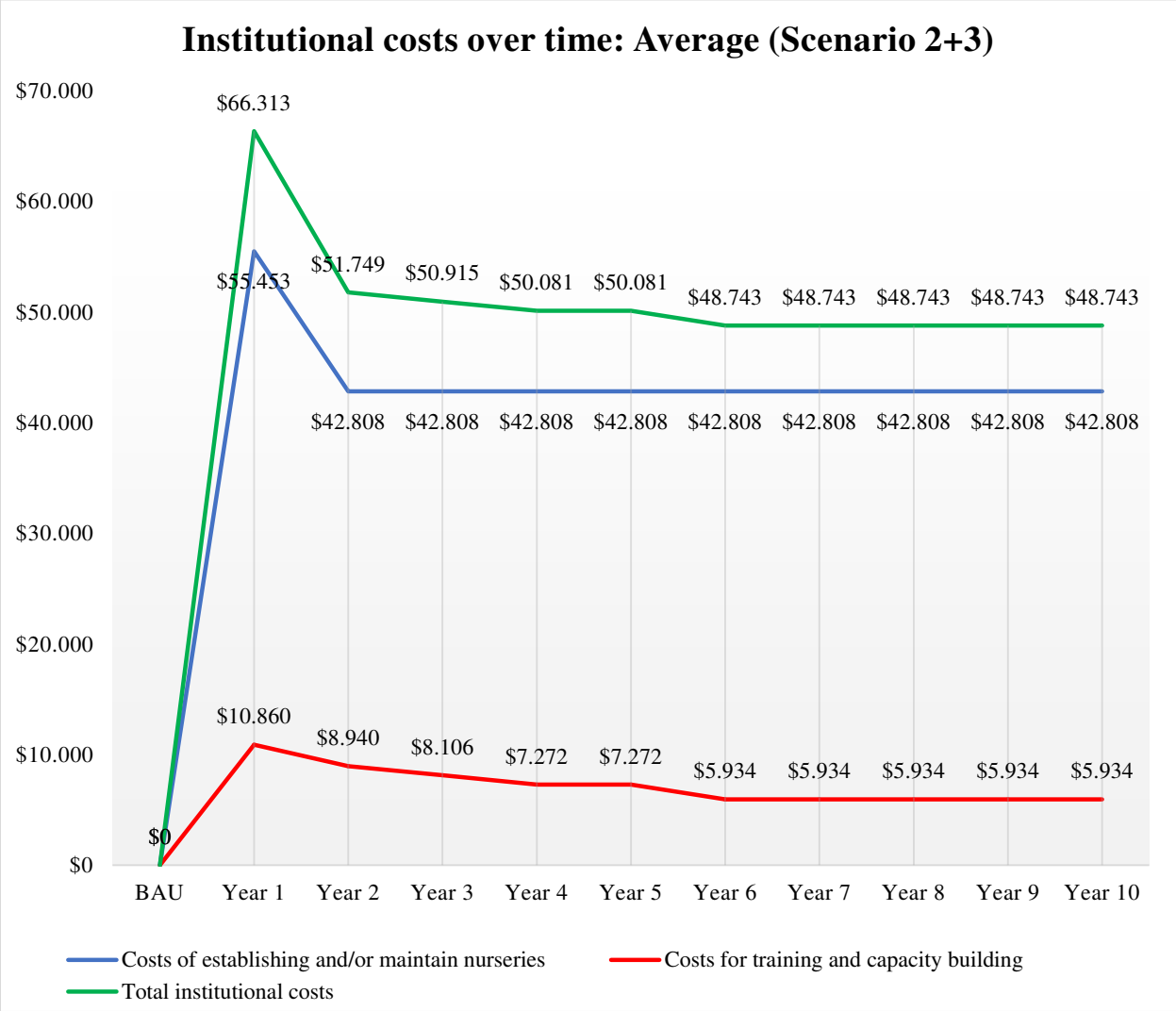


Figure 5: Institutional costs over time in (US$): Target B1

Table 5: Investment costs in nursery establishment and maintenance in the first year: Target B1

	Unit/measurement	Investment Costs	
		Scenario 2	Scenario 3
		Year1	Year 1
Establishment of a nursery			
Land purchase for nursery set-up	ha^{-1}	$10,021.14	$10,021.14
Labour for Seedbeds construction	ha^{-1}	$95.26	$144.12
Shed construction	ha^{-1}	$15.88	$24.02
Substrate preparation	ha^{-1}	$31.75	$48.04
Nursery materials and inputs			
Purchase of poles	Pieces	$569.04	$860.86
Nails	kg	$47.63	$72.06
Thatching material for shade	bundles	$338.71	$512.41
Manure for small pots of Gliridicia and tree tomato	tons	$58.62	$78.16
Tree seeds	kg	$180.65	$450.79
Scions for avocado grafting	pecies	$130.27	$0.00
Grafting materials	pecies	$58.62	$0.00
Polythene tubes/pots (small)	kg	$260.55	$347.40
Polythene tubes/pots (large)	kg	$75.99	$278.64
Manure for large pots	Ton	$9.77	$35.83
Sand soil transport	tons	$18.24	$30.40
Watering cans	Piece	$15.88	$24.02
Wheelbarrow	Piece	$58.22	$88.07
Insecticide -Rocket	Litre	$12.03	$12.03
Sprayer	Piece	$50.11	$50.11
Sheetings for the construction of shelter and storage of materials	Piece	$35.07	$24.05
Secateurs	Piece	$5.29	$8.01
Hoes	Piece	$3.70	$5.60
Machete	Piece	$2.12	$3.20
Spade	Piece	$3.18	$2.40
Rakes	Piece	$2.65	$4.00
Notebook and pen (register)	Pieces	$4.01	$3.20
Fungicide (Thiovit)	kg	$28.06	$28.06
Personnel and Administration (nursery)			
Communication	Month	$481.01	$721.52
Project manager	Month	$8,417.76	$12,626.64
Technician	Month	$6,012.69	$9,019.03
Administration cost	Month	$1,803.81	$150.32

Administrative assistant	Month	$4,208.88	$721.52
Permanent nursery worker	man-days	$360.76	$6,313.32
Permanent nursery workers fornursery maintenance	man-days	$571.58	$864.70
Watchman	man-days	$270.57	$541.14
Casual labourers for pot filling for small-sized pots	man-days	$195.41	$260.55
Casual labourers for pot filling for large-sized pots	man-days	$32.57	$119.42
Casual labourers for transport and arrangement of pots in seed/pot beds	man-days	$70.63	$137.25
Casual labourers for pricking out	man-days	$70.63	$137.25
Casual labour for grafting	man-days	$61.07	$0.00
Transport hire	per day	$11,063.34	$16,595.02
Supervision allowance for Project manager	per day	$962.03	$577.22
Supervision allowance for Technician	per day	$962.03	$865.83
Allowances for administrative staff	per day	$240.51	$180.38
Total costs of establishing nurseries		$47,917.73	$62,987.74

Note: The tree seeds in scenario 2 are for: Gliricidia *speium*, Cyphomandra *betacea*, and Persea *americana* at a total cost of US$ 76.53, US$ 38.98, and US$ 65.14 respectively. On the other hand, tree seeds in scenario 3 include: Garcinia *buchananii,* Vernonia *amygdalina,* and Strychnos *spinosa* at a total cost of US$ 300, US$24.89, and US$ 125.26 respectively.

Extra investment costs for institutional services incurred during the first year will be for training and capacity development of extension staff from government, NGOs, community-based organizations and lead farmers that will support the day-to-day operations of the nursery. Capacity development the process by which individuals, groups, and institutions develop, enhance, and organize their systems, knowledge, and resources. Capacity development and training have been a critical method of building community capacity to adopt agroforestry practices. **Error! Reference source not found.**6 shows the breakdown of the training and capacity development that are needed and their respective costs. It's important to note that these costs reduce in the consecutive years as explained in the previous sections.

Table 6 : Investment costs in training and capacity development in the first year: Target B1

	Unit/measurement	**Investment Costs**	
		Scenario 2	**Scenario 3**
		Year 1	**Year 1**
Training and capacity building (nursery, tree management, soil management, fruit production)			
Hiring training venue	Day	$400.85	$400.85
Trainer perdiem	Person	$513.08	$513.08
Trainer accommodation	Person	$765.62	$765.62
Lead farmer allowance	Person	$48.10	-
Farmer allowance	Person	$300.63	$300.63
Nursery operator allowance	Person	$36.08	$36.08

Agronomist allowance	Person	$40.08	$40.08
Local leader (SEDO) allowance	Person	$40.08	$40.08
Sector leader (ES) allowance	Person	$40.08	$40.08
Vehicle costs for trainers	Day	$921.95	$921.95
Vehicle costs for exchange visits	Day	$400.85	$400.85
Training materials	Lump	$384.81	$384.81
Meals for participants	Person	$641.35	$641.35
Booklet/flyer for training	Lump	$192.41	$192.41
Accommodation for trainees	Person	$962.03	$400.85
Gender sensitive facility	Lump	$400.85	$962.03
Establishment of demonstration plots	ha	-	$0.56
Training and capacity building (Gender mainstreaming)			
Hiring training venue	Day	$200.42	$200.42
Trainer perdiem	Person	$128.27	$256.54
Trainer accommodation	Person	$191.40	$382.81
Lead farmer allowance	Person	$24.05	$1,202.54
Farmer allowance	Person	$120.25	-
Agronomist allowance	Person	$20.04	-
Local leader (SEDO) allowance	Person	$20.04	$240.51
Sector leader (ES) allowance	Person	$20.04	$160.34
Vehicle costs for trainers	Day	$230.49	$1,843.89
Training materials	Lump	$282.60	-
Meals for participants	Person	$470.99	$2,565.41
Booklet/flyer for training	Lump	$141.30	-
Gender sensitive facility	Lump	$400.85	-
Nursery operator allowance	Person	-	$72.15
Vehicle costs for external visits	Day	-	$400.85
Total costs for training & capacity building		$8,339.60	$13,366.76

Integrating trees in agricultural lands can require careful management and thus tends to be labour intensive and costly to farmers in terms of additional inputs required. More specifically, integrating well managed trees increases labor costs from about US$ 420.89 in the BAU to about US$ 467.08, and US$ 476.98 which is about an 11% and a 13% increase in cost per ha for both scenarios 2 and 3 respectively. However, as we have seen in the previous sections, the total labor costs to the farmer per year reduce to about US$ 434.42 and US$ 423.89 in the consecutive years in scenarios 2 and 3. The breakdown of costs of labor requirements are illustrated in Table 7 and Table 8.

Table 7: Labor costs investment associated with the integration of trees: Target B1

Type of farmer related costs	**Unit/measurement**	**BAU**	**Senario 2**	**Senario 3**
Labor costs associated with annual crops (maize and beans)				
Site preparation	Mandays ha-1 year-1	$150.32	$150.32	$150.32
Transporting manure	Mandays ha-1 year-1	$84.18	$84.18	$84.18
Annual crop sowing, digging holes and manure: maize	Mandays ha-1 year-1	$15.03	$15.03	$15.03
Annual crop sowing, digging holes and manure: Beans	Mandays ha-1 year-1	$15.03	$15.03	$15.03
Weeding	Mandays ha-1 year-1	$99.21	$99.21	$99.21
Spraying	Mandays ha-1 year-1	$12.03	$12.03	$12.03
Harvesting	Mandays ha-1 year-1	$36.08	$36.08	$36.08
Labor costs associated with integrating trees				
Digging planting holes	Mandays ha-1 year-1	-	$8.14	$12.32
Transplanting	Mandays ha-1 year-1	-	$6.11	$9.24
Mulching	Mandays ha-1 year-1	-	$4.51	$4.59
Pesticide application	Mandays ha-1 year-1	-	$6.01	$6.01
Manure application	Mandays ha-1 year-1	-	$3.01	$3.01
Coppicing	Mandays ha-1 year-1	-	$3.01	$3.01
Harvesting	Mandays ha-1 year-1	-	$3.01	$3.01
Seedling transport	Mandays ha-1 year-1	-	$4.89	$7.39
Beating up	Mandays ha-1 year-1	-	$1.50	$1.50
Casual labour for marking planting holes	Mandays ha-1 year-1	-	$4.51	$4.51
Labour for protecting fence of planted trees	Mandays ha-1 year-1	-	$1.50	$1.50
Total labor costs to farmers per ha		**$420.89**	**$467.08**	**$476.98**

Table 8: Commercial input costs associated with the integration of trees: Target B1

Cost of inputs to the farmer (per ha)	**Unit/measurement**	**BAU**	**Scenario 2**	**Scenario 3**
Input costs associated with annual crops				
Sowing seeds (Beans)	kgs ha-1 year-1	$27.56	$27.56	$27.56
Sowing seeds (Maize)	kgs ha-1 year-1	$13.78	$13.78	$13.78
Insecticides	liters ha-1 year-1	$30.06	$30.06	$30.06

Basal Fertiliser (Urea)	kgs ha-1 year-1	$28.56	$28.56	$28.56
Top dressing fertiliser (NPK)	kgs ha-1 year-1	$64.14	$64.14	$64.14
Manure costs	kgs ha-1 year-1	$200.42	$200.42	$200.42
DAP	kgs ha-1 year-1	$70.15	$70.15	$70.15
Input costs associated with integrating trees				
Seedlings	nits	-	$65.14	$131.95
Fungicides	liters ha-1 year-1	-	$7.01	$7.01
Insecticides	liters ha-1 year-1	-	$12.03	$12.03
Manure costs	kgs ha-1 year-1	-	$1.25	$8.52
Mulching	ha-1 year-1	-	$1.84	$8.52
Peggs		-	$4.61	$21.29
Sitcks for protecting fence of planted trees		-	$1.00	$3.67
Total input costs to the farmer per ha		**$434.67**	**$527.55**	**$627.66**

Note: The tree seeds in scenario 2 are for: Gliricidia *speium*, Cyphomandra *betacea*, and Persea *americana* at a total cost of US$ 10.02, US$ 25.05, and US$ 30.06 respectively. On the other hand, tree seeds in scenario 3 include: Garcinia *buchananii,* Vernonia *amygdalina,* and Strychnos *spinosa* at a total cost of US$ 25.05, US$40.08, and US$ 66.81 respectively.

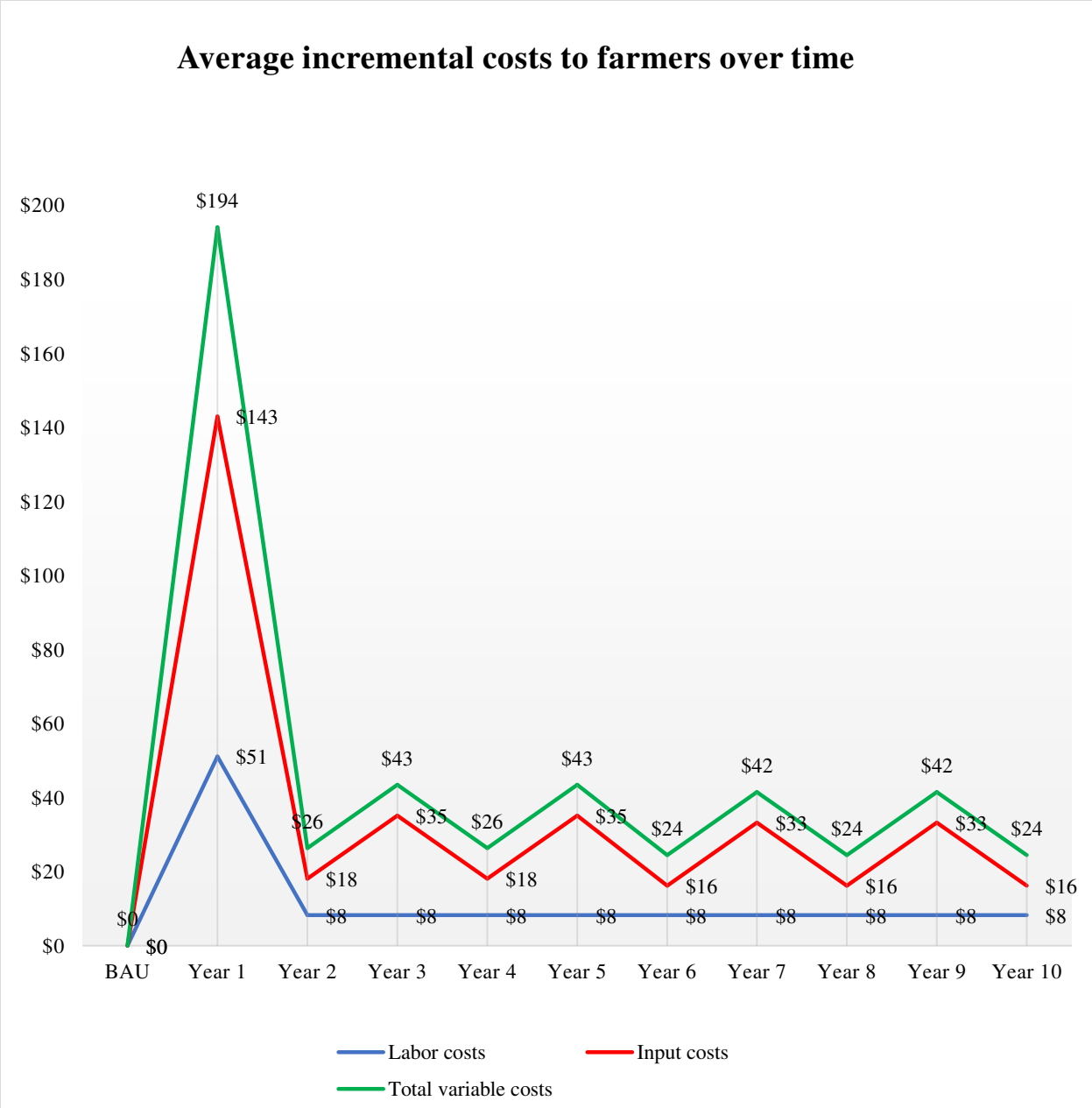


Figure 6: Incremental costs to farmers over time (in USD per ha per year): Target B1

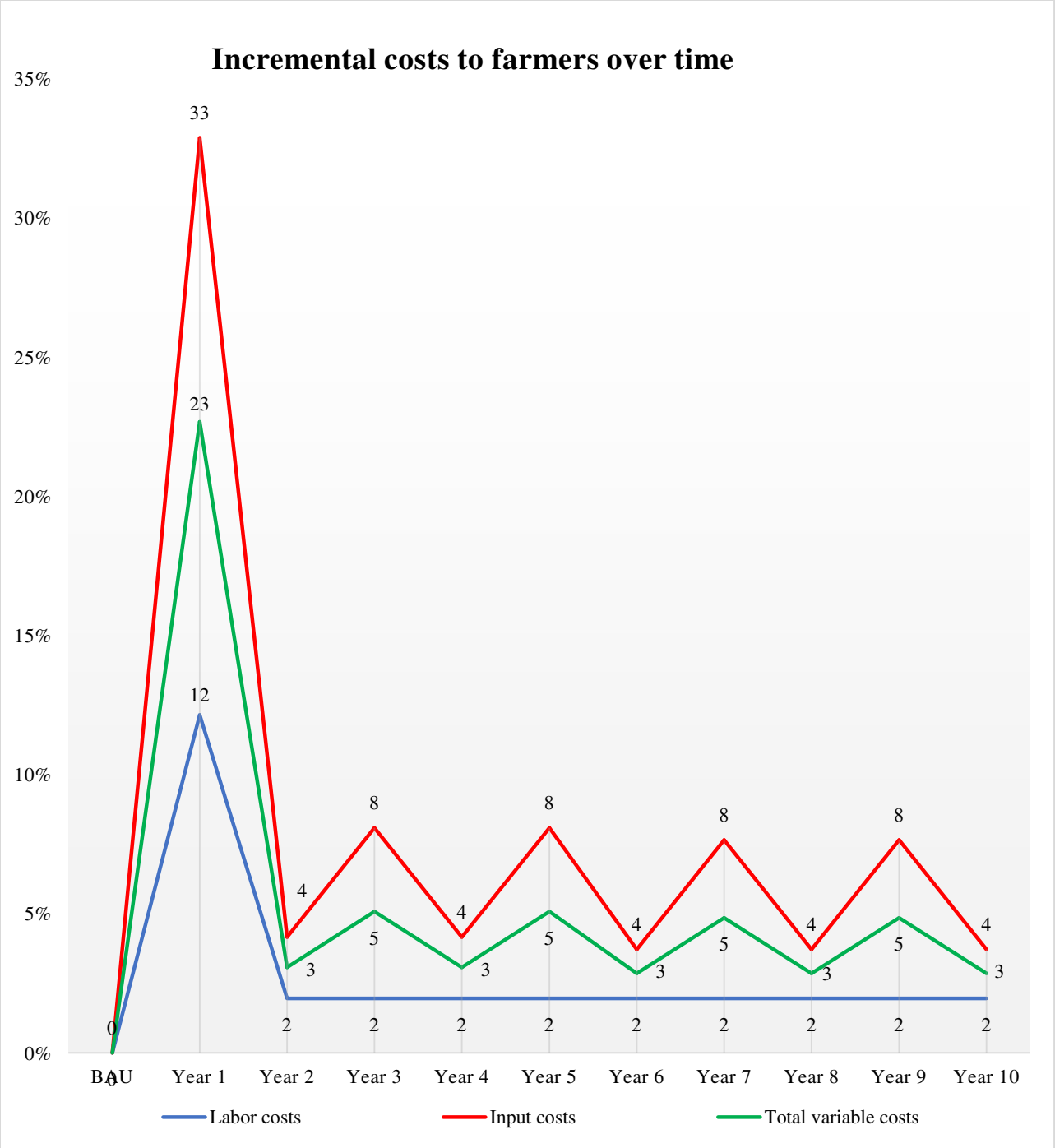


Figure 7: Incremental costs to farmers over time (in % per ha per year): Target B1