Georgia: Pilot Programme to Deliver a Carbon Neutral and Sustainable Hydropower Project

Project number: C30272/AUS1-2014-08-04

Handbook

REFORESTATION PROGRAMME

FS Consult

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1. INTRODUCTION

This Handbook serves the purpose of guiding the afforestation activities within the Dariali Energy hydropower plant reforestation project. The reforestation project aims at compensating the CO_2 emissions of the construction of the Dariali Energy hydropower plant. The CO_2 sequestration shall be achieved by afforesting > 100 ha with native tree species in the Kazbegi district. Afforestations will be done by fencing areas and planting seedlings grown in a nursery and by fencing areas where there is a high potential for natural regeneration and letting natural forest succession take place. The CO_2 sequestration potential of natural forest types in the Kazbegi district was assessed based on field measurements. The timeframe for the achievement of the full CO_2 compensation by the afforestations has been set to 70 years. The forests shall be sustainably managed for the benefit of the local population. The afforestation project also aims at creating jobs and promoting sustainable forest management techniques in the Kazbegi district. With the afforestation and monitoring activities the following knowledge will be promoted:

- Knowledge on tree species-specific seedling production
- Knowledge on operating a nursery
- Silvicultural and forest management knowledge in planning and implementing reforestation measures (fencing, planting, weeding)
- Knowledge on silvicultural monitoring

The suitable tree and shrub species for afforestation were identified during field investigations in the region and from literature on the natural vegetation of the High Caucasus. The recommended woody plant species are Caucasian pine (*Pinus kochiana*), Beech (*Fagus orientalis*), Caucasian oak (*Quercus macranthera*), Mountain ash (*Sorbus aucuparia*), Trautvetter's maple (*Acer trautvetteri*), Birch (*Betula litwinowii*), Aspen (*Populus tremula*), Willow (*Salix carea, S. kazbekensis, S. kusnetzowii*), Caucasian wild pear (*Pyrus caucasica*), Wild apple (*Malus orientalis*), Common barberry (*Berberis vulgaris*), Sea buckthorn (*Hippophaë rhamnoides*), Juniper (*Juniperus communis var. depressa, J. sabina*), Stone goosberry (*Ribes biebersteinii*), Common briar (*Rosa canina*), Spirea (*Spiraea hypericifolia*).The field survey indicated that there is asignificant potential for a natural regeneration dynamic, in particular considering specific site conditions, seed trees in the surrounding area of the planting sites and low grazing pressure. High natural regeneration potential exists for birch, willow, poplar, maple and sea-buckthorn. This gives a great opportunity to combine natural and artificial regeneration in a mixed-mode reforestation. Advantages to follow those procedures are:

- positive influence on genotypes, more tree species (biodiversity)
- harnessing site-specific conditions (mirco sites, micro-climate)
- reduction of natural risks for tree growth
- reduction of costs

In total about 30 % of the reforestation area have been estimated with high potential for natural regeneration, if grazing pressure will be stopped. A plant need of about 385.000 plants (seedlings) in total is calculated for artificial regeneration (reforestation).

Table 1: Planned reforestation area [ha] in total; defined share [ha] of natural and artificial (planting) regeneration and calculated plant need frame (in 1,000)

	reforestation area	regeneration method		plant need
tree species	[ha]	natural [ha]	artificial [ha]	[number in Tsd.]
birch, maple, willow, other tree species	75/(70-80)	45/(40-50)	30	30 - 40
poplar	2/(2-3)	1-2	2	2- 3
seabuck thorn	4/(3-5)	1-2	4	4-5
pine	87/(80-90)	7/(5-10)	80	320 - 360
	168	**52**	**116**	**360 - 400**

Figure 1: Natural regeneration dynamics of *Betula litwinowii* within polygon 188/4 (right part of the picture), which should be augmented by additional planting of *Acer, Sorbus* and *Fagus*. Within the rock-forest (polygon 188/6, left corner of the picture) the *Betula* trees are already higher, what is due to less browsing damages in this steep terrain.

Figure 2: **Natural regeneration dynamics of willow, pine and birch within polygon139/1.**

Figure 3: Mixed-mode reforestation for polygon 188/4 and 188/6; yellow: existing natural regeneration; red line: fence.

2. DETAILED REFORESTATION PLAN

2.1. Overview

As described in the **Interim Report** in 52 sites are proposed for reforestation activities. These sites (also called polygons) are located in 9 survey regions in the Kazbegi district (Figure 4- Figure 14). The selection of the proposed reforestation sites is based on extensive field survey (site characteristics, growth characteristics of observed forest types), literature research on the native tree species and their growth requirements, carbon sequestration potential of the recommended forest types and legal and social considerations.

The time schedule for the afforestation activities has to consider the seedling production options in the nurseries and the availability and balanced demand of labour. The proposed schedule for the afforestation of the nine regions and the afforested area per year is given in Table 2.

Table 2 Schedule for the afforestation of the different regions, annual area to be afforested, and annual area to be afforested including the area where natural regeneration is anticipated.

Year	Region	Planting (ha)	Planting + natural regeneration (ha)
Year 1 (2016)	2 (153/1)	1-3	2-3
Year 2 (2017)	8	7-9	10-11
Year 3 (2018)	1	16-18	29-31
Year 4 (2019)	3+7	37-39	57-58
Year 5 (2020)	2 (141/4)+4+9	39-43	49-50
Year 6 (2021)	5+6	13-15	19-20
		116/(113-127)	**170/(166-173)**

The polygons that are recommended for afforestation and the recommended species groups per polygon are given Table 3. The **Birch + Hardwood** group **(B)** encompasses Birch (*Betula litwinowii*), Beech (*Fagus orientalis*), Caucasian oak (*Quercus macranthera*), Mountain ash (*Sorbus aucuparia*), Trautvetter's maple (*Acer trautvetteri*), Caucasian wild pear (*Pyrus caucasica*), Wild apple (*Malus orientalis*). The **Popular + Willow** group **(W)** includes Aspen (*Populus tremula*) and different Willow species (*Salix carea, S. kazbekensis, S. kusnetzowii*). In addition there is **Pine (P)**, Caucasian pine (*Pinus kochiana*) and **Sea buckthorn** (*Hippophaë rhamnoides*). For every plot the optimal share of species is given in Table 4. If the production of the hardwood species is to demanding and if not all of these species can be produced to the required extent the main species for planting will be birch and pine. To support biodiversity and naturalness of the plantations the utilisation of at least 10% mixture/hardwood species is recommended for every site. Based on the findings of the field survey regarding site conditions, natural regeneration potential, tree specific plant density and spacing Table 3 gives an overview about the estimated plant need as a guideline for each reforestation area (polygon). For birch and hardwood species, poplar and willow, and for sea-buckthorn a planting density of 1100 plants per hectare was assumed. For pine a planting density of 4000 plants per hectare is suggested. For birch the estimated plant need was reduced by 40% because natural regeneration is expected to come. With existing natural regeneration the plant need was reduced by 80%.For pine the estimated plant need was reduced by 50% if there is already natural pine regeneration. It is important to understand that the calculated plant need per reforestation area is a guideline, which should be adapted by findings during the detailed planning process.

Table 3: Estimated plant need per reforestation area (polygon), Area total is the area of a polygon (ha), Area effective is the effective afforestation area (ha), which is smaller due to already existing trees, shrubs or due to surface rock areas and Area reduced is the effective afforestation area minus the area where natural regeneration is anticipated (ha);

						Number of plants			
Polygon	Region	Year of afforestation	Area total	Area effective	Area reduced	Birch + Hardwood (B)	Popular + Willow (W)	Pine (P)	Sea-buckthorn
153/1	2	Year 1 (2016)	3.7	3.3	2.9	700	0	9,300	0
303/10	8	Year 2 (2017)	1.6	1.6	1.6	0	0	6,300	0
303/4	8	Year 2 (2017)	9.5	8.1	6.5	2,700	0	16,400	0
303/8	8	Year 2 (2017)	1.1	1.1	0.8	500	0	1,300	0
176/2	1	Year 3 (2018)	6.7	5.4	1.1	1,200	0	0	0
177/1	1	Year 3 (2018)	9.2	9.2	8.4	300	0	32,800	0
177/4	1	Year 3 (2018)	1.0	1.0	0.3	200	200	0	0
188/12	1	Year 3 (2018)	20.1	8.1	7.4	1,100	0	25,800	0
188/4	1	Year 3 (2018)	4.8	3.4	0.7	800	0	0	0
188/5	1	Year 3 (2018)	3.0	3.0	2.6	900	0	7,400	0
161/3.2	3	Year 4 (2019)	1.0	1.0	0.7	700	200	0	0
161/3.3	3	Year 4 (2019)	0.4	0.4	0.3	300	100	0	0
171/2	3	Year 4 (2019)	17.2	16.4	9.2	6,500	0	13,100	0
171/3	3	Year 4 (2019)	7.3	6.4	5.6	1,300	0	17,900	0
171/9	3	Year 4 (2019)	7.8	7.0	1.4	1,600	0	0	0
172/10	3	Year 4 (2019)	0.7	0.5	0.3	100	0	900	0
172/4	3	Year 4 (2019)	1.6	0.8	0.7	200	0	2,300	0
172/5	3	Year 4 (2019)	9.8	8.8	8.1	1,200	0	28,300	0
172/6	3	Year 4 (2019)	1.0	0.4	0.4	100	0	1,300	0
172/8	3	Year 4 (2019)	0.7	0.5	0.4	200	0	1,300	0
172/8.2	3	Year 4 (2019)	0.5	0.4	0.3	100	0	900	0
173/11	3	Year 4 (2019)	1.2	1.2	0.7	800	0	0	0
173/4	3	Year 4 (2019)	4.7	4.4	3.7	1,200	0	10,700	0
173/52	3	Year 4 (2019)	3.8	3.4	2.8	900	0	8,100	0
173/52.1	3	Year 4 (2019)	0.5	0.4	0.3	200	0	1,000	0
302/1	7	Year 4 (2019)	2.5	2.5	1.5	1,700	0	0	0
302/2	7	Year 4 (2019)	0.2	0.2	0.1	100	0	400	0
302/4	7	Year 4 (2019)	0.6	0.4	0.4	200	0	1,100	0
302/5	7	Year 4 (2019)	1.1	1.0	0.2	300	0	0	0
302/6	7	Year 4 (2019)	1.2	1.1	0.8	500	0	1,700	0
141/4	2	Year 5 (2020)	30.5	25.9	24.5	3,300	0	75,600	2,900
129/1	4	Year 5 (2020)	8.1	5.3	2.8	700	0	8,600	0
139/2	4	Year 5 (2020)	2.5	1.9	0.8	300	700	0	0
151/1	4	Year 5 (2020)	0.9	0.8	0.7	200	0	2,300	0
151/2	4	Year 5 (2020)	4.7	3.8	2.3	500	0	7,700	0
151/3	4	Year 5 (2020)	0.5	0.4	0.2	300	0	0	0
151/4	4	Year 5 (2020)	1.5	1.1	1.0	100	0	3,700	0
151/5	4	Year 5 (2020)	1.2	1.1	0.9	400	0	2,300	0
151/7	4	Year 5 (2020)	1.1	0.6	0.6	0	0	0	700
151/8	4	Year 5 (2020)	1.1	0.9	0.5	100	0	1,400	100
152/2	4	Year 5 (2020)	0.7	0.4	0.3	100	0	1,100	0
301/1	9	Year 5 (2020)	7.6	7.4	4.7	4,400	900	0	0
108/1	5	Year 6 (2021)	3.8	3.5	2.7	300	0	9,900	0
108/2	5	Year 6 (2021)	2.1	2.1	1.6	200	0	5,900	0
117/1	5	Year 6 (2021)	1.2	1.1	0.6	200	0	1,800	0
117/2	5	Year 6 (2021)	0.9	0.8	0.6	400	0	1,300	0
118/1	6	Year 6 (2021)	2.6	2.5	2.3	400	0	8,100	0
118/3	6	Year 6 (2021)	1.3	1.1	0.9	300	0	3,000	0
118/4	6	Year 6 (2021)	3.9	1.6	1.1	900	0	1,300	0
119/1	6	Year 6 (2021)	1.7	1.5	0.4	300	200	0	0
119/2	6	Year 6 (2021)	1.8	1.7	1.6	300	0	5,500	0
119/3	6	Year 6 (2021)	3.9	1.6	1.4	300	0	5,000	0
119/4	6	Year 6 (2021)	2.7	2.0	1.8	300	0	6,300	0
			211	**170**	**124**	**40,200**	**2,300**	**329,800**	**3,700**
Calculated need (+10 %):						**44,200**	**2,500**	**362,800**	**4,100**

Table 4Recommended species for each polygon, given in one-tenth proportions; species codes are composed of the first three letters of the genus and the first two letters of the specific epithet.

Polygon	Region	Pinko	Quema	Sorau	Betli	Poptr	Acetr	Salca	Salsp	Malor	Pyrca	Fagor	Hiprh
176/2	1	—	—	5	—	—	5	—	—	—	—	—	—
177/1	1	8	—	2	—	—	—	—	—	—	—	—	—
177/4	1	—	—	1	5	—	3	—	1	—	—	—	—
188/12	1	8	2	—	—	—	—	—	—	—	—	—	—
188/4	1	—	—	3	—	—	3	—	—	—	—	4	—
188/5	1	6	—	—	—	—	1	—	—	—	—	3	—
141/4	2	6	2	1	—	—	—	—	—	—	—	—	1
153/1	2	7	—	—	1	—	2	—	—	—	—	—	—
161/3.2	3	—	—	—	3	—	3	—	1	—	—	3	—
161/3.3	3	—	—	—	3	—	3	—	1	—	—	3	—
171/2	3	4	—	—	3	—	3	—	—	—	—	—	—
171/3	3	7	3	—	—	—	—	—	—	—	—	—	—
171/9	3	—	—	2	2	—	3	—	—	—	—	3	—
172/10	3	4	—	3	3	—	—	—	—	—	—	—	—
172/4	3	7	3	—	—	—	—	—	—	—	—	—	—
172/5	3	8	2	—	—	—	—	—	—	—	—	—	—
172/6	3	8	2	—	—	—	—	—	—	—	—	—	—
172/8	3	6	3	1	—	—	—	—	—	—	—	—	—
172/8.2	3	6	3	1	—	—	—	—	—	—	—	—	—
173/11	3	—	—	—	—	—	5	—	—	—	—	5	—
173/4	3	6	—	—	1	—	3	—	—	—	—	—	—
173/52	3	6	4	—	—	—	—	—	—	—	—	—	—
173/52.1	3	6	4	—	—	—	—	—	—	—	—	—	—
129/1	4	3	—	—	2	—	3	—	—	—	—	2	—
139/2	4	—	—	3	—	3	4	—	—	—	—	—	—
151/1	4	7	2	1	—	—	—	—	—	—	—	—	—
151/2	4	5	—	—	3	—	2	—	—	—	—	—	—
151/3	4	—	—	—	—	—	5	—	—	—	—	5	—
151/4	4	8	—	2	—	—	—	—	—	—	—	—	—
151/5	4	5	—	2	—	—	3	—	—	—	—	—	—
151/7	4	—	—	—	—	—	—	—	—	—	—	—	10
151/8	4	8	—	1	—	—	—	—	—	—	—	—	1
152/2	4	7	2	1	—	—	—	—	—	—	—	—	—
108/1	5	7	—	—	1	—	2	—	—	—	—	—	—
108/2	5	7	—	—	1	—	2	—	—	—	—	—	—
117/1	5	4	—	—	2	—	2	—	—	—	—	2	—
117/2	5	4	—	—	2	—	2	—	—	—	—	2	—
118/1	6	8	—	2	—	—	—	—	—	—	—	—	—
118/3	6	7	3	—	—	—	—	—	—	—	—	—	—
118/4	6	2	—	—	—	—	—	—	—	4	4	—	—
119/1	6	—	—	—	3	—	3	1	—	—	—	3	—
119/2	6	8	2	—	—	—	—	—	—	—	—	—	—
119/3	6	8	2	—	—	—	—	—	—	—	—	—	—
119/4	6	8	—	2	—	—	—	—	—	—	—	—	—
302/1	7	—	—	2	2	—	3	—	—	—	—	3	—
302/2	7	6	—	—	—	—	4	—	—	—	—	—	—
302/4	7	6	—	—	—	—	4	—	—	—	—	—	—
302/5	7	—	—	2	1	—	4	—	—	—	—	3	—
302/6	7	4	—	3	—	—	3	—	—	—	—	—	—
303/10	8	10	—	—	—	—	—	—	—	—	—	—	—
303/4	8	2	—	2	—	—	3	—	—	—	—	3	—
303/8	8	3	—	2	3	—	2	—	—	—	—	—	—
301/1	9	—	—	—	—	—	9	—	1	—	—	—	—

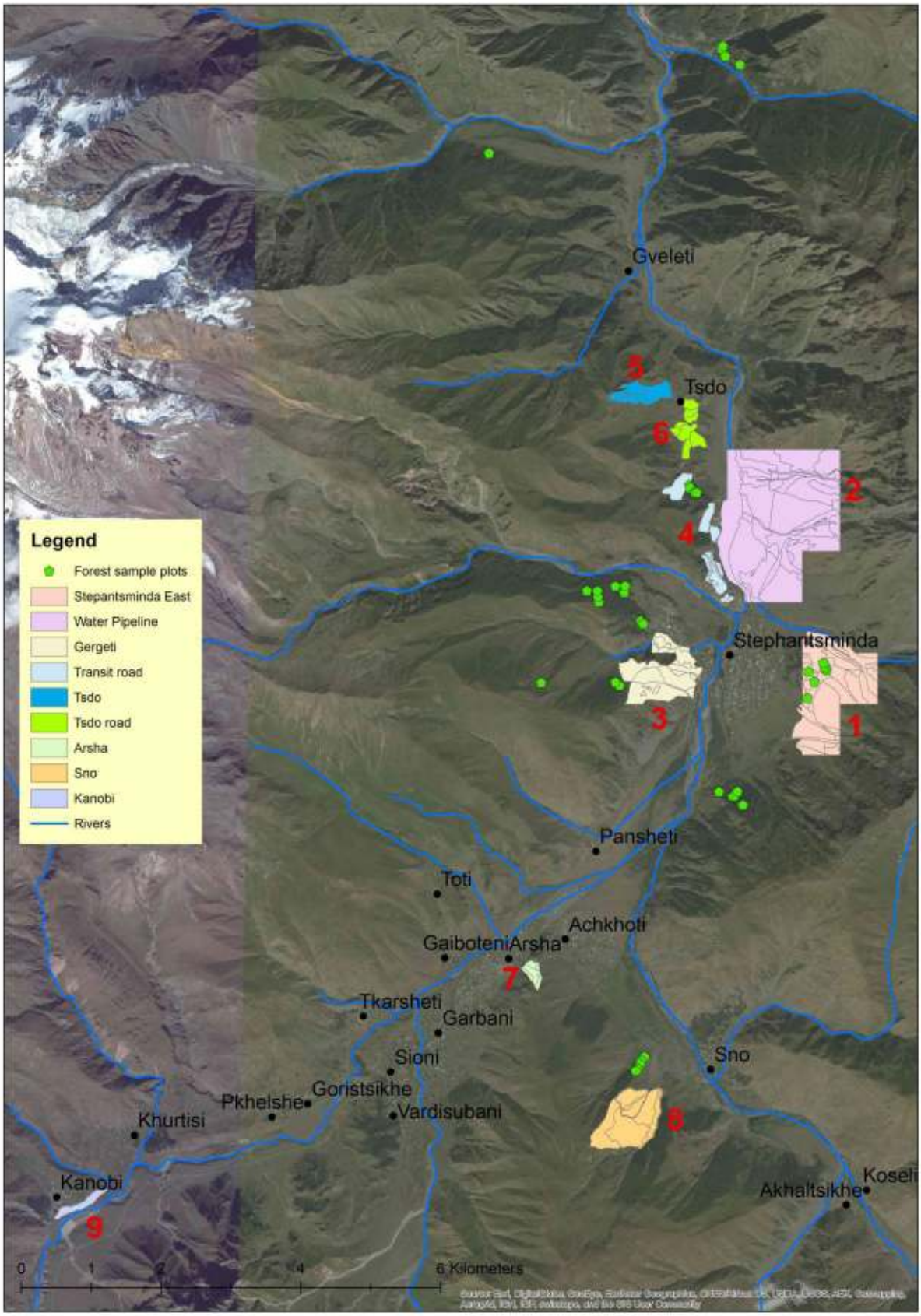

Figure 4: GIS-map, displaying the nine field survey regions with the single land cover polygons and the forest survey sample plots in the area of Stephantsminda.

2.2.**Year 1**

In the first year the production of pine (*Pinus kochiana*) seedlings from the seed material collected in the region commences in a nursery near Tbilisi and the operation of the nursery in Stepantsminda starts. With the plant material that shall be available in autumn of the first year (one year old seedlings)a first, so called test plantation of 1-2 ha is proposed. The test plantation can be split in subareas and different fence types can be tested for the subareas. Proposed fencing types are electric fence, fence with smooth wire in five rows (or a similar type which the people have experience with), or mesh wire fence. The test plantation also serves the purpose of gaining experience with the planting technique. GIS-map, displaying the nine field survey regions with the single land-cover polygons and the forest survey sample plots in the area of Stephantsminda.

Figure 5: The potential afforestation area of map polygon 153/1, a steep slope at the lower area of the scree-cone of Stepantsminda, situated above the power plant line, with visible areas where open erosion takes place.

Figure 6: View at the area related to map polygon 153/1 from above, it shows the open erosion areas there even better. Also the course of the power plant line becomes very well visible from this perspective.

2.3.**Year 2**

In year 2 the area of defined reforestation area close to the village of Snow can be afforested. The approximate area for planting trees is 8-9 ha. The total afforestation area is 10-11 ha, including areas with natural regeneration.

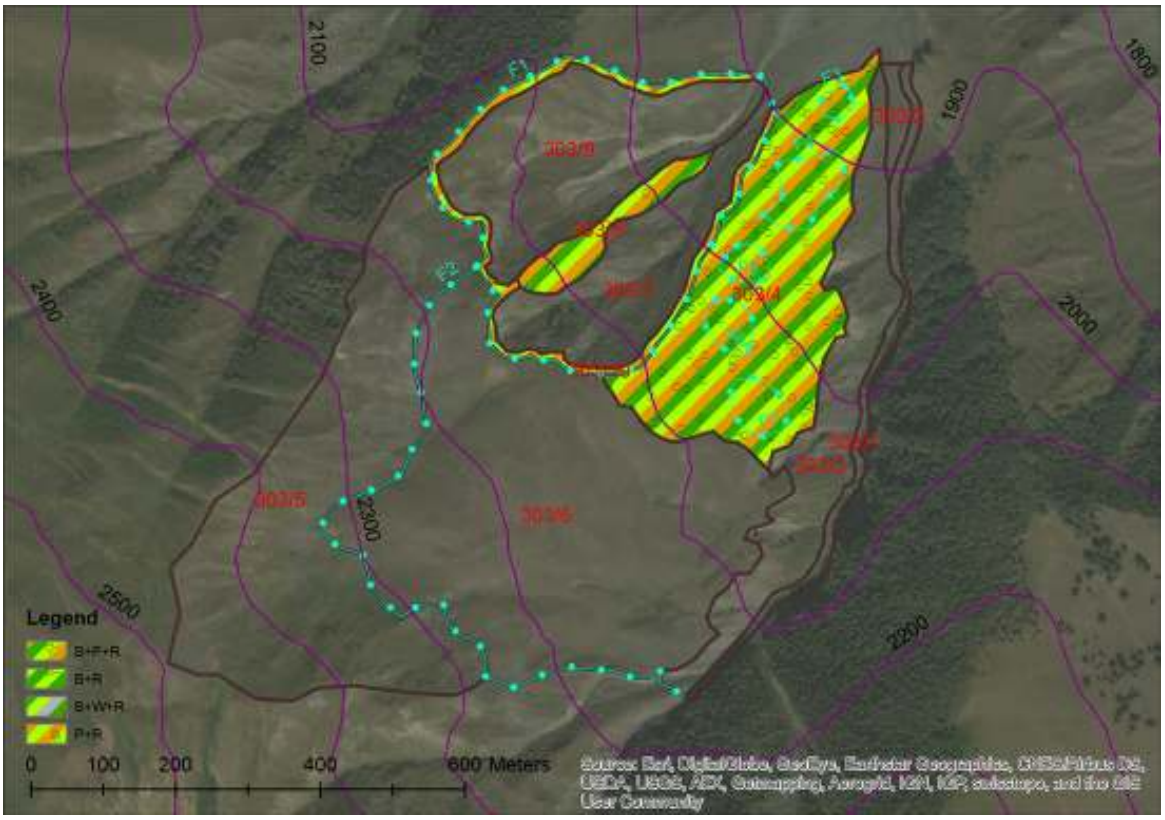

Figure 7: GIS-map of survey region VIII, displaying the field survey sites from Sno, and recommended fencing (F1 – F7), B…Birch+Hardwood, P…Pine, W…Poplar+Willow, R…Natural regeneration, circles….mixture species;

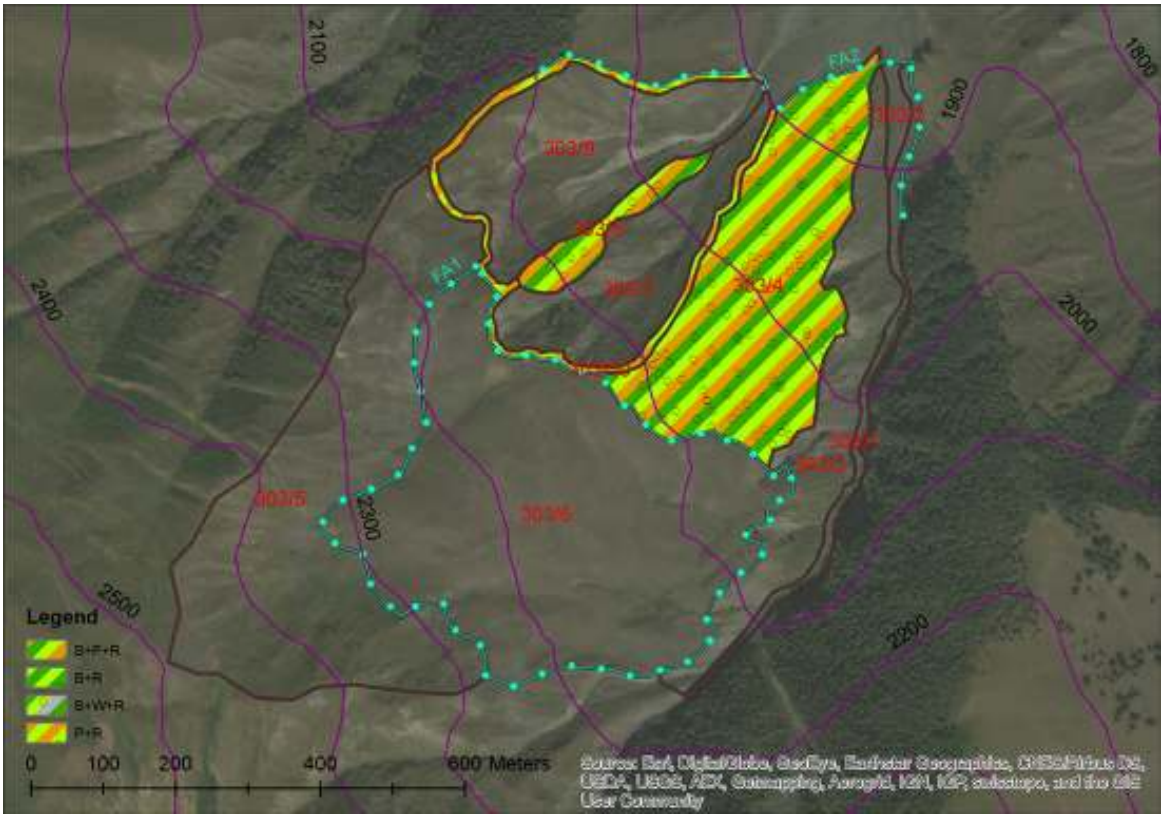

Figure 8: GIS-map of survey region VIII, displaying the field survey sites from Sno, and alternative recommended fencing (FA1, FA2), B…Birch+Hardwood, P…Pine, W…Poplar+Willow, R…Natural regeneration, circles….mixture species;

2.4. **Year 3**

In year 3 the area of defined reforestation area to the East of Stepantsminda can be afforested. The approximate area for planting trees is 17-20 ha. The total afforestation area is 30 ha, including areas with natural regeneration.

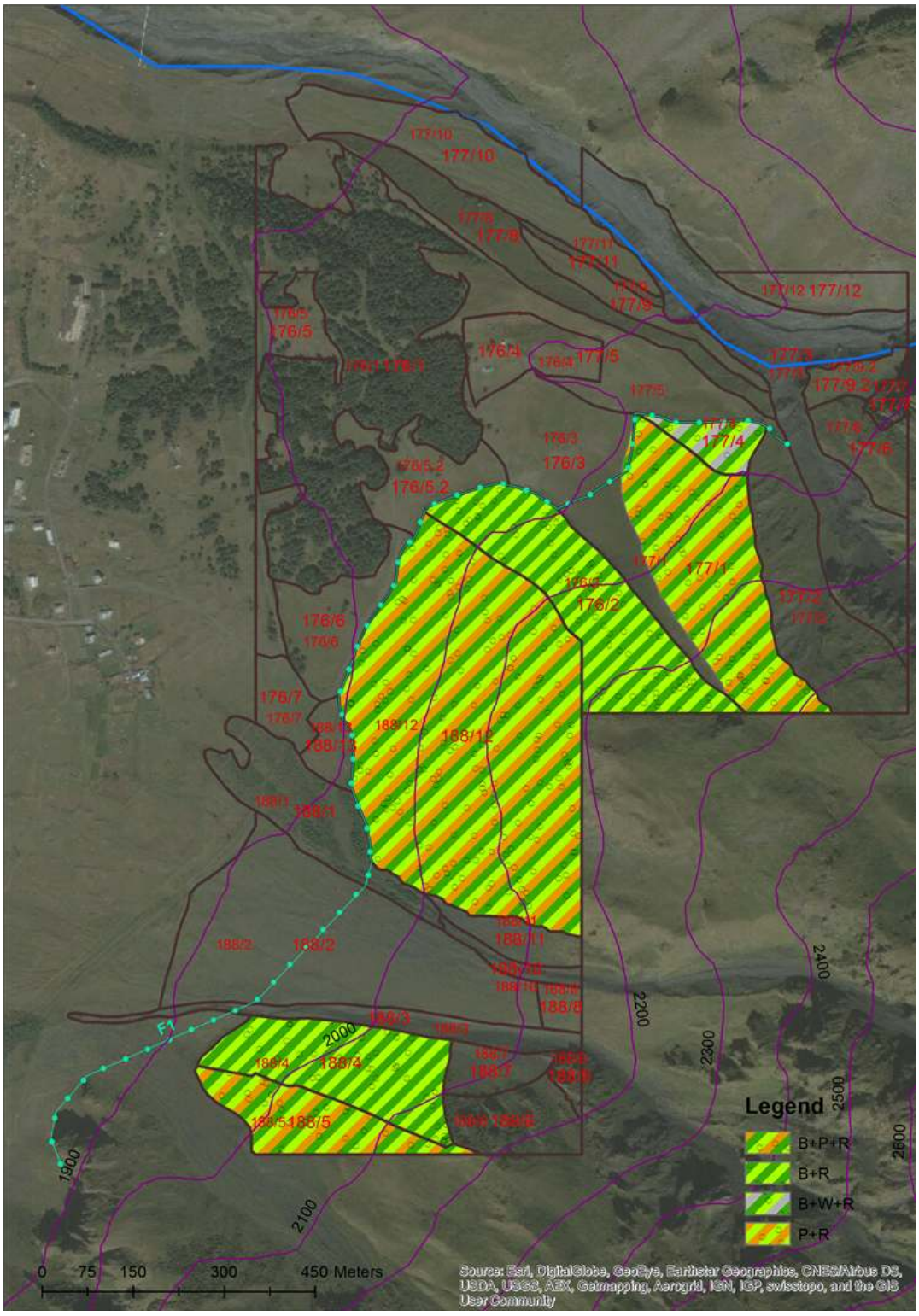

Figure 9: GIS-map of survey region I, displaying the field survey sites to the East of Stepantsminda, and recommended fencing (F1), B…Birch+Hardwood, P…Pine, W…Poplar+Willow, R…Natural regeneration, circles….mixture species;

2.5. **Year 4**

In year 4 the area of defined reforestation area to the West of Gergeti and to the South-East of the village of Arsha can be afforested. The approximate area for planting trees is 38 ha. The total afforestation area is 57 ha, including areas with natural regeneration.

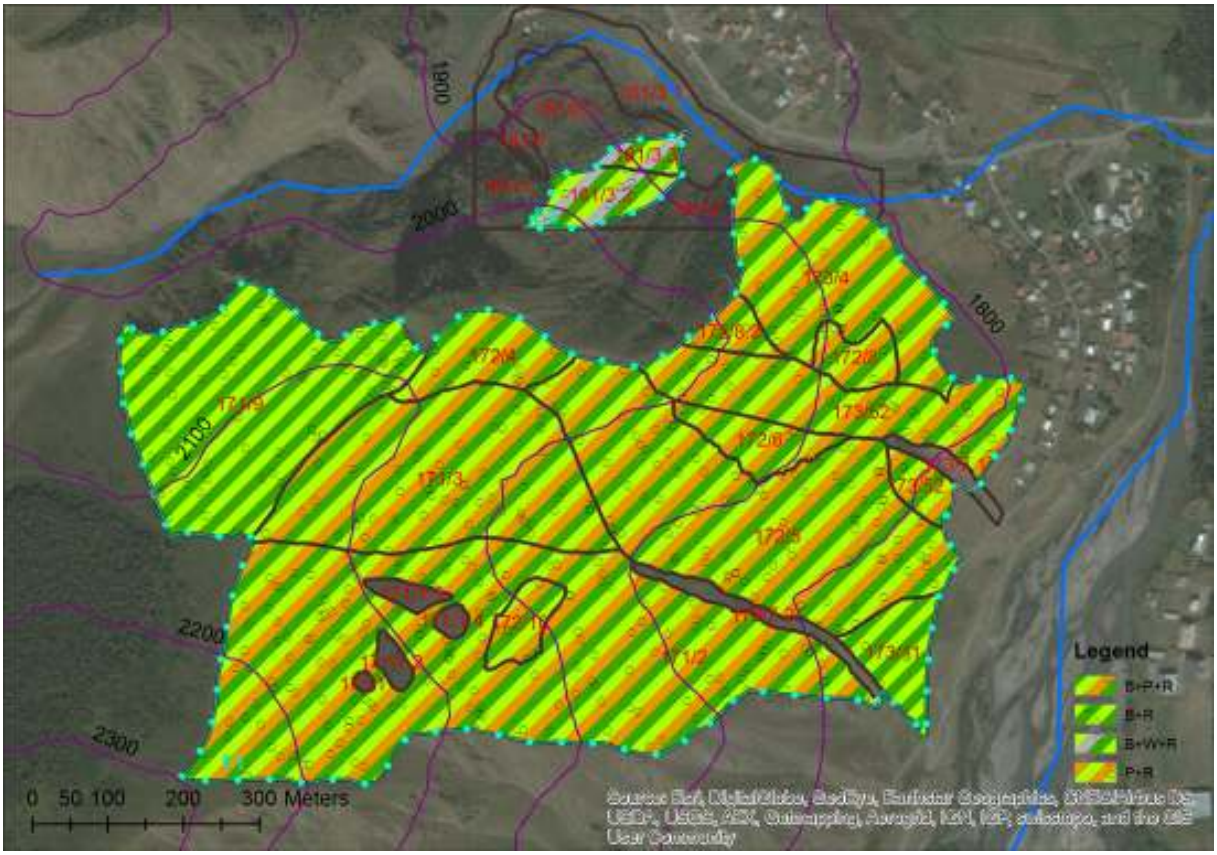

Figure 10: GIS-map of survey region III, displaying the field survey sites in the area of Gergeti, and recommended fencing (F1, F2), B…Birch+Hardwood, P…Pine, W…Poplar+Willow, R…Natural regeneration, circles….mixture species;

Figure 11: GIS-map of survey region VII, displaying the field survey sites from Arsha (sites above the village), and recommended fencing (F1, F2), B…Birch+Hardwood, P…Pine, W…Poplar+Willow, R…Natural regeneration, circles….mixture species;

2.6.**Year 5**

In year 5 the area of defined reforestation area along the pipeline (141/4),along the transit road to the North of Stepantsminda and the slope below the village of Kanobi can be afforested. The approximate area for planting trees is 39 ha. The total afforestation area is 53 ha, including areas with natural regeneration.

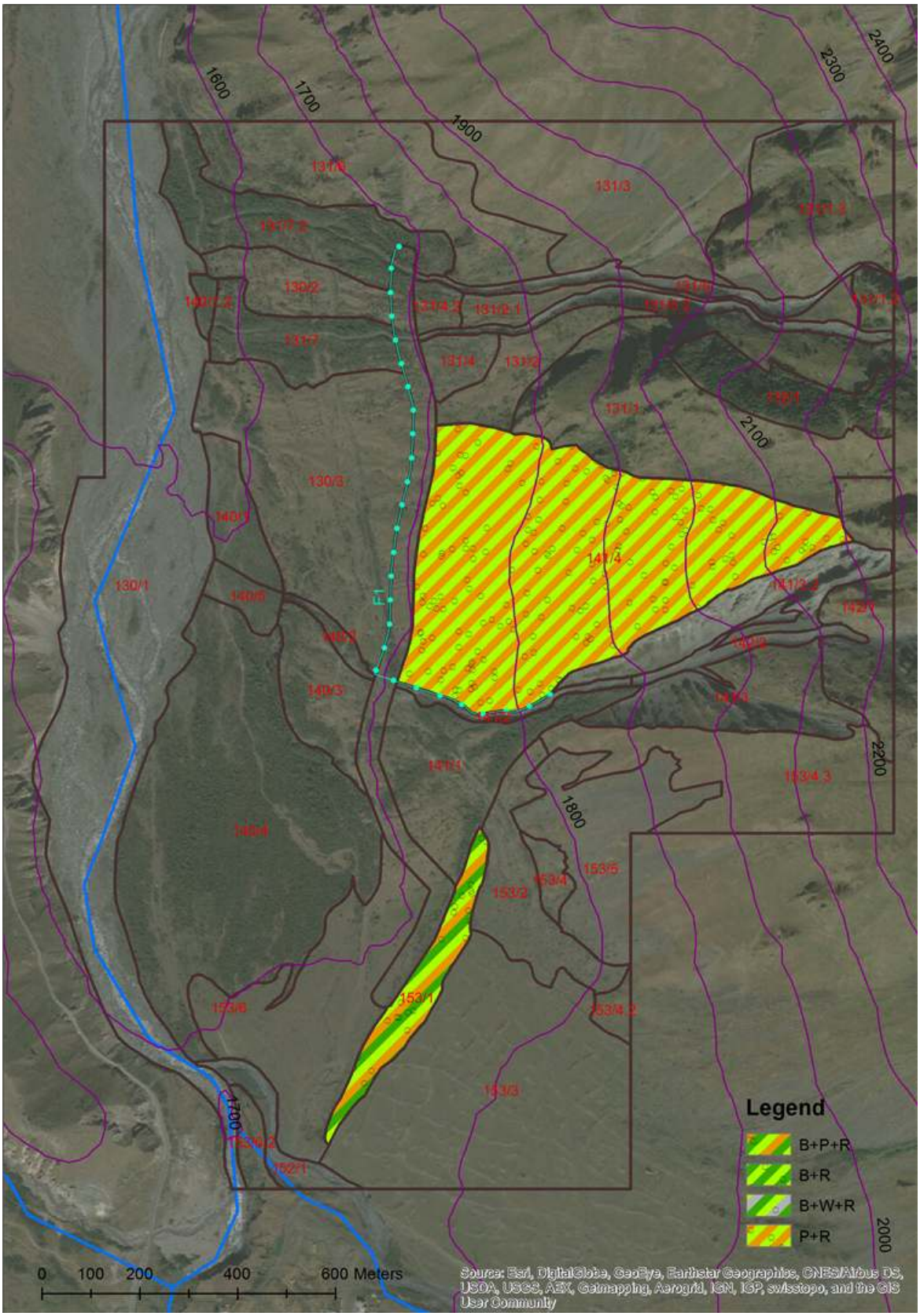

Figure 12: GIS-map of survey region II, displaying the field survey sites along the hydro power plant water pipeline, and recommended fencing (F1), B…Birch+Hardwood, P…Pine, W…Poplar+Willow, R…Natural regeneration, circles….mixture species;

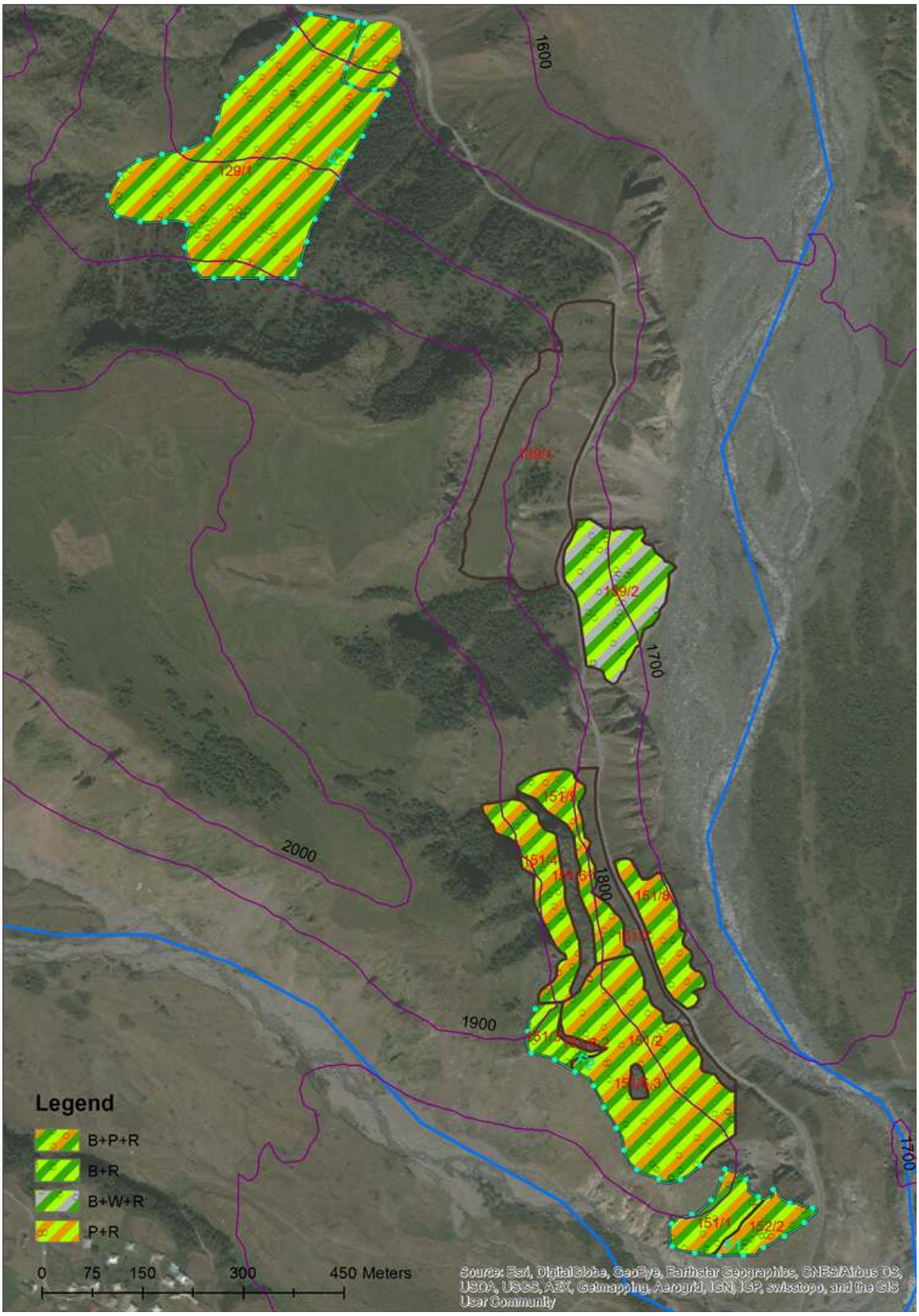

Figure 13: GIS-map of survey region IV, displaying the field survey sites along the transit road to the North of Stepantsminda, and recommended fencing (F1 – F3), B…Birch+Hardwood, P…Pine, W…Poplar+Willow, R…Natural regeneration, circles….mixture species;

Figure 14: GIS-map of survey region IX, displaying the field survey sites from Kanobi, B…Birch+Hardwood, P…Pine, W…Poplar+Willow, R…Natural regeneration, circles….mixture species;

2.7.**Year 6**

In year 6 the area of defined reforestation around the village of Tsdo can be afforested. The approximate area for planting trees is 15 ha. The total afforestation area is 19 ha, including areas with natural regeneration.

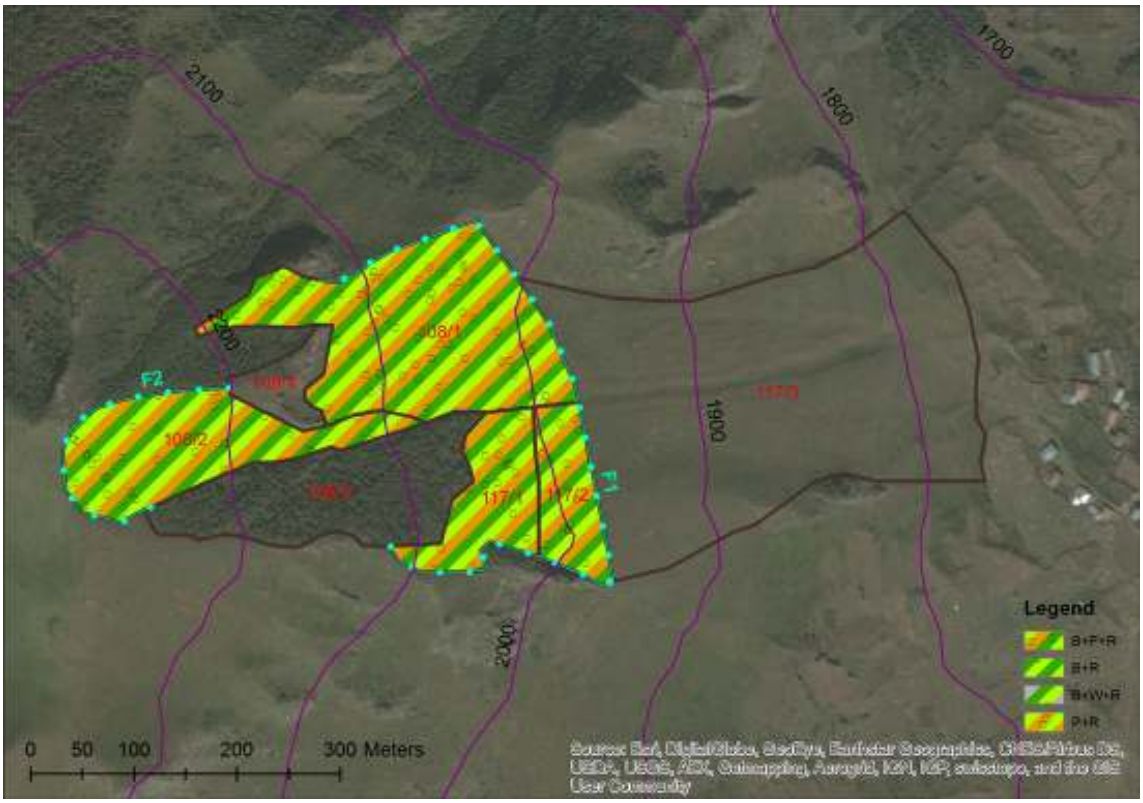

Figure 15: GIS-map of survey region V, displaying the field survey sites from Tsdo (sites above the village), and recommended fencing (F1, F2), B…Birch+Hardwood, P…Pine, W…Poplar+Willow, R…Natural regeneration, circles….mixture species;

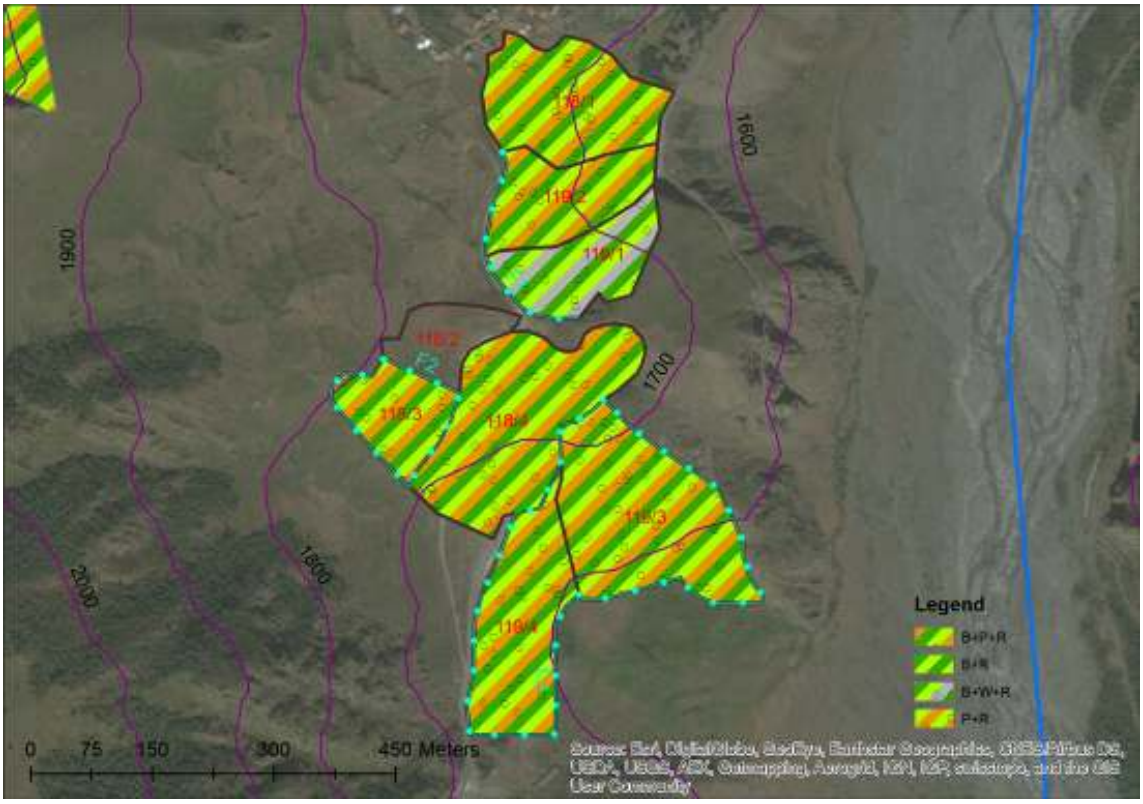

Figure 16: GIS-map of survey region VI, displaying the field survey sites from Tsdo (sites close to the transit road), and recommended fencing (F1 – F3), B…Birch+Hardwood, P…Pine, W…Poplar+Willow, R…Natural regeneration, circles….mixture species;

3. DEVELOPMENT OF CARBON STORAGE POTENTIAL

The afforestation activities will lead to CO_2 sequestration that will compensate for carbon emissions of the hydropower plant construction. Table 5 and Figure 17 show an overview about the development of the estimated CO_2 storage potential (t CO_2 ha^{-1}) for the project period 2016 – 2021. The CO_2 storage potential is calculated for the future forest stands at an age of 60-70.

The fundamentals for generating the values of Table 5 were formed by summarizing the reforestation areas (natural and artificial regeneration areas) and the estimated CO_2 storage potential of all planned location sites (Table 6). CO_2 storage potential for each reforestation sites (polygon) and per ha will be helpful information for calculating the actual CO_2 storage potential after successful reforestation (see chapter 9.3)

Table 5: Reforestation area (ha) in total, artificial (planting) areas (ha) per tree species and estimated CO_2 storage potential (t CO_2 ha^{-1}) at an age of 60-70 years following the planned activities 2016 – 2021

Year	Reforestation area [ha]	birch + hardwood [ha]	poplar+wollow [ha]	pine [ha]	seabuck thorn [ha]	CO2-storage potential [t CO2]	accumulated CO2-storage potential [t CO2]
Y- 2016	2	0	0	2	0	1100	1100
Y- 2017	11	7	0	3	0	3900	5000
Y-2018	31	16	0	16	0	12400	17400
Y-2019	57	32	0	25	0	20300	37700
Y-2020	50	23	1	22	3	18900	56600
Y-2021	19	7	0	12	0	7700	64300
Total	170	85	2	81	3	64300	

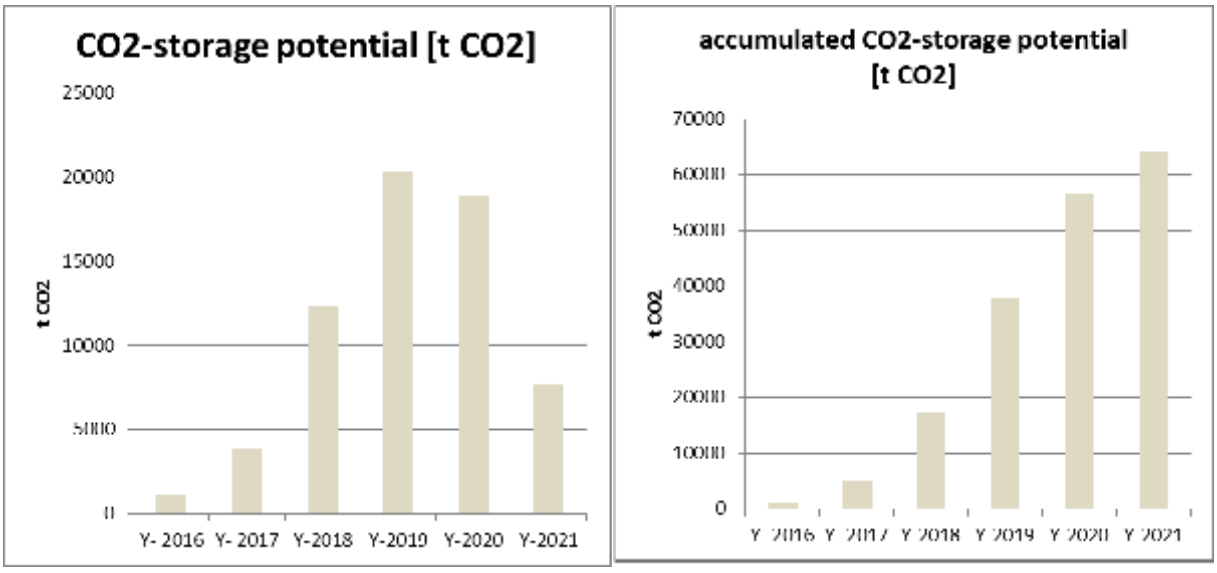

Figure 17: Estimated and accumulated CO_2 storage potential (t CO_2 ha^{-1}) at an age of 60-70 years following the planned activities 2016 – 2021

Table 6: Reforestation area (ha) in total, artificial (planting) areas (ha) per tree species and estimated CO_2 storage potential (t CO_2 ha^{-1}) at an age of 60-70 years for each polygon

Year	site quality	Polygon	Reforestation area [ha]	birch + hardwood [ha]	poplar+wollow [ha]	pine [ha]	seabuck thorn [ha]	CO2-storage potential [t CO2]	CO2-storage potential per ha [t CO2.ha-1]
2016	**good**	**test site**	**2,0**			**2,0**		**1100**	**550**
	2016		**2**	**0**	**0**	**2**	**0**	**1100**	**550**
2017	**good**	303/10	1,6	0,0	0,0	1,6	0,0	853	550
		303/4	8,1	6,5	0,0	1,6	0,0	2693	334
		303/8	1,1	0,7	0,0	0,3	0,0	386	361
		good	**10,7**	**7,2**	**0,0**	**3,5**	**0,0**	**3932**	**368**
	2017		**10,7**	**7,2**	**0,0**	**3,5**	**0,0**	**3932,0**	**368,0**
2018	**good**	176/2	5,4	5,4	0,0	0,0	0,0	1506	280
		177/1	9,2	1,8	0,0	7,3	0,0	4539	496
		177/4	1,0	0,9	0,1	0,0	0,0	299	298
		188/4	4,8	4,8	0,0	0,0	0,0	1347	280
		188/5	3,0	1,2	0,0	1,8	0,0	1345	442
		good	**23,4**	**14,1**	**0,1**	**9,1**	**0,0**	**9035**	**386**
	medium	188/12	8,1	1,6	0,0	6,4	0,0	3408	423
		medium	**8,1**	**1,6**	**0,0**	**6,4**	**0,0**	**3408**	**423**
	2018		**31,4**	**15,7**	**0,1**	**15,6**	**0,0**	**12443**	**396**
2019	**bad**	172/5	8,8	1,8	0,0	7,1	0,0	3085	350
		172/6	0,4	0,1	0,0	0,3	0,0	138	350
		bad	**9,2**	**1,8**	**0,0**	**7,4**	**0,0**	**3223**	**350**
	good	161/3.2	1,0	0,9	0,1	0,0	0,0	304	298
		161/3.3	0,4	0,4	0,0	0,0	0,0	121	298
		171/2	16,4	9,8	0,0	6,5	0,0	6351	388
		171/9	7,0	7,0	0,0	0,0	0,0	1956	280
		172/10	0,5	0,3	0,0	0,2	0,0	210	388
		173/11	1,2	1,2	0,0	0,0	0,0	328	280
		302/1	2,5	2,5	0,0	0,0	0,0	694	280
		302/2	0,2	0,1	0,0	0,1	0,0	67	442
		302/4	0,4	0,2	0,0	0,3	0,0	192	442
		302/5	1,0	1,0	0,0	0,0	0,0	276	280
		good	**30,5**	**23,3**	**0,1**	**7,1**	**0,0**	**10499**	**344**
	medium	171/3	6,4	1,9	0,0	4,5	0,0	2537	397
		172/4	0,8	0,2	0,0	0,6	0,0	317	397
		172/8	0,5	0,2	0,0	0,3	0,0	193	371
		172/8.2	0,4	0,1	0,0	0,2	0,0	139	371
		173/4	4,4	1,8	0,0	2,7	0,0	1641	371
		173/52	3,4	1,3	0,0	2,0	0,0	1245	371
		173/52.1	0,4	0,2	0,0	0,2	0,0	142	371
		302/6	1,1	0,6	0,0	0,4	0,0	337	319
		meduim	**17,3**	**6,4**	**0,0**	**10,9**	**0,0**	**6552**	**379**
	2019		57,1	31,5	0,1	25,4	0,0	20274	355
2020	**bad**	151/7	0,6	0,0	0,0	0,0	0,6	2	3
		151/8	0,9	0,1	0,0	0,7	0,1	286	335
		bad	**1,4**	**0,1**	**0,0**	**0,7**	**0,7**	**287**	**198**
	good	129/1	5,3	3,7	0,0	1,6	0,0	1897	361
		141/4	25,9	7,8	0,0	15,5	2,6	10742	415
		151/2	4,2	2,1	0,0	2,1	0,0	1740	415
		151/3	0,4	0,4	0,0	0,0	0,0	103	280
		151/5	1,1	0,6	0,0	0,6	0,0	473	415
		301/1	7,4	6,6	0,7	0,0	0,0	2196	298
		good	**44,2**	**21,1**	**0,7**	**19,8**	**2,6**	**17151**	**388**
	medium	139/2	1,9	1,3	0,6	0,0	0,0	516	268
		151/1	0,8	0,2	0,0	0,6	0,0	312	397
		151/4	1,1	0,2	0,0	0,9	0,0	478	423
		152/2	0,4	0,1	0,0	0,3	0,0	149	397
		medium	**4,2**	**1,9**	**0,6**	**1,7**	**0,0**	**1456**	**345**
	2020		49,9	23,1	1,3	22,2	3,3	18894	379
2021	**bad**	118/4	1,6	1,2	0,0	0,3	0,0	312	200
		119/3	1,6	0,3	0,0	1,2	0,0	543	350
		bad	**3,1**	**1,6**	**0,0**	**1,6**	**0,0**	**855**	**275**
	good	108/1	3,5	1,1	0,0	2,5	0,0	1655	469
		108/2	2,1	0,6	0,0	1,5	0,0	975	469
		117/1	1,1	0,6	0,0	0,4	0,0	418	388
		119/1	1,5	1,3	0,1	0,0	0,0	438	298
		good	**8,2**	**3,7**	**0,1**	**4,4**	**0,0**	**3487**	**427**
	medium	117/2	0,8	0,5	0,0	0,3	0,0	256	319
		118/1	2,5	0,5	0,0	2,0	0,0	1058	423
		118/3	1,1	0,3	0,0	0,7	0,0	424	397
		119/2	1,7	0,3	0,0	1,4	0,0	724	423
		119/4	2,0	0,4	0,0	1,6	0,0	830	423
		meduim	**8,0**	**2,0**	**0,0**	**6,0**	**0,0**	**3293**	**409**
	2021		19,3	7,2	0,1	11,9	0,0	7635	395
	2016-2021	total	170	85	2	81	3	64279	377

4. SEEDLING PRODUCTION

4.1. Seedling production

In general for seed collection following steps are suggested:

- Gather information about regulatory framework for seed collection
- Hire a person, who has expert knowledge about seed collection
- Contact a company ('kiln'), which has experience with seed collection and seed extraction and storage of seeds for technical advice

4.1.1. Pine

Seed collection and treatment

- Consider the regulatory framework for seed collection; Search for a person, who has expert knowledge about seed collection
- Contact a kiln for technical advice, where you can share operational experience in seed collection, seed extraction as well as in storage of seeds for pine.
- Select 2 – 3 natural pine stands of good quality (age >50 years, e.g. natural pine forest stands near the Russian border; natural pine stands near river Tergi)
- Ask the owner of the pine stands for permission to collect cones
- Select 20-30 trees per stand for cone collection (cones – 2 years old)
- Collect and store the cones in wide meshed jute bag under cool (shade) and efficient self-ventilated conditions

1 kg of good quality seed material should be enough to produce 40,000 – 50,000 pine seedlings, but this calculation have to be adapted to local experiences.

Figure 18: Seed extraction (pine cones) at LEPL National Forestry Nursery

Figure 19: Starting seed extraction (pine cones) at LEPL National Forestry Nursery

Seedling production

It is recommended to produce 2-years bare-rooted seedlings of pine with a satisfying shoot/root ratio. This defined quality should be ensured by a seed bed density of 80 trees per square meter (80 trees per m^2; 125cm^2 per tree).Drill sowing (spacing of rows 25 cm; 20 seeds per linear meter) should be used. This spacing allows an efficient weed control.
Testing seed quality needs to be done before sowing: basic parameters are the germination percent (germination percent ≥ 90% is expected), and purity of the seed lot (99.5% pure seeds expected). Seed analysis can be ordered from regional laboratories (e.g. university).
Sowing is done in spring or in autumn after seed bed preparation. In general, autumn sowing will produce better developed 1-year seedlings, but precautions to minimize over-winter loss caused by birds and small mammals and freezing have to be taken.
Crucial for the germination success is a thin layer of substrate (0.8 cm), in particular a mixed sand-peat substrate.
The seed bed needs to be protected against damage by frost, heavy rainfall, radiation but also against birds. Therefore a removable shelter has to be installed, which covers the seed bed at a level of 30-50 cm above ground (no side walls!; self-ventilation!). We recommend greenhouse shade nets (level 70%). Alternatively, reed mats are recommended. The shelter should be periodically opened for regular management of the seed bed.

Figure 20: Drill sowing

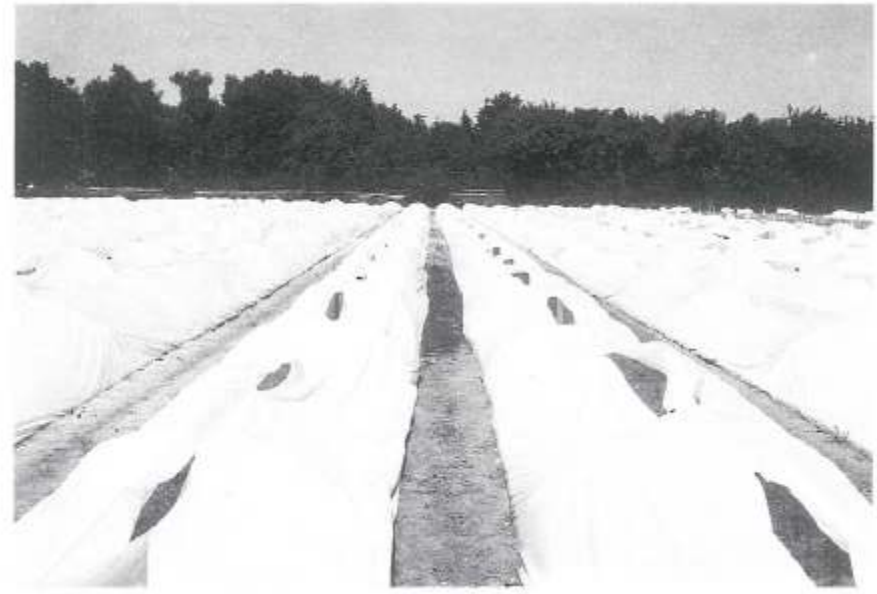

Figure 21: Seed covered with foils and air slots

Figure 22: Seed under reed mats

4.1.2. **Poplar and willow**

Seed collection and treatment

- Collecting fruit capsules in the period between May and June. Caution!: never collect before pappus of the seeds appears at the base of catkins!
- Afterwards store fruit capsules at room temperature (no direct sunlight!) until capsules open. Clean seeds from pappus (seed cotton). The use of any vacuum suction device is helpful.
- Poplar: seeds of poplar species must be dried for two days (room temperature 20°C-30°C; air ventilation, diffused light) for reducing moisture content to 4 or 5 percent. Storage in vacuum packed (sealed) polyethylene bags is possible at temperature between 10°C and 20°C in a dark room for 3 to 5 years.
- Willow: same procedure as for poplars.
- **Caution!** Seeds of certain willow species have a short life time of few days. In this case, sowing is recommended to be carried out immediately after harvest. But alpine and arctic willow species (also: *Salix petandra*) show natural seed dormancy and will germinate one year after harvest. Seeds of these species need pre-treatment (cold-wet-stratification) before seeding.

Seedling production

It is recommended to sow the cleaned seeds on rolled seed bed and to press the seed by irrigation into the ground. Preconditions for germination are suitable soil moisture and sun light! Thus seed bed should be covered by a small tunnelhouse or some plastic mulch (transparent membrane /foil) until germination (appearance of first seedlings) beginning of July.

Spacing: Broadcast seeding recommended.

Cuttings

<u>Hardwood cuttings</u>

Poplar and willow hardwood cuttings should be collected from vital and healthy trees while they are dormant in the late winter or early spring before the bud break.

Cuttings should be taken from the ends of the branches (previous summers' growth) and can be 7.5 cm to 1.0 meter long, depending on the individual tree and the growth conditions during the last year. Cuttings then are cut into smaller cuttings which should be approximately 15 cm to 25 cm long and should include at least four to five buds.

If the cuttings are taken in early winter, they must be stored in sealed plastic bags and placed in a snowbank on the north side of a building until they can be planted in spring. Another method is to store them in a cooler, at below freezing temperatures. The best method is to harvest the cuttings approximately a week before the bud break occurs; the cuttings should be placed in a plastic bag and kept in the refrigerator at 5.0°C until the ground thaws and the cuttings can be planted. If the cuttings are collected directly before the planting, they can be put into the fridge in a loose plastic bag until the planting, or placed into water for a day, but no longer. The sticks should not yet start to grow roots, which would be very fragile and would break off when the cutting is pushed into soil.

Figure 23: Having planted an unrooted cuttings in winter, this photograph shows the amount of growth one can expect in early spring.

<u>Softwood Cuttings</u>

Only for propagation of alpine willows!!!

Softwood cuttings of willow can be done in June or July, or as soon as there is sufficient new growth (about 13 cm).

Softwood cuttings (15-20cm long) from sexually mature trees are taken when shoots begin to become woody. The lower leaves are removed, leaving 2-4 leaves at the tip. The cutting is dipped into rooting hormone before rooted in substrate such as sand or perlite. The moisture of the substrate needs to be controlled. When the softwood cuttings are rooted, they should be planted in pots about 1-2months before transplanting them into the field.

4.1.3. **Birch**

Seed collection and treatment

Collect the catkins during July /August before catkins open (colour: yellow-brownish). Cut off branches with catkins, if necessary. Store the catkins in a dry and cool room for post-ripening (2-3 weeks). Turn and mix the catkins 2-3 times a week until the catkins decompose. Crumble the catkins by hand, if necessary. The birch seeds should reach a moisture content between 4 and 5 percent after this procedure. The mixture out of seeds and catkin pieces should be cleaned from big twig pieces by hand. Store the ready mixture in vacuum packed (sealed) polyethylene bags at temperature between 0°C and -6°C in a dark room for 3 to 5 years.

Seedlings per kg seed about 15,000 – 30,000 (germination percentage 20-35 %).

Seedling production

There are two options for seedling production:

A) Immediate seeding
B) Seeding the following spring time

Ad A) Sowing the seeds as soon as possible after the seed harvest. Seedbed should be covered by a very thin substrate layer (1.5 to 3 mm), roll the seed bed and keep it moist.

Ad B) Seeding the seeds from storage without stratification beginning of May. Cover seedbed with a thin substrate layer (1.5-3mm) as described above, roll the seedbed and keep it moist. (Harvest: up to 300,000 – 500,000 seedlings per kg seeds)

Spacing: Broadcast seeding recommended: 1 kg seeds per 50-100 square meters!

Shelter: Thus seed bed should be covered by a small tunnelhouse or some plastic mulch (transparent membrane /foil) until germination (appearance of first seedlings). Later on: use a removable shelter, which covers the seed bed at a level of 30-50 cm above ground (no side walls!; self-ventilation!). We recommend greenhouse shade nets (level 70%). Alternatively, reed mats are recommended. The shelter should be periodically opened for regular management of the seed bed.

Cuttings

<u>Softwood Cuttings</u>

15-20 cm long cuttings from young branches are taken when shoots begin to become woody, remove the lower leaves, leaving 2-4 leaves at the tip and dip into rooting hormone before rooted in media such as sand or perlite and keep special attention to the moisture of media. Rooted should be planted in pots for 1-2month before transplanting to field. Rooted cuttings also can be an effective propagation method for sea-buckthorn.

4.1.4. **Sea-buckthorn**

Seed collection and treatment

Collect seeds in September / October. A) Pick them directly from the bush or B) cut off twigs with fruits, freeze in a freezer (-20°C) for 24 hours and afterwards shake the twigs in order to get the fruits off the twigs.
Post-ripening / cleaning: water bath for 1-2 weeks: change water from time to time, in particular if fermentation starts (foam). Use running water as well as a suitable sieve for cleaning seeds from the fleshy part of the fruit. Dry the clean seeds for 1-2 weeks in a cool, dry (air circulation) and dark (!) room. Store the seeds in a jar at temperature between 0°C and -6°C in a dark room for up to 3 to 5 years. Long term storage affects seed viability, up to 60 % after 4 – 5 years.

Seedling production

Preparation: Start seed stratification in February. Do stratification for 2 to 3 months; sowing the seeds in May (optimal temperature for germination 18 to 20 ° C), sowing the seeds, covered 1 to 2 mm with sand. Germination process is light depending! Seeds should start to germinate within 5 – 10 days, based on the condition of the seeds and the species of sea-buckthorn. Protection against seed predators (birds, mammals) is necessary!

Sea-buckthorn seeds can also be seeded indoors in pots in January or early February, one seedling per pot is allowed to grow for 3 months before transplanting them into the field in early May.

Seed characteristics: 1 kg of fruits gives up to 4500 grains. 1 kg of seeds has 65,000-80,000 grains.

Cuttings

Hardwood cuttings

Cuttings should be chosen in Jan. – Feb. from healthy, well developed plants in fruiting stage, so the sex can be determined.

Cuttings (15-20 cm long) should be taken from the previous year’s growth during dormancy in the early spring / late winter. Bundles of cuttings are soaked in water (room temperature and changed once a day) and covering 2/3 of their length until the beginning of formation of roots. Cuttings should be treated with rooting hormone. Cuttings can be transplanted when the roots are 1-2 cm long, directly to the field with films.

Figure 6: Where to place the cuts for hardwood cutting.

Figure 7: Where to place the cuts in softwood cutting.

Softwood cutting

15-20 cm long cuttings from sexually mature trees are taken, when shoots begin to become woody, remove the lower leaves, leaving 2-4 leaves at the tip and dip into rooting hormone before rooted in media such as sand or perlite and keep special attention to the moisture of the media.

Once being rooted, they should be cultivated in pots for 1-2 months before transplanting them to the field.

Root cutting

Rooted cuttings also can be an effective propagation method for sea-buckthorn.

5. NURSERY PLANNING AND MANAGEMENT

5.1. General conditions for a tree seedling nursery

Selection of suitable site for nursery establishment is decisive for the success in growing high-quality bare-root seedlings.

Recommended site requirements are:

- a moderate local climate (high risks are caused by drought or coldness)
- suitable and manageable soils (good nutrient availability, good texture; preferably sandy soils)
- easy and sustainable access to water supply
- no harmful residual effects of former land use
- moderate slopes (< 3 % slope) or adequate conditions for terracing
- easy access to efficient transportation
- southwest exposition

In case of less favourable conditions, action has to be taken in order to mitigate negative factors. In case of wind-problems, as for instance, wind protection shelter (e.g. hedge-rows) needs to be planned and established in a proper way.

5.2. Nursery area planning

For the planned production of 320.000 pine seedlings and about 40.000 cuttings/seedlings of deciduous tree species (birch, willow, poplar and sea-buckthorn) the land requirement is up to 8.500 m^2. Once selected, the nursery location has to be assessed /analysed for defining micro-site conditions, which allow optimised cultivation of the respective target species. The position of the seed beds, the road network, buildings, water supply etc. has to be designed regarding factors like wind protection, water runoff, frost protection.

Table 7: Annual fenced land requirement for plant production in m²

		2016	2017	2018	2019	2020	2021
Seed bed area (including footh path)							
pine	m²	2.700	5.400	4.725	4.725	675	675
birch, willow, poplar, seabuck thorn	m²	0	0	68	135	203	135
area for green manuring	m²	810	1.620	1.438	1.458	263	243
other areas for infrastructure (compost, huts, storage buildings)	m²	540	1.080	959	972	176	162
total		4.050	8.100	7.189	7.290	1.316	1.215
nursery area	**m²**	**4.500**	**8.500**	**8.500**	**8.500**	**1.500**	**1.500**

5.3. **Nursery operations**

Following (key) operations are essential for successful seedling/plant production:

- Soil cultivation
  - mechanical soil working (ploughing, ripping)
    For a satisfying germination process of the seed intensive soil cultivation is crucial. Loose soil without humus layer is beneficial.
  - maintenance of the soil (compost, farmyard manure and green manure)

- Irrigation
  Optimal irrigation is necessary, especially after sowing to favour the germination process. Irrigation of the plants is done by aiming the water low at the plants with micro-sprinklers or by forming fog-like conditions.

- Fertilization
  For the seedlings production within the project it will not be necessary to fertilize, if the soil is moderate nutrient rich and loose. Use of fertilisers should only follow an examination (practical experiences) or testing of the soil.

- Weeding
  Weeding (pulling of weeds) in early state in the seed bed (prefer mechanical treatment) is continuous necessary.

Figure 24: Transplanting of cuttings in rows

5.4. Lifting (digging) of seedlings

Success in planting depends on good coordination between the nursery manager and responsible persons for planting operations. The advantage within this project is that the environmental conditions at the nursery coincide more or less with those of the planting sites. The seedlings should be dug out before the break dormancy in spring and put the seedlings into foilbags in a not too wet state.

The foilbags should be stored in shady places, cool cellars or in a cold storage room for a short period.

Prevent sun from shining directly on foilbags!!!

Temporary storage of seedlings:
It is recommended to store bare-root seedlings at shady, moist and cool places, sheltered from wind, nearby the planting sites before planting starts. This helps to prevent the fine roots from drying out.

5.5. Findings – Field excursion to LEPL National Forestry Nursery

During the meeting in February 2016 LEPL National Forestry Nursery was visited. Because of the good experiences and existing know-how for operating seed treatment (kiln) and a nursery pine and deciduous tree species (e.g. birch) a strategic decision was made to combine seedling production in National Forest Nursery near Tbilisi and in Sno (nursery area 4000 to 6000 m²). It is proposed to produce primary pine seedlings in Sno. It may be seen as an advantage for successful seedling production, when experiences are transferred to Sno Nursery.

It is of importance too, that the area of Sno Nursery can be used as temporary storage for seedlings, which have to be lifted early in spring in National Forestry nursery near Tbilisi.

Figure 25: LEPL National Forestry Nursery

Figure 26: Seedling production (container) in foil house at LEPL National Forestry Nursery

Figure 27: Starting soil preparation at Sno Nursery

Figure 28:Starting soil preparation at Sno Nursery

5.6. **Work plan**

Table 8, Table 9 and Table 10 show a detailed description of the work plan [activities in h] for nursery management for the period 2016 – 2021 and down by month for each year.

Table 8: Work plan for nursery management 2016 -2021 [activities in h]

Activities		2016	2017	2018	2019	2020	2021
preparing soil (hoening manually); green manuring; (fertilizing); turf; compost	[h]	405	820	739	739	132	122
preparing seed bed	[h]	225	456	411	411	73	68
composting	[h]	90	182	164	164	29	27
total 1		**720**	**1458**	**1314**	**1314**	**234**	**216**
sowing of seed/cuttings and covering	[h]	**135**	**270**	**236**	**236**	**34**	**34**
cuttings	[h]	0	6	17	17	17	11
cover with film/plastic foil	[h]	90	182	164	164	29	27
total 2	[h]	225	458	417	417	80	72
weeding	[h]	**180**	**365**	**329**	**329**	**59**	**54**
total 1+2+3	[h]	**1125**	**2280**	**2060**	**2060**	**372**	**342**
lift of seedlings/cuttings	[h]	**0**	**300**	**488**	**863**	**1013**	**225**
working hours	[h]	**1125**	**2580**	**2547**	**2922**	**1385**	**567**
person-days		141	323	318	365	173	71
person-weeks		**28**	**65**	**64**	**73**	**35**	**14**
person-month (temporarily)		**7**	**16**	**16**	**18**	**9**	**4**
1 worker (continuous)		**12**	**12**	**12**	**12**	**12**	**6**
total - person month		**19**	**28**	**28**	**30**	**21**	**10**

Activities		2016	2017	2018	2019	2020	2021
sedd collection; cuttings	h	7	100	300	300	200	0
person-days		1	13	38	38	25	0
person-weeks		**0**	**3**	**8**	**8**	**5**	**0**
person-month (temporarily)		**0**	**1**	**2**	**2**	**1**	**0**

Table 9: Working plan for nursery management 2016 -2018, down by month for each year [activities in h]

2016: Activities	hours [n]	Jan	Feb	March	April	May	June	July	August	September	Oct	Nov	Dec
preparing soil	405				405								
preparing seed bed	225				225								
composting	90				90								
sowing of seed; cuttings	135					135							
cuttings	0					0							
film/plastic foil	90				30	30	30						
weeding	180						90	90					
lift of seedlings/cuttings	**0**												
total	1125				750	165	120	90					
	weeks [n]				19	4	3	2					
	persons [n]				5	1	1	1					
1 worker	persons [n]	0,5	0,5	1,4	1,4	1,4	1,4	1,3	1,3	1,3	0,5	0,5	0,5
2017: Activities	hours	Jan	Feb	March	April	May	June	July	August	September	Oct	Nov	Dec
preparing soil	820				820								
preparing seed bed	456				456								
composting	182				182								
sowing of seed; cuttings	270					270							
cuttings	6					6							
film/plastic foil	182				30	30	30						
weeding	365						182	182					
lift of seedlings/cuttings	**300**					**300**							
total	2580				1488	606	212	182					
	weeks [n]				37	15	5	5					
	persons [n]				9	4	1	1					
1 worker	persons [n]	0,5	0,5	1,4	1,4	1,4	1,4	1,3	1,3	1,3	0,5	0,5	0,5
2018: Activities	hours	Jan	Feb	March	April	May	June	July	August	September	Oct	Nov	Dec
preparing soil	739				739								
preparing seed bed	411				411								
composting	164				164								
sowing of seed; cuttings	236					236							
cuttings	17					17							
film/plastic foil	164				30	30	30						
weeding	329						164	164					
lift of seedlings/cuttings	**488**					**488**							
total	2547				1344	771	194	164					
	weeks [n]				34	19	5	4					
	persons [n]				8	5	1	1					

Table 10: Working plan for nursery management 2019 -2021, down by month for each year [activities in h]

1 worker	persons [n]	0,5	0,5	1,4	1,4	1,4	1,4	1,3	1,3	1,3	0,5	0,5	0,5
2019: Activities	hours	Jan	Feb	March	April	May	June	July	August	September	Oct	Nov	Dec
preparing soil	739				739								
preparing seed bed	411				411								
composting	164				164								
sowing of seed; cuttings	236					236							
cuttings	17					17							
film/plastic foil	164				30	30	30						
weeding	329						164	164					
lift of seedlings/cuttings	**863**					**863**							
total	2922				1344	1146	194	164					
	weeks [n]				34	29	5	4					
	persons [n]				8	7	1	1					
1 worker	persons [n]	0,5	0,5	1,4	1,4	1,4	1,4	1,3	1,3	1,3	0,5	0,5	0,5
2020: Activities	hours	Jan	Feb	March	April	May	June	July	August	September	Oct	Nov	Dec
preparing soil	132				132								
preparing seed bed	73				73								
composting	29				29								
sowing of seed; cuttings	34					34							
cuttings	17					17							
film/plastic foil	29				30	30	30						
weeding	59						29	29					
lift of seedlings/cuttings	**1013**					**1013**							
total	1385				264	1093	59	29					
	weeks [n]				7	27	1	1					
	persons [n]				2	7	0	0					
1 worker	persons [n]	0,5	0,5	1,4	1,4	1,4	1,4	1,3	1,3	1,3	0,5	0,5	0,5
2021: Activities	hours	Jan	Feb	March	April	May	June	July	August	September	Oct	Nov	Dec
preparing soil	122				122								
preparing seed bed	68				68								
composting	27				27								
sowing of seed; cuttings	34					34							
cuttings	11					11							
film/plastic foil	27				30	30	30						
weeding	54						27	27					
lift of seedlings/cuttings	**225**					**225**							
total	567				246	300	57	27					
	weeks [n]				6	8	1	1					
	persons [n]				2	2	0	0					
1 worker	persons [n]	0,5	0,5	1,4	1,4	1,4	1,4	1,3	1,3	1,3	0,5	0,5	0,5

6. PROCEDURES - OVERVIEW

6.1. Overview - Site specific reforestation activities

Examination of the legal conditions and an agreement with the landowner (contract) are crucial before starting planting operations. In Figure 29 you will find a description of the procedures for decision making.

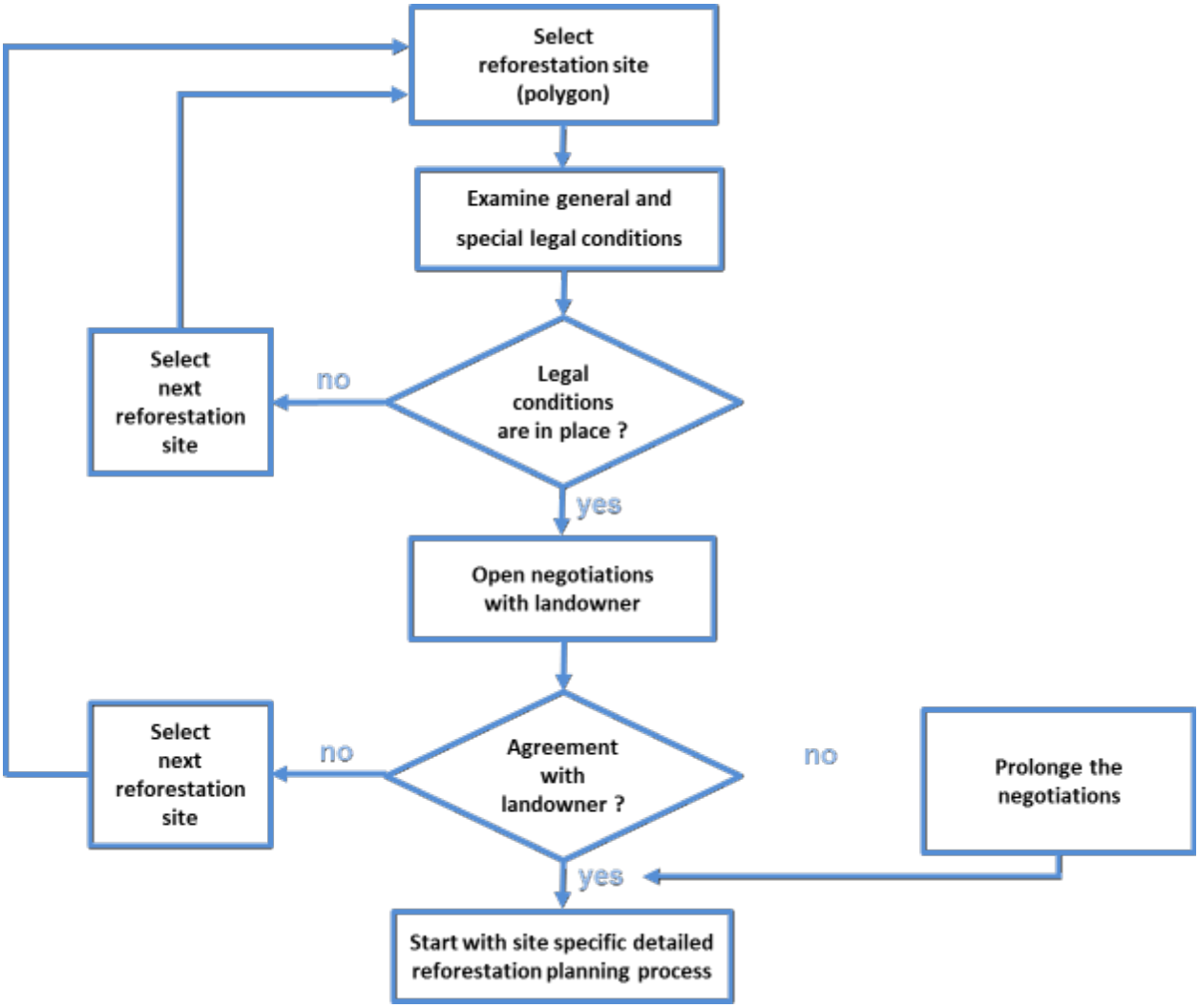

Figure 29: Flow chart 1 showing the detailed description of the procedure for final decision of the reforestation site

7. DETAILED DESCRIPTION OF PROCEDURES

7.1. Institutional and legal schedule

7.1.1. Land Ownership Status

A significant part of the land plots allocated for afforestation has no ownership status, which means that currently these plots are not registered in the Public Registry and their owners cannot be identified. This is a very common feature in Georgia, where the majority of land plots lacks an official ownership status. Under an ongoing legislative initiative of the Government of Georgia, if there is no ownership rights registered over a land plot, this land plot will be registered in state ownership on the basis of application of the National Agency of State Property Management at the Ministry of Economy[1].

In case above amendments are approved by the Parliament of Georgia and come into force, the land plots subject to further afforestation may be included in the Forest Fund lands or transferred into ownership of the local Municipalities in accordance with the procedures described in this Paragraph.

7.1.2. Procedures to be carried out before Afforestation

Land Plots with no Ownership Status

Despite the fact that land plots are not registered in the Public Registry it is still possible that a third party has rights (ownership or other *in rem* rights as e.g. usufruct rights) over the land plot. For avoiding afforestation on any plots that are not free from any third party right it is recommended to register the land plot in the ownership of the local municipality prior to starting any afforestation activity. It is within the competence of Kazbegi Municipality through consultation with the local community to identify land plots that are free from any third party's rights and potential claims.

For registration of e land plots suitable for afforestation, the following procedures should be undertaken:

A surveyor (expert) will draw cadastral measurements of the certain land plot;

As local municipalities are allowed to have real estate in ownership under the Code of Self Government, Article 19, in accordance with the Law of Georgia on the State Property, Article 18, Paragraph 1, Kazbegi Municipality may apply to the National Agency of State Property Management with request to transfer the appropriate land plot in its ownership through direct sale. The municipality should properly ground in its application why the status of the land plot should not be agricultural and why it should be used for afforestation purposes.

As soon as the grounded and reasonable application on transfer of the land plot into ownership of Kazbegi Municipality is received by the National Agency of State Property Management, procedures

[1] http://parliament.ge/ge/law/11140/28083

for transferring the land plot into ownership of Kazbegi Municipality will be initiated. Under Article 113, Paragraph 2 of the Code of Self Government, after submission of the application to the National Agency of State Property Management it takes 55 days to receive decision on transfer of the land plot in the municipality ownership and submit the application and the relevant documents to the Government of Georgia;

After the Government of Georgia receives the decision of the National Agency of State Property Management, it has to approve the decision within 45 days;

After all above steps are completed, the land plot can be registered as ownership of Kazbegi Municipality in the Public Registry. Kazbegi Municipality should submit an application on registration of the land plot to the Public Registry and attach the decision of the Government of Georgia and respective cadastral measurement to the Public Registry.

After the land plot is registered in the ownership of Kazbegi Municipality, Dariali Energy may enter into the land plot lease agreement with Kazbegi Municipality.

For general recommendations on a term-sheet for lease agreements refer to paragraph 3.

Land Plots in State Ownership

7.1.3. Land Plots outside of Protected Areas

State Forest Fund Lands

The laws of Georgia do not consider any regulations on transfer of the Forest Fund lands into ownership or under a lease / management agreement to private law entities or individuals. Afforestation of these areas should be carried out only under supervision and with consent of the Forestry Agency.

Local Forest Fund Lands

With respect to Forest Fund Lands, the laws of Georgia do not provide any grounds for transferring Local Forest Fund lands under a lease / management agreement to private law entities or individuals. Afforestation of such areas can be carried out only under supervision and with consent of Kazbegi Municipality in direct cooperation with the Forestry Agency.

State owned Lands outside the State / Local Forest Fund

The state owned non-agricultural lands can be transferred into ownership of Kazbegi Municipality in accordance with the procedures described in Paragraph 2.2 and after transferred to Dariali Energy for afforestation under lease agreement.

State Owned Lands – Protected Areas

The laws of Georgia do not provide any regulations on transfer of lands within the borders of protected areas into the ownership of local municipalities. The lands within the borders of protected areas cannot be lease or transferred under management agreements to private law entities or

individuals. Afforestation of these areas should be carried out only under supervision and with formal consent of the Agency of Protected Areas.

Lands owned by individuals or private law legal entities

Afforestation of private owned lands can be carried out on the basis of the lease / management agreement between the land owner and Dariali Energy.

For general recommendations on a term-sheet for lease agreements refer to paragraph 3.

Agreements with owners of the lands

Afforestation of land plots owned by Kazbegi Municipality or private owners can be carried out only after lease / land plot management agreements have been concluded between the owner/user and Dariali Energy.

The agreement with the owner/user should consider the following provisions:

Dariali Energy / contractors, successors or employees of Dariali Energy should be allowed to fence the territory for afforestation for a 15 years period;

Within the afforestation area, Dariali Energy / contractors, successors or employees of Dariali Energy should be allowed to plant trees and to undertake any necessary tending activities, as e.g. weeding;

The owner should be obliged to guarantee that the forest on the area of afforestation will persist for 70 years, as this period is a timeframe necessary for the required amount of carbon has been captured. The agreement should provide specific liabilities for violation of the mentioned obligation by the owner;

The agreement should determine which party of it and when is responsible for forest thinning and cleaning activity;

The agreement should regulate timber use-rights of the contracting parties and the local community at thinning and harvesting;

The owner should guarantee that grazing on the area of afforestation should be allowed not before 20 years after fencing the area for afforestation;

The owner should guarantee that local community for purposes of sustainable management of the forest will not overexploit the forest on the afforestation area.

Under existing practice, state owned lands are not leased for more than 49 years. This limitation under the laws of Georgia is applicable only to agricultural lands, though, generally state / municipality lands are not leased to individuals or private law legal entities for more than 49 years. It is recommended that the lease agreement is made for 70 years – the period which will be necessary for the required amount of carbon to be captured. However, in case there is no possibility to extend the agreement to 70 years, the agreement should stay in force for 49 years with a prolongation option that cannot be refused by the owners of the land plot without proper excuse.

Lease agreements should be registered within the Public Registry under Article 11, Paragraph 1 of the Law of Georgia on Public Registry.

As the land plots within the borders of the state and local Forest Fund cannot be leased or transferred for management to Dariali Energy, afforestation can be carried out with consent and under supervision of the Forestry Agency and the local municipality in case of Local Forest Fund territories .

Afforestation of the land plots within the borders of the protected areas can be carried out with consent and under supervision of the Agency of Protected Areas. As afforestation of territories within the borders of protected areas are subject to strict regulations, it is recommended not to carry out afforestation activities within the territories of protected areas.

In case Dariali Energy carries out afforestation on the land plots without prior registration of the local municipality as the land plot owner, the local municipality should take responsibility to ensure that all necessary measures for sustainable management of the afforested areas should be followed:

Fencing for up to 15 years - Dariali Energy / contractors, successors or employees of Dariali Energy should be allowed to fence the territory for afforestation;

Planting trees and weeding - within the afforestation area Dariali Energy / contractors, successors or employees of Dariali Energy should be allowed to plant trees and to do weeding;

Persisting the forest on the area of afforestation for 70 years and undertaking all necessary measures provided by the respective laws of Georgia for proper management of the afforested areas.

7.2. **Planting operations**

7.2.1. **Afforestation plan**

As a complement to the recommendations worked out based on field survey (site conditions; site specific tree species choice) a detailed site specific afforestation plan [spatial concept for reforestation pattern] should be prepared for each reforestation site by the responsible forester. To facilitate a successful implementation of the afforestation plan, revisions of the site specific afforestation plans is crucial. In this way one can take into account and/or balance the interests of the landowners (land managers).

Such a plan should include:

- localisation and borders of the reforestation area
- line of the fence
- detailed estimate and localisation of favourable and non-favourable sites for natural regeneration and planting
- no-plant areas [access lines; cattle/sheep passes]
- defining sites suitable for the different species

- tree specific planting density and spacing

Such plans will support workers in the course of planting and provide practical means for controlling reforestation operations once planting begins.

For securing high quality of planting the suitable planting sites depending on the species, topography and micro-climatic conditions should be marked by the responsible person at the reforestation area.

Characteristics for defining non favourable sites for reforestation and species-specific favourable sites: non favourable sites:

- very steep slopes, rocky areas, areas with long lasting snow situation and(or snow gliding

- favourable sites:
  - Birch: exposure all directions, slope inclination till 40°, snow rich areas (norther hillsides), sandy and medium loamy soils, heavy clay;
  - Pine: exposure south-east to south west, moderate slope inclination, sandy and medium loamy soils, pioneer tree on eroded areas;
  - Willow, poplar: exposure all directions, slope inclination till 30°, sandy and medium loamy soils, heavy clay;
  - Seabuck thorn: exposure all directions, slope inclination till 10°, sandy and medium loamy soils, heavy clay; drought tolerant

Figure 30: Partial area planting of spruce on favourable sites [v-shaped](example from Switzerland)

Figure 31: Pine reforestation in Kanobi. Source: E. Hochbichler

Figure 32: Pasture forest (pine trees in patches/groups)at Gudauri area, similar to a light pasture in Austria. This pattern of tree groups and pasture could be used for creating reforestation patterns.

Regarding tree specific characteristics (risks of diseases, pest infestations, individual tree mortality, etc.) tree densities and spacing as in Table 11 are suggested.

Table 11: Suggested tree densities and spacing for the recommended tree species.

Species	Tree density	Spacing
Pine	4,000 N/ha	2.5 m * 1 m ; 3.0 m * 0.8 m
Birch, poplar, willow (other deciduous tree species)	1,100 N/ha	3.0 m * 3.0 m
Sea-buckthorn	1,100 N/ha	3.0 m * 3.0 m

For partial planting a minimum size of 1,000 – 1,500 m² (for example 400-600 pines; 130 to 160 linear meter fence) is suggested.

Figure 35 and Figure 36 give examples for various planting patterns regarding pasturing aspects, site conditions and natural regeneration dynamics.

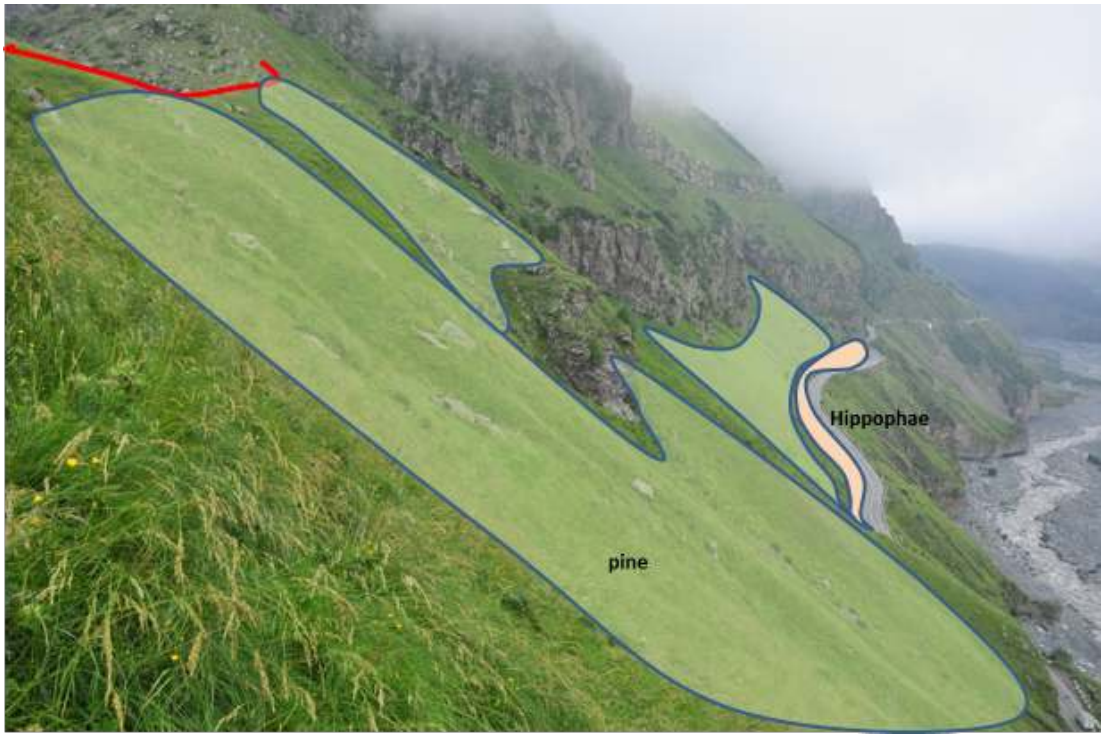

Figure 33:Recommended planting pattern as an example for a part of polygon 151/6)

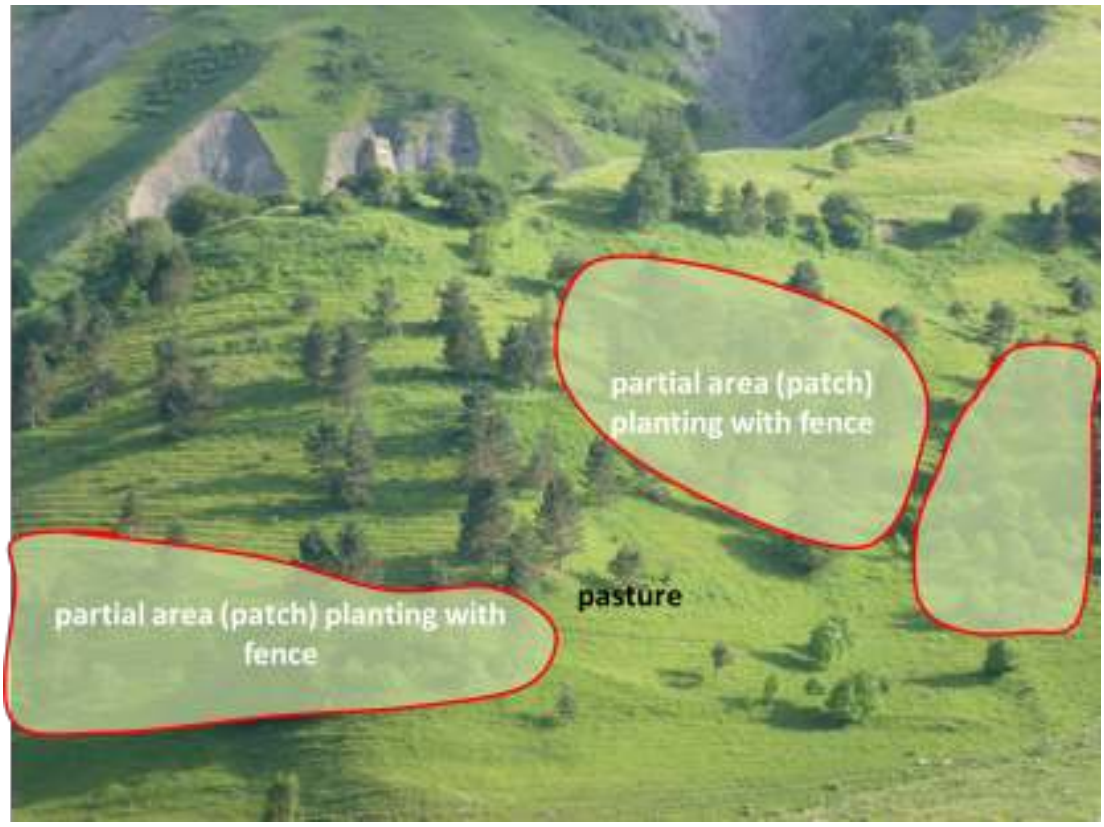

Figure 34: Recommended planting pattern as an example for partial planting (light pasture concept)

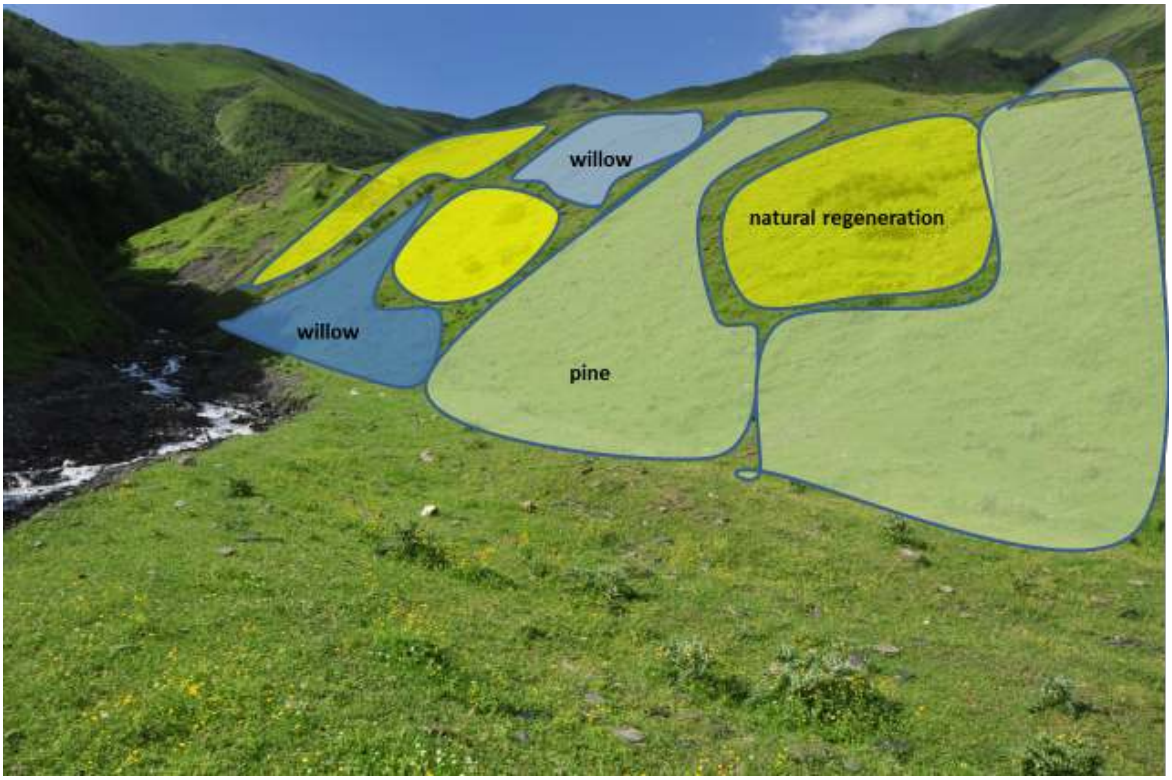

Figure 35: Mixed-mode reforestation as an example for a partial area of polygon 303/3

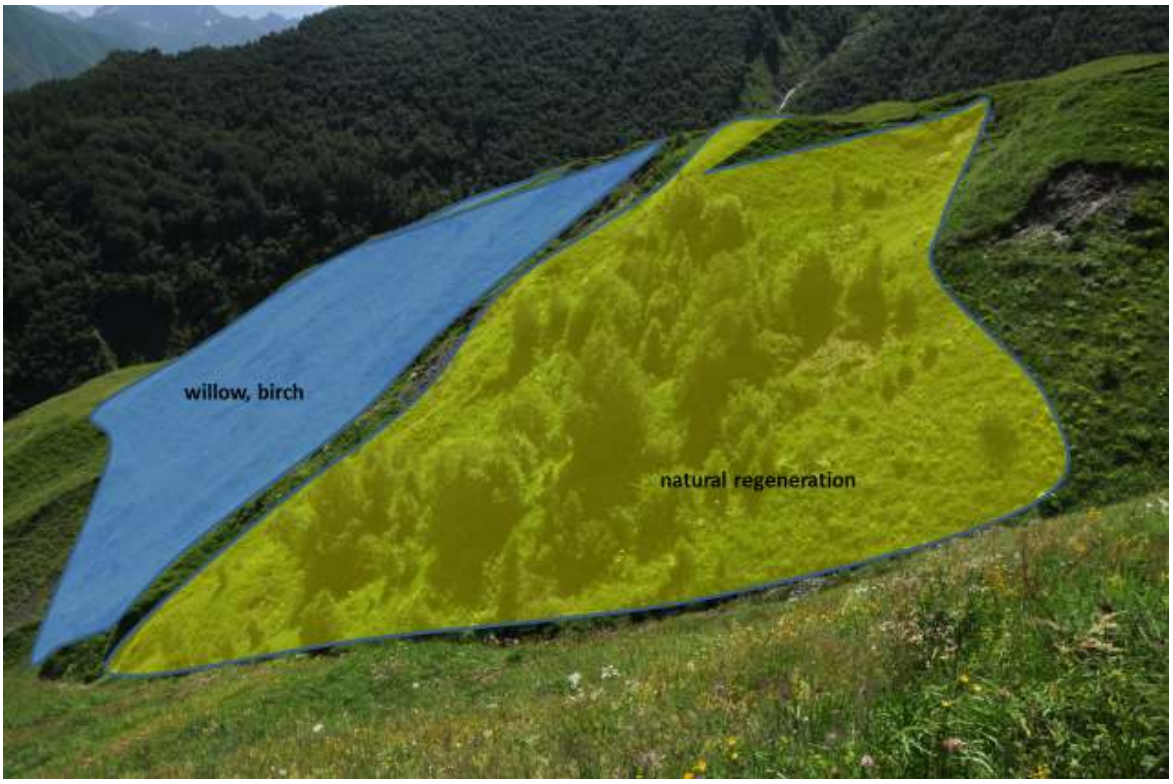

Figure 36: Mixed-mode reforestation as an example for a part of polygon 303/7

Planting is possible in spring and in autumn.

Spring: It is recommended to schedule the planting for just before native vegetation begins to grow to ensure good survival of the tree individuals.

Autumn: Planting in autumn (September to October) is also possible as seedlings are produced in the regional environment. Autumn planting benefits from secondary root growth which starts after the plants have finished height growth. Planting on shady slopes is suggested. Autumn planting can also be organised well, because the preparation of holes for planting and fencing can be done during summertime what promotes work progress and keeps workers busy after spring planting.

7.2.2. **Fencing**

For protection against cattle and sheep/goat grazing, fencing of the reforestation area is indispensable. The fence should be established before or the latest when finishing planting activities.

Figure 37: Cattle grazing in the Kazbegi area during summer time

Figure 38: Sheep grazing at polygon 177/1 during summer time

Following fence types are suggested:

Suitable for cattle:

- wooden or steel posts (spacing 4-5m) and three rows of smooth wire

Suitable for cattle and sheep:

- wooden or steel posts and mesh wire fence/mesh plastic fence

- wooden or steel posts and galvenised steel fence types for sheep/goats [height 1,0m or 1.5 m]

[fence construction: material costs: fence 2-4 Euro/linear meter, wooden or steel posts 1-2 Euro/linear meter, in total 4-6 Euro/linear meter; fence maintenance: 0,5 Euro/linear meter]

- flexible electric fence, wire in three – four rows, charger with solar equipment

[fence construction: 3 – 6 Euro/linear meter; fence maintenance: 0,2 - 1,3 Euro/linear meter]

In very steep slopes, where risks of avalanches and snow gliding effects are high, the smooth wires or mesh wire fence should be put down to the ground during winter time.

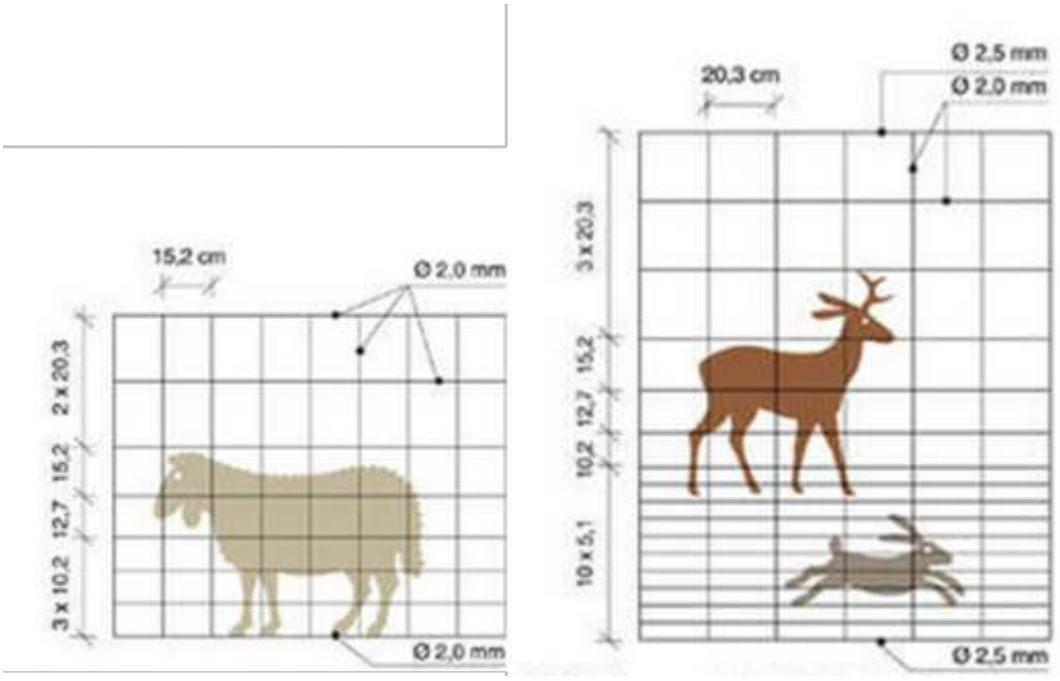

Figure 39: Galvenised steel fence types for sheep/goats [height 1,0m or 1.5 m] [Lagerhaus, 2013]

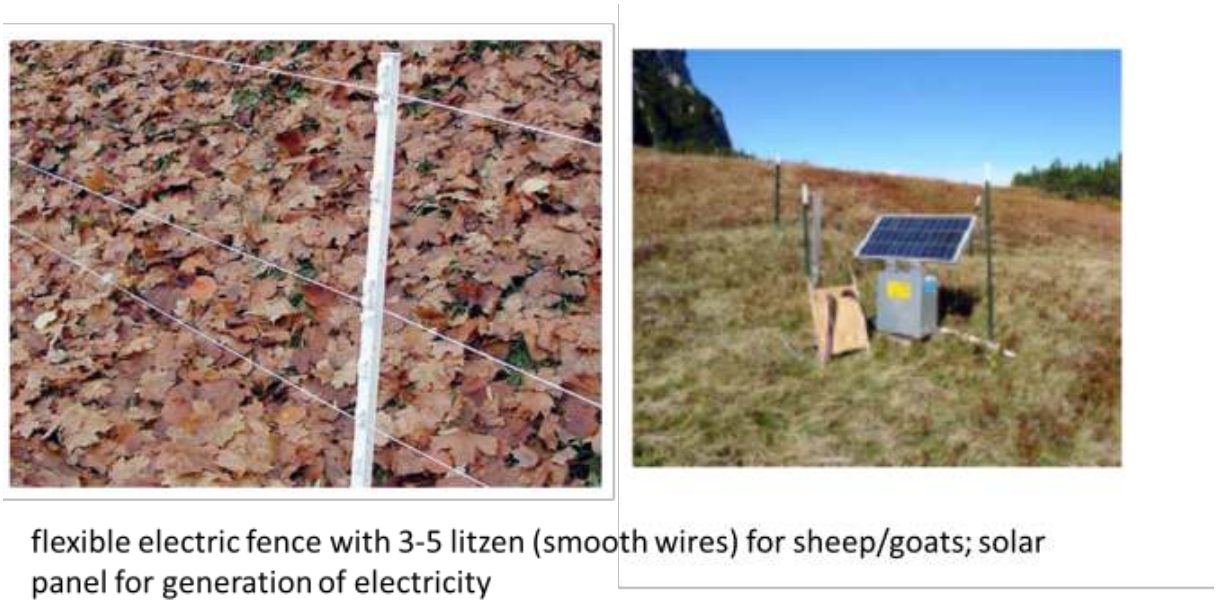

Figure 40: Flexible electric fence and solar panel [Jaritz and Burkart-Aicher, 2013]

7.2.3. **Planting methods**

Planting in holes and small terraces is very common and suitable for bare-root seedlings and cuttings.

Planting in holes:

The holes need to be specific for the plant assortment. It is of high importance, that the roots are placed well in the hole. Planting mattock, spade and hand-hoe are suitable tools.

Figure 41: Planting in holes and in small terraces

[http://www.wsl.ch/dienstleistungen/gutachten/verjuengung/Nacktwurzler_DE]

Planting in small terraces:

Small terraces are 40 cm x 30 cm in size. Using a planting mattock or spade, the grass stubble is tipped and later in form of a grass sod reinstalled. Small terraces can be used for planting in rows or partial planting in patches.
At very steep slopes technical support against snow glide effects may be necessary to ensure the growth of the seedlings.

Figure 42: Technical support against snow glide

Figure 43: Terraces, which were used for agriculture in the past, are now favourable sites for planting

7.2.4. **Direct sowing**

If it is conceivable, that sufficient seed material (pine, birch) will be available, direct sowing in late autumn or early spring (sowing on snow cover) could be tested. If the results are promising, direct sowing should be used as an additional regeneration method. Raw soils are very favourable sites for such a strategy.

Site preparation for direct seeding is not recommended because of negative effects on erosion, but fencing is essential.

Figure 44: Slope with raw soils (Ranker), erosion process caused by cattle grazing, could be used for testing direct seeding (polygon 171/3)

7.2.5. **Weed Control**

In the first five years after planting, dense and competing herbaceous plants and shrubs may be eliminated and/or suppressed. Spot weeding using mechanical methods is suggested.

7.2.6. **Work plan**

Table 12, Table 13 and Table 14 show a detailed description of the work plan [activities in h] for planting operations for the period 2016 – 2021 and down by month for each year.

Table 12: Working plan for planting operations 2016 -2021 [h, days, weeks]

Tree species	2016	2017	2018	2019	2020	2021
birch, willow, poplar, sea-buckthorn [n]		0	5.000	15.000	15.000	10.000
pine [n]	12.000	40.000	60.000	100.000	120.000	20.000
birch, willow, poplar, seabuck thorn [ha]	0	0	5	14	13	9
pine [ha]	3	8	12	24	28	5
planting [ha]	3	8	17	38	41	14
fence [establishing] [ha]	15	49	55	39	10	
Activities [hours]	2016	2017	2018	2019	2020	2021
preparation of holes for planting or small terraces	300	800	1.650	3.751	4.100	1.401
transport of seedlings/cuttings	6	16	33	75	82	28
planting	384	1.024	2.113	4.802	5.248	1.793
	690	**1.840**	**3.796**	**8.628**	**9.430**	**3.222**
fence [establishing]	924	2.962	3.298	2.310	588	0
weeding	90	240	495	1.125	1.230	420
fence [maintaining]	90	240	495	1.125	1.230	420
working hours [h]	**1.794**	**5.282**	**8.084**	**13.189**	**12.478**	**4.063**
person-days	224	660	1.010	1.649	1.560	508
person-weeks	45	132	202	330	312	102
person-month (temporarily)	**11**	**33**	**51**	**82**	**78**	**25**
forest manager [person month]	12	12	12	12	12	12

Table 13: Working plan for planting operations 2016 -2018 down to month for each year [h]

2016: Activities	hours [n]	Jan	Feb	March	April	May	June	July	August	September	Oct	Nov	Dec
preparation [holes; terraces]	300				150	150							
transport	6				225	6							
planting	384					384							
fence [establishing]	924				462	462							
weeding	90								90				
fence [maintaining]	90								18	45	27		
total	1794				837	1002			108	45	27		
	weeks [n]				21	25			3	1	1		
	persons [n]				5	6			1	0	0		
2017: Activities	hours [n]	Jan	Feb	March	April	May	June	July	August	September	Oct	Nov	Dec
preparation [holes; terraces]	800				150	150							
transport	16				225	16							
planting	1024					1024							
fence [establishing]	2962				1481	1481							
weeding	240								240				
fence [maintaining]	240								48	120	72		
total	5282				1856	2671			288	120	72		
	weeks [n]				46	67			7	3	2		
	persons [n]				12	17			2	1	0		
2018: Activities	hours [n]	Jan	Feb	March	April	May	June	July	August	September	Oct	Nov	Dec
preparation [holes; terraces]	1650				150	150							
transport	33				225	33							
planting	2113					2113							
fence [establishing]	3298				1649	1649							
weeding	495								495				
fence [maintaining]	495								99	248	149		
total	8084				2024	3944			594	248	149		
	weeks [n]				51	99			15	6	4		
	persons [n]				13	25			4	2	1		

Table 14: Working plan for planting operations 2019 -2021 down to month for each year [h]

2019: Activities	hours [n]	Jan	Feb	March	April	May	June	July	August	September	Oct	Nov	Dec
preparation [holes; terraces]	3751				150	150							
transport	75				225	75							
planting	4802					4802							
fence [establishing]	2310				1155	1155							
weeding	1125								1125				
fence [maintaining]	1125								225	563	338		
total	13189				1530	6182			1350	563	338		
	weeks [n]				38	155			34	14	8		
	persons [n]				10	39			8	4	2		
2020: Activities	hours [n]	Jan	Feb	March	April	May	June	July	August	September	Oct	Nov	Dec
preparation [holes; terraces]	4100				150	150							
transport	82				225	82							
planting	5248					5248							
fence [establishing]	588				294	294							
weeding	1230								1230				
fence [maintaining]	1230								246	615	369		
total	12478				669	5774			1476	615	369		
	weeks [n]				17	144			37	15	9		
	persons [n]				4	36			9	4	2		
2021: Activities	hours [n]	Jan	Feb	March	April	May	June	July	August	September	Oct	Nov	Dec
preparation [holes; terraces]	1401				150	150							
transport	28				225	28							
planting	1793					1793							
fence [establishing]	0												
weeding	420								420				
fence [maintaining]	420								84	210	126		
total	4063	0			375	1971			504	210	126		
	weeks [n]				9	49			13	5	3		
	persons [n]				2	12			3	1	1		

8. FINANCIAL AND PERSONNEL PLANNING

8.1. Demand for workers

From the work plans for the nursery and the planting operations the total demand for personnel can be derived. For 2-4 years 7-8 persons will be needed for 2 months approximately from April to June for the seedling production. One worker is needed year round in the nursery. Also for 2-4 years 10-25 persons will be needed during 2-3 months for planting operations. The effective number of works employed for planting depends on whether only spring planting or both spring planting and autumn planting are done. Later would mean that there is work to do from spring to autumn, and the peak of worker-demand would be reduced.

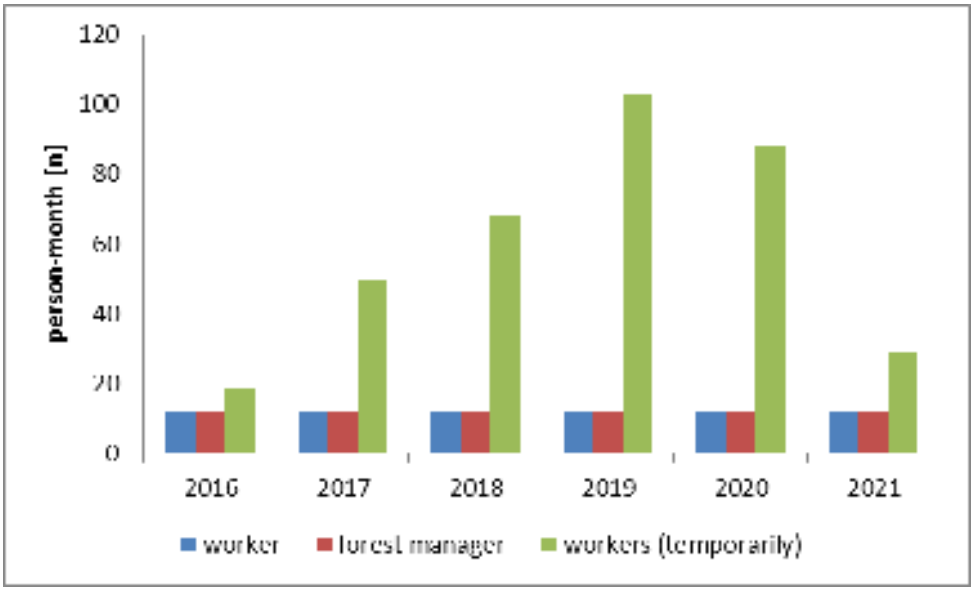

Figure 45: Person months needed for management, seedling production and planting operations from 2016 until 2021

8.2. **Cost planning**

Based on the detailed planning for plant production and planting (168 ha in total; for artificial regeneration 116 ha; pine: 340.000 seedlings; birch, poplar, willow, sae-buckthorn: 45.0000 plants; fencing: 168 ha) the preliminary cost plan (Interim Report) was again revised.

Table 15: Working plan for planting operations 2016 -2021 down to month for each year [h]

seed collection + plant production		2016	2017	2018	2019	2020	2021	Total
person-month (temporarily)	[month]	7	17	17	20	10	4	74
1 worker (continuous)	[month]	12	13	14	15	16	17	87
personnal costs	[Euro]	**12.207**	**19.042**	**19.828**	**22.218**	**16.580**	**13.148**	103.022
material costs; transport costs	[Euro]	7.000	8.000	8.000	8.000	7.000	5.000	43.000
	[Euro]	19.207	27.042	27.828	30.218	23.580	18.148	146.022
planting + fencing + weeding		2016	2017	2018	2019	2020	2021	
person-month (temporarily)	[month]	**11**	**33**	**51**	**82**	**78**	**25**	280
personnal costs	[Euro]	**9.900**	**29.700**	**45.900**	**73.800**	**70.200**	**22.852**	252.352
material costs (fence, tools)	[Euro]	**7.000**	**7.000**	**7.000**	**7.000**	**7.000**	**7.000**	42.000
material costs; transport costs	[Euro]	**5.000**	**5.000**	**5.000**	**5.000**	**5.000**	**5.000**	30.000
	[Euro]	21.900	41.700	57.900	85.800	82.200	34.852	324.352
forest manager	[Euro]	24.000	24.000	24.000	24.000	24.000	24.000	144.000
total		**45.900**	**65.700**	**81.900**	**109.800**	**106.200**	**58.852**	**614.374**
risk add- on [15%]	[Euro]							706.530
monitoring; fence [maintaining]; repair planting	[Euro]						2021-2030	200.000
Total [2016 - 2030]	**[Euro]**							**906.530**

9. OPERATIONAL PLANNING, CONTROL AND MONITORING

9.1. Overview

The following flow chart (Figure 46) summarizes the stepwise decision making process from starting with detailed reforestation site specific planning, implementation and monitoring.

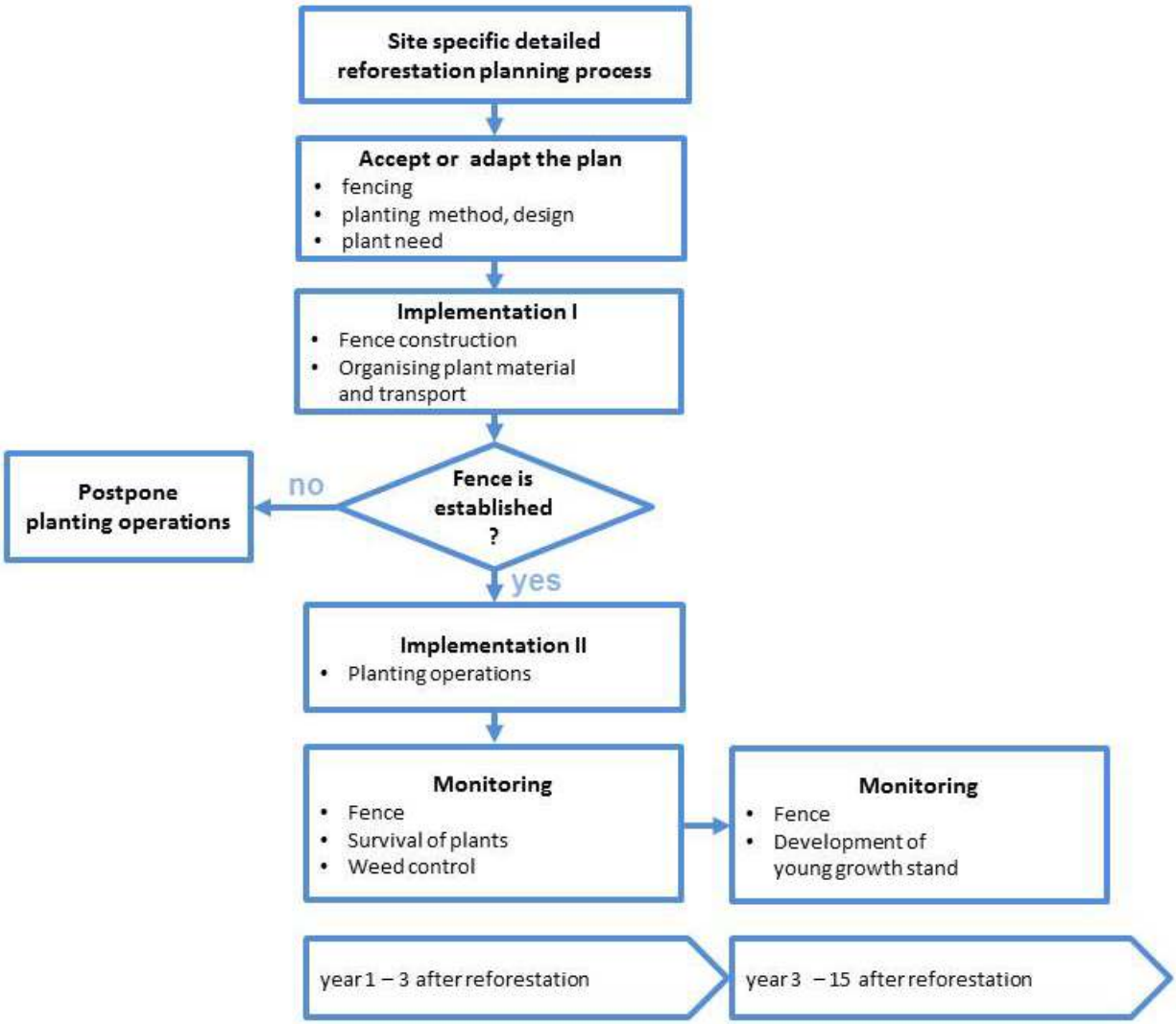

Figure 46: Flow chart 2 on the reforestation planning.

9.2. Planning and monitoring of reforestation programme [2016 – 2021]

For operational planning and for the defined reforestation sites (polygons) and control following steps are recommended:

- **Collect basis data** [reforestation area, regenerations methods, fence line, artificial regenerations methods and plant need] (tables 3,4 and 6) and **start with time scheduling** for legal preconditions and reforestation measurements (status form; Table 17)
- **Adapt basis data** [reforestation area, regenerations methods, fence line, artificial regenerations methods and plant need] after detailed field survey (see Chapter 6.2) and **revise time scheduling** for legal preconditions and reforestation measurements (form; Table 18)
- **Report the results** of execution (form, Table 19)

Annual on-site inspections with special focus on plant development, damages, weed competition and fence state are necessary in spring, during summertime and in autumn till the first 3-5 years after planting. Documentation of the inspection is necessary.

The presented forms in Table 17, Table 18 and Table 19 are examples for tools, which are suggested to support planning and control activities. An Excel file for each reforestation area (polygon) is recommended (see attachment: Planning, Control, Monitoring). For the recalculation of the CO_2 sequestration potential of the afforestation sites the values in Table 16, giving the CO_2 sequestration potential of the different species at different site qualities, which have been determined from the field measurements, have to be used.

Table 16: Estimated CO_2 storage potential (t CO_2 ha^{-1}) at an age of 60 - 70 years for the different species groups and different site qualities.

Species groups	good	medium	bad
Birch, hardwood	280	215	150
Poplar, willow	460	390	320
Pine	550	475	400
Shrubs	5	4	3

Table 17: Status form as basis for planning framework (for example: polygon pilot area)

Plan

reforestation location	**polygon test 1**
pilot area [ha]	**2,0**

	2016	2017	2108	2019	2020	2021
planned time for reforestation [year, month]	September					

cadastre parcel	74xxxxxx
area (m²)	20.000
land use	alpine pasture
owner	Kazbegi Municipality
ownership	state

reforestion area [ha]	2
natural regeneration [ha]	0
artificial regenration [ha]	2
fence length [m]	600

artificial regeneration method	**planting**		**sowing**	
tree species	area [ha]	tree number	area [ha]	kg
birch				
pine	2	8000		
maple				
willow				
poplar				
other deciduous trees				
seabuck thorn				

fencing	**fence type**	area [ha]	length [m]
	steel posts and mesh wire fence	2	600
	wood posts and electric fence		

Carbon storage potenzial [t CO2]	**tree species**	area [ha]	t CO2	t CO2/ha
	birch	0	0	0
	pine	2	1100	550
	maple	0	0	0
	willow	0	0	0
	poplar	0	0	0
	other deciduous trees	0	0	0
	seabuck thorn	0	0	0

legal preconditions	**planned time [year, month]**	2016	2017	2018	2019	2020	2021
	agreement landowner	June					
	agreement land user/manager	June					
	official permit administrative bodies	June					

Reforestation measurements	**Activities/planned time [month/year]**	2016	2017	2018	2019	2020	2021
	defining and marking the fenceline	April					
	defining and marking the reforestation pattern and tree specific planting areas	June					
	fence making	July					
	fence management						
	preparation of holes and/or terraces	Aug/Sept					
	plant transport	Aug/Sept					
	planting	Aug/Sept					
	repair planting						
	weeding						
	fence: mid term maintenance						
	inspection		October	April, Oct.	April, Oct.	April, Oct.	April, Oct.

Table 18: Form as basis for revised planning framework (for example: polygon pilot area)

revised plan

reforestation location	polygon test 1
pilot area [ha]	2,0

artificial regeneration method		planting		sowing	
	tree species	area [ha]	tree number	area [ha]	kg
	birch				
	pine	2	8000		
	maple				
	willow				
	poplar				
	other deciduous trees				
	seabuck thorn				

fencing	fence type	area [ha]	length [m]
	steel posts and mesh wire fence	2	600
	wood posts and electric fence		

Carbon storage potenzial [t CO2]	tree species	area [ha]	t CO2	t CO2/ha
	birch	0	0	0
	pine	2	1100	550
	maple	0	0	0
	willow	0	0	0
	poplar	0	0	0
	other deciduous trees	0	0	0
	seabuck thorn	0	0	0

legal preconditions	planned time [year, month]	2016	2017	2018	2019	2020	2021
	agreement landowner	June					
	agreement land user/manager	June					
	official permit administrative bodies	June					

Reforestation measurements	Activities/planned time [month/year]	2016	2017	2018	2019	2020	2021
	defining and marking the fenceline	April					
	defining and marking the reforestation pattern and tree specific planting areas	June					
	fence making	July					
	fence management						
	preparation of holes and/or terraces	Aug/Sept					
	plant transport	Aug/Sept					
	planting	Aug/Sept					
	repair planting						
	weeding						
	fence: mid term maintenance						
	inspection		October	April, Oct.	April, Oct.	April, Oct.	April, Oct.
	inspection						

Table 19: Form as basis for documentation of execution (for example: polygon pilot area)

execution

reforestation location	polygon test 1
pilot area [ha]	2,0

legal preconditions	time [year, month]	2016	2017	2018	2019	2020	2021
	agreement landowner	June					
	agreement land user/manager	June					
	official permit administrative bodies	June					

Reforestation measurements	Activities/ time [month/year]	2016	2017	2018	2019	2020	2021
	defining and marking the fenceline	April					
	defining and marking the reforestation pattern and tree specific planting areas	June					
	fence making	July					
	fence management						
	preparation of holes and/or terraces	Aug/Sept					
	plant transport	Aug/Sept					
	planting	Aug/Sept					
	repair planting						
	weeding						
	fence: mid term maintenance						
	inspection		October	April, Oct.	April, Oct.	April, Oct.	April, Oct.
	inspection						

artificial regeneration method		planting		sowing	
	tree species	area [ha]	tree number	area [ha]	kg
	birch				
	pine	2	8000		
	maple				
	willow				
	poplar				
	other deciduous trees				
	seabuck thorn				

fencing	fence type	area [ha]	length [m]
	steel posts and mesh wire fence	2	600
	wood posts and electric fence		

Carbon storage potenzial [t CO2]	tree species	area [ha]	t CO2/ha	t CO2
	birch	0	0	0
	pine	2	550	1100
	maple	0	0	0
	willow	0	0	0
	poplar	0	0	0
	other deciduous trees	0	0	0
	seabuck thorn	0	0	0

9.3. **Target-actual comparison per year**

For internal control a target-actual comparison should be done by end of the year. These results can be used for external communication too (Table 20).

Table 20: Reforestation area (ha) in total, artificial (planting) areas (ha) and number of planted tree species and estimated CO_2 storage potential (t CO_2 ha^{-1}) at an age of 60-70 years following the planned activities 2016 – 2021

Year	Reforestation area [ha]	birch + hardwoods [number]	poplar+wollow [number]	pine [number]	seabuck thorn [number]	total [number]
Y- 2016-target	2	0	0	8000	0	8000
actual						0
Y- 2017-target	16	5500	0	14000	0	19500
actual						0
Y-2018-target	26	4500	100	62400	0	67000
actual						
Y-2019-target	57	13900	200	101500	0	115600
actual						0
Y-2020-target	50	10200	1500	88800	3600	104100
actual						0
Y-2021-target	19	3200	200	47700	0	51100
actual						0
Total-target	170	37300	2000	322400	3600	365300
actual						

Year	Reforestation area [ha]	birch + hardwoods [ha]	poplar+wollow [ha]	pine [ha]	seabuck thorn [ha]	CO2-storage potential [t CO2]	accumulated CO2-storage potential [t CO2]
Y- 2016-target	2	0	0	2	0	1100	1100
actual							
Y- 2017-target	16	13	0	3	0	5400	6500
actual							
Y-2018-target	26	10	0	16	0	10900	17400
actual							
Y-2019-target	57	32	0	25	0	20300	37700
actual							
Y-2020-target	50	23	1	22	3	18900	56600
actual							
Y-2021-target	19	7	0	12	0	7700	64300
actual							
Total-target	170	85	2	81	3	64300	
actual							

Figure 47 shows an example for control and description of the development of estimated and accumulated CO_2 storage potential based on execution of the reforestation programme (see Attachment: Planning, Control, Monitoring; Excel file)

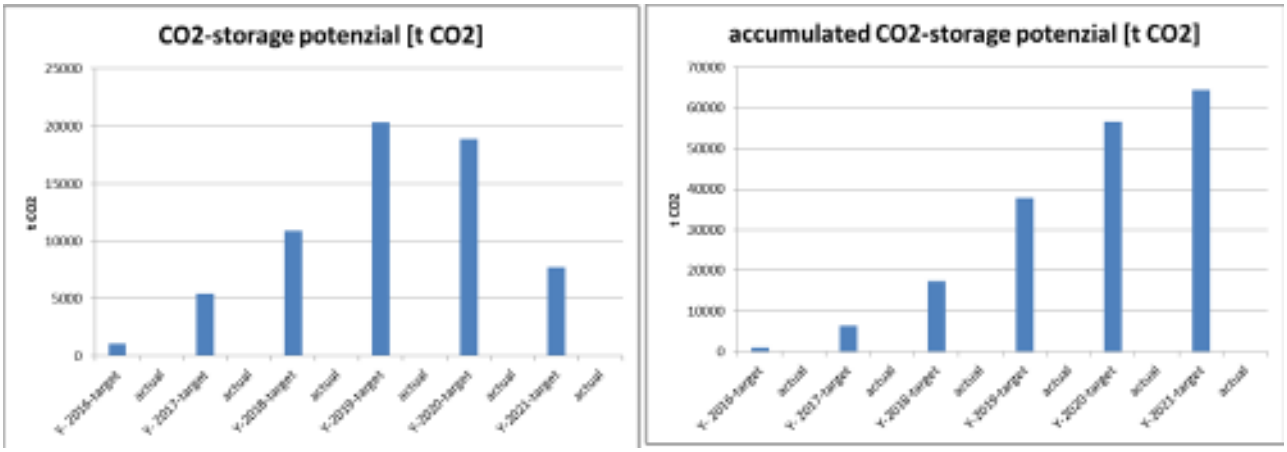

Figure 47: Estimated and accumulated CO_2 storage potential (t CO_2 ha^{-1}) at an age of 60-70 years following the planned activities 2016 – 2021

9.4. Mid-term monitoring [2021 - 2030]

In the mid-term development stage of the regeneration (young growth stand) the higher risks for diseases and/or mortality and especially for grazing damages require a continuous afforestation control.
Annual on-site inspections with special focus on plant development, damages, weed competition and fence state are necessary in spring, during summertime and in autumn till year 2030. Documentation of the inspection is necessary.

10. ENVIRONMENTAL AND SOCIAL SCHEDULE

The planning and afforestation activities shall be communicated to the public. As the appropriate tool a special website shall be created and linked to the website of Dariali Energy. The progress of the afforestation activities shall be documented with text but also with pictures. The annual reports of Dariali Energy shall be made available on this website. Every month a new photograph on the website should document the past month's activities. A disclosure of this handbook (except the specific planting schedule) is aspired in order to spread the knowledge on planning and performing afforestation activities.