EuropeAid Project Reference no: **CCGS/124**
CFCU/TR2013/0327.05.01-02/124 – EuropeAid/138406/ID/ACT/TR

This Programme is co-funded by the European Union and Republic of Turkey

Project: Development of a common protocol to assess the impact of forest management practices on climate change

Report on the scenarios analysis to assess the impact of different forest management practices on climate change

Deliverable 3.2

November 2018

Contents

1. Scope

The Action aims to examine sustainable forest management practices to optimize carbon balance and counter-steer climate change impacts. To this end different management scenarios are analyzed in order to validate and finalize the common guidelines (D3.1) and propose the suitable treatments/management activities in each case. The analysis results will be incorporated into the guidelines, which will determine the best practices, based on the current conditions and management objectives.

According to EU regulation 2018/841, it is essential to ensure the long-term stability and adaptability of carbon pools in order for forest management measures aiming at increasing carbon sequestration to be effective. The development of the scenarios examined through this Action has been based on this principle. Moreover, the scenarios are in line with forest management policies and measures taken for Climate change mitigation in the EU regarding planted forests.

The ecosystem-based functional planning currently applied in the forests of Turkey provides a high average carbon stock by increasing and sustaining constant forest cover, soil protection, conservation of biodiversity, productivity, regenerative capacity, and vitality.

However, adapting the forest management practices to produce timber of larger dimensions can increase the amount of carbon sequestered in wood biomass, as well as the time that carbon remains stored, according to EU policy priorities in the field of Land Use, Land Use Change and Forestry (LULUCF). The default half-life values of forest products are determined by IPCC[1] are as follows:

(a) 2 years for paper;
(b) 25 years for wood panels;
(c) 35 years for sawn wood

Therefore, what is important is to investigate management adaptations that can contribute towards both directions.

[1] http://www.ipcc.ch/ipccreports/sres/land_use/index.php?idp=12

2. Current status

Field sampling carried out during WP2 has resulted in the following findings regarding the planted *Fagus orientalis* forests within the management units of Vakfıkebir, Tonya and Düzköy:

- Canopy closure affects the balance between tree stem and litter carbon pools within the plots. Higher canopy closure is inversely proportional to the carbon storage in tree stems (Figure 1).

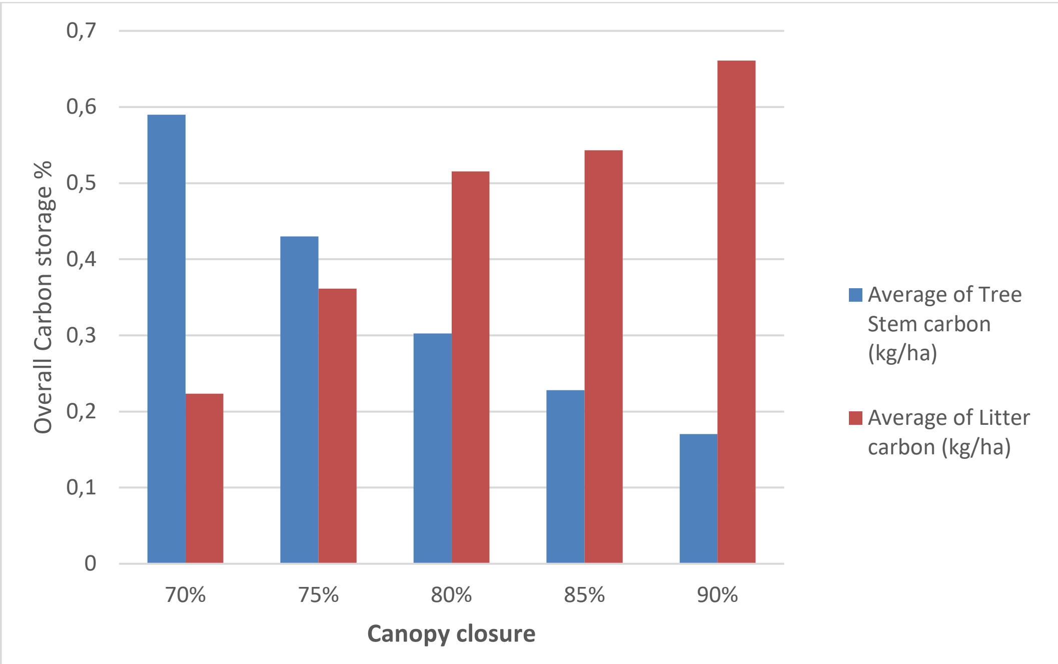


Figure 1. Effect of canopy closure on tree stem & litter carbon pools

- Tree stem biomass and litter account for more than 70% of the carbon storage (Figure 2)
- Carbon storage in tree branches is insignificant, whereas the third larger carbon pool in the study area is lying deadwood, followed by shrubs and tree foliage (Figure 2)

The accumulation of large amounts of litter in forest stands inhibits the soil enrichment with nutrients and reduces the soil carbon storage. Therefore, the most important carbon pool, which adapted forest management targets, is tree stem.

The models developed in WP2 revealed a significant correlation between breast height diameters, biomass and carbon storage in oriental beech forests.

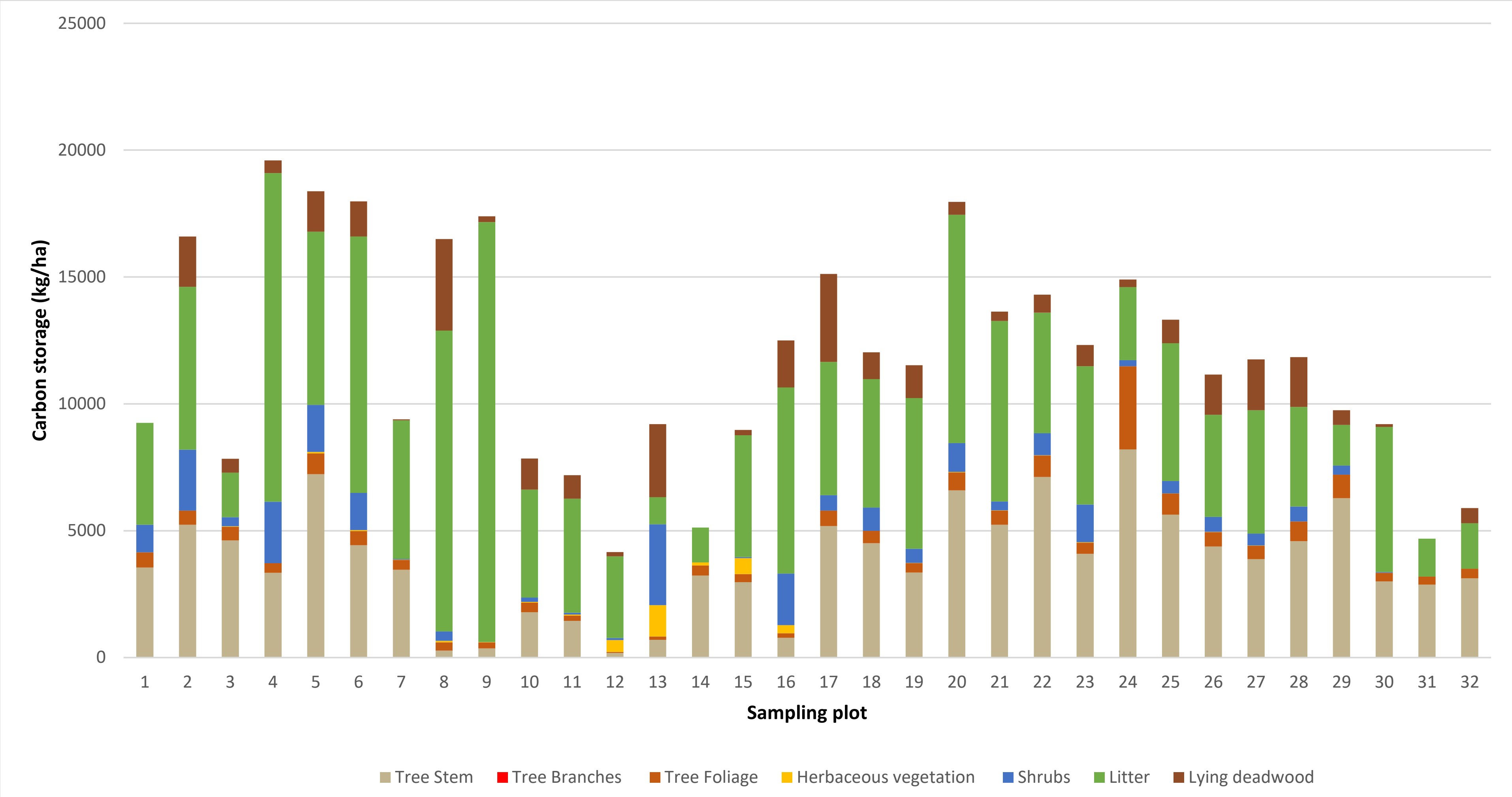


Figure 2. Allocation of carbon storage in various forest stand carbon pools

3. Management Scenarios

In order to evaluate the impact of different management practices in beech forests of the Trabzon area the following four (4) alternative scenarios were investigated:

1. Current management practice
2. Less frequent thinnings
3. Less intensive thinnings
4. Increase of the rotation age

For each of these scenarios the overall carbon stored per age class and site quality was estimated. Diameter increment was calculated based on the average diameter for oriental beech determined by KTU. Carbon storage was then calculated using the equations also developed by KTU in WP2:

$$Stem\ Carbon\ (kg) = 0.06373 - 0.13234 \times d + 0.22919 \times d^2, R^2 = 0.976, S_{y.x} = 2.7kg$$

$$Branch\ carbon\ (kg) = 0.02378 \times 0.14339^d, R^2 = 0.82, S_{y.x} = 1.0\ kg$$

$$Leaf\ carbon\ (kg) = 0.00742 \times 1.3123^d, R^2 = 0.927, S_{y.x} = 1.5\ kg$$

The scenarios focus on tree stem carbon, since this is the main carbon pool in the beech forests within the project area, as the sampling results have shown. The models used to calculate future stand development and consecutive carbon storage have been elaborated in the frame of this project, using data from the pilot areas. Therefore, the results presented in this report are based on the data and equations developed for the pilot area and they reflect tendencies induced by each management scenario. Their generalization should be done with cautiousness and only after proper testing and scientific justification through further research.

Data from very young stands, with diameter 0.8 – 1.3 cm (sampling plots 12 – 15) have not been included in the analysis due to the following reasons:

- The amount of carbon stored in saplings is very low and no models have been developed to efficiently assess it in the project area
- At the stage of saplings no treatment is recommended due to very early growth stage which poses limitations regarding tree diameter growth, survival rate, etc.

Therefore, the following results refer to tree stands over 10 years old (age class II).

Age classes are defined as follows for the project area:

Age class	Age (years)
II	10 - 20
III	20 - 30
IV	30 - 40
V	40 - 50
VI	50 - 60

Scenario 1. Current management practice

The current management practice includes frequent thinnings, every 5 – 7 years, until the age of 40 (Table 1). The first thinning takes place during age class II, whereas until the stand reaches age class III, three additional thinnings have been applied. During the final logging the remaining trees of the old stand are removed thus regenerating the forest.

Table 1. Thinning plan of Scenario 1

Stand Age	Thinning intensity per Site class		
	Good	Medium	Poor
15 yrs	20%	15%	10%
22 yrs	30%	25%	20%
27 yrs	40%	30%	25%
30 yrs	40%	30%	25%
35 yrs	45%	35%	27%
40 yrs	45%	35%	30%

The current management practice (Scenario 1) results in minor variations between carbon storage in sites of good and medium quality. Carbon storage ranges from 1.7 to 2.5 tonnes/ha in good quality sites and declines with age. Due to the high intensity thinnings trees with larger diameters are removed thus reducing the carbon stock. The carbon storage in medium site classes is approximately 3 tonnes/ha ± 0.3, whereas the larger quantities of carbon are stored in poor sites. Most likely, due to less intense thinnings, carbon storage is increasing with age, even though the sites are less productive (Figure 3).

Figure 3. Scenario 1 carbon sequestration per age class & site quality

Scenario 2. Less frequent thinnings

This scenario involves reducing the thinnings by half, from six (6) that are currently applied to three (3), maintaining the same intensity (Table 2). The first thinning takes place during age class II and is followed by two consecutive thinnings at the age of 30 (Class III) and 40 (Class IV).

Table 2. Thinning plan of Scenario 2

Stand Age	Thinning intensity per Site class		
	Good	Medium	Poor
15 yrs	20%	15%	10%
30 yrs	40%	30%	25%
40 yrs	45%	35%	30%

Scenario 2 results in higher carbon storage than scenario 1, which consistently increases with age. However, carbon stocks seem to be inversely correlated with site quality with higher values found in poor sites (Figure 4).

Figure 4. Scenario 2 carbon sequestration per age class & site quality

Scenario 3. Less intensive thinnings

This scenario involves reducing the intensity of the thinnings, at least by 5%, in all age classes and site qualities (Table 3). The stand age of each thinning remains the same as in Scenario 1.

Table 3. Thinning plan of Scenario 3

Stand Age	Thinning intensity per Site class		
	Good	Medium	Poor
15 yrs	15%	10%	5%
22 yrs	25%	20%	10%
27 yrs	30%	25%	10%
30 yrs	30%	25%	10%
35 yrs	35%	27%	10%
40 yrs	35%	30%	10%

Scenario 3 results in higher carbon storage as stand age increases in sites of medium and poor quality. In good quality sites carbon storage peaks at age class III but decreases over time after that point. (Figure 5).

Figure 5. Scenario 3 carbon sequestration per age class & site quality

Scenario 4. Increase of the rotation age

This scenario includes increasing the rotation age, reducing the number of thinnings by half and reducing the intensity of the thinnings (Table 4). The thinnings are reduced to three (3), same as in scenario 2 and are less intense, same as in Scenario 3 (Table 2). The first thinning takes place during age class II and is followed by two consecutive thinnings at the age of 30 (Class III) and 60 (Class IV).

Table 4. Thinning plan of Scenario 4

Stand Age	Thinning intensity per Site class		
	Good	Medium	Poor
15 yrs	15%	10%	5%
30 yrs	30%	25%	10%
60 yrs	35%	30%	10%

Scenario 4 results in higher carbon storage in all site qualities, which is increasing over time (Figure 6). Carbon stocks double from age class II to age class III and exceed 10 tonnes/ha in age class IV. The increase of the rotation age by 20 years significantly boosts carbon storage in age class V, regardless of the site quality.

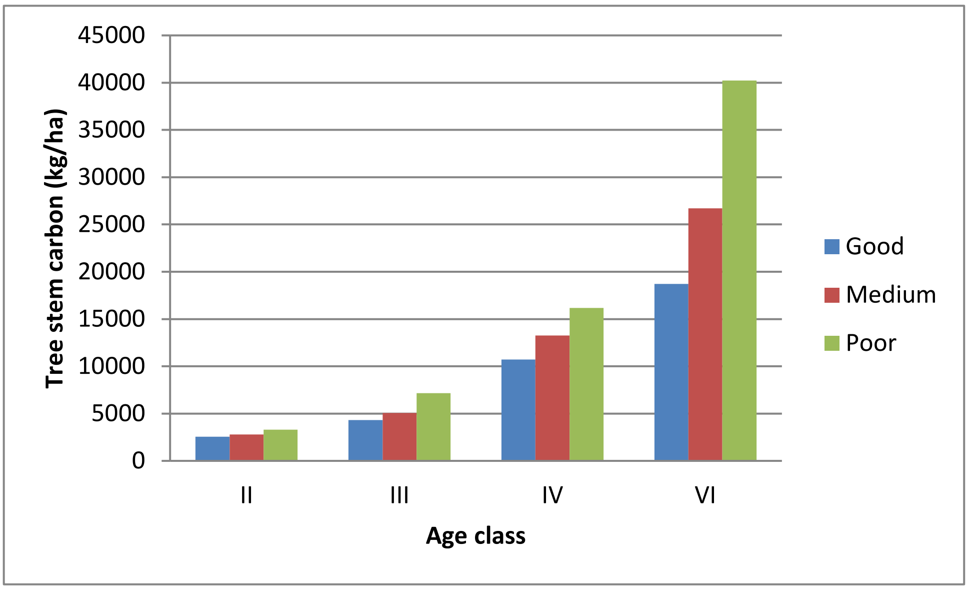


Figure 6. Scenario 4 carbon sequestration per age class & site quality

4. Comparison of different scenarios

The management scenarios investigated have shown that short rotation periods do not favor carbon storage (Figure 7). However, even slight modifications in the current management, such as those presented in Scenarios 2 and 3, can increase the carbon pool in the project area.

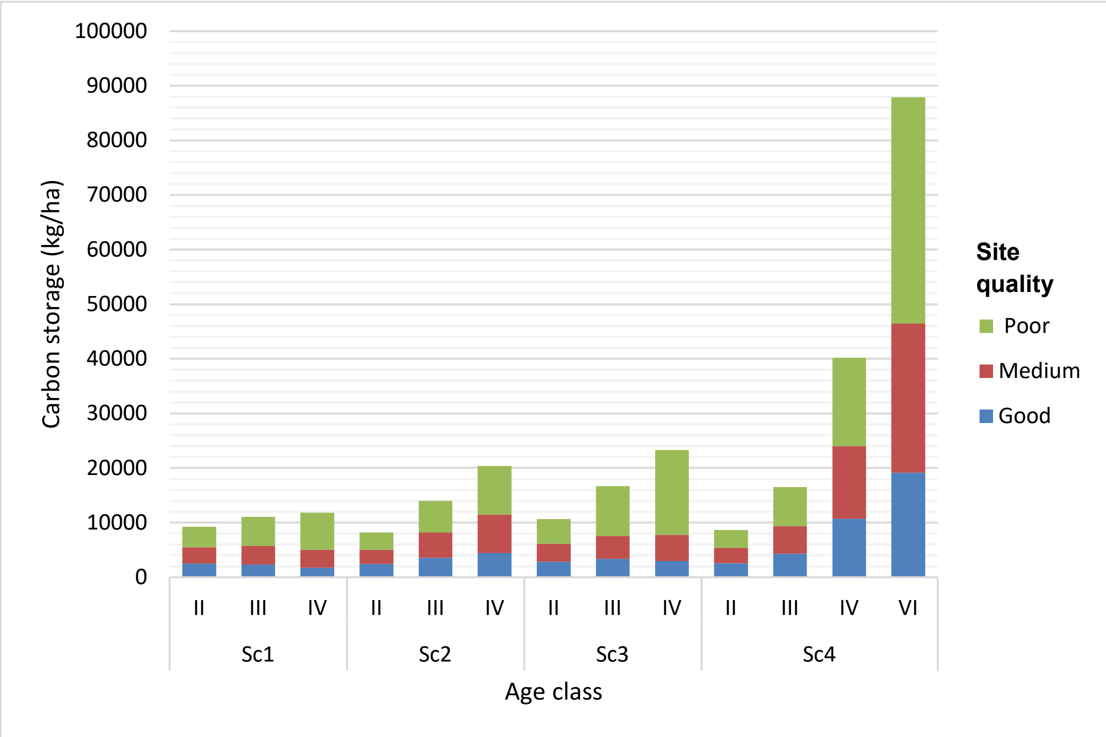
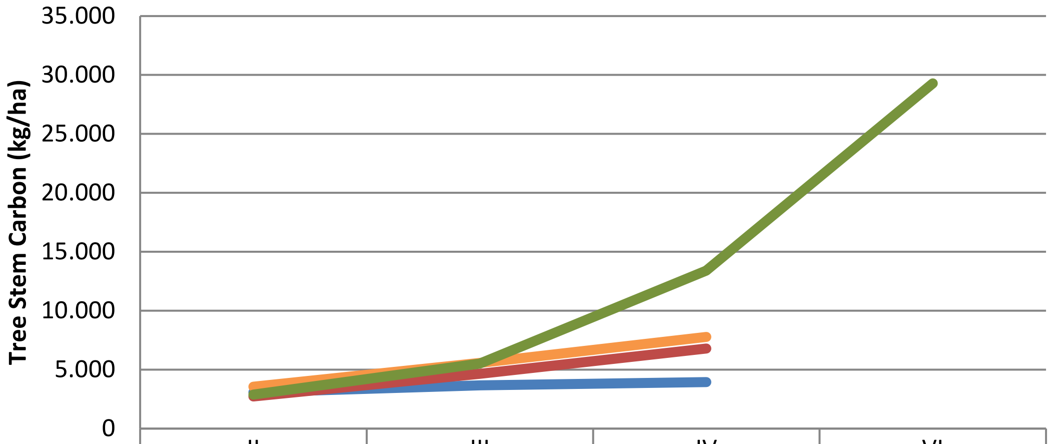


Figure 7. Overall carbon storage per age class, site quality category and management scenario

Less frequent thinnings (Scenario 2) lead to slightly less carbon storage in young stands (age class II), by up to 20%. The benefits of extending the time interval between thinnings are evident as the stand grows (age classes III & IV), when carbon storage increases by 25 – 60% (Figure 8). On the other hand, less intense thinnings (Scenario 3), compared to the currently applied practice (Scenario 1), generally increase carbon storage by approximately 12% in age class II to over 55% in age class IV (Figure 8). The combination of extending the rotation period and decreasing the intensity of the thinnings (Scenario 4) is by far the optional practice to increase carbon storage in the project area as seen in Figures 7 and 8.



	II	III	IV	VI
Sc1	3.077,03	3.680,54	3.945,97	
Sc2	2.726,26	4.660,36	6.793,42	
Sc3	3.555,65	5.566,18	7.777,68	
Sc4	2.885,68	5.510,84	13.390,20	29.290,46

Age class

Figure 8. Average tree stem carbon storage per site class and management scenario

Reducing both the intensity and frequency of thinnings (Scenario 4) leads to lower carbon stocks in age class II which is compensated as the stand grows. Carbon stocks in age class III under scenario 4 exceed the corresponding amounts of scenario 1 by 25 - 45%. This percentage increases even more in age class IV to over 80%. The extension of the rotation age by 20 years substantially increases forest carbon stocks, almost doubling them between the ages of 40 and 60 the carbon stock

When assessing management scenarios in favor of climate change, however, there are more aspects to consider than carbon storage solely. These include less GHG emissions from forest works, less disturbance in the forest, frequency of financial revenues and wood products with larger dimensions, which potentially will be transformed to wood products with longer half-life values. These aspects have been considered, together with carbon storage, in the scoreboard presented in table 5.

Table 5. Scenarios scoreboard

Benefits	**Sc1**	**Sc2**	**Sc3**	**Sc4**
Less GHG emissions from forest works		1		1
Less disturbance in the forest		1		1
Frequent financial revenue	1		1	
Wood products with larger dimensions				1
Carbon storage (1 point for the minimum value tonnes of carbon stored/ha[2])	1	1.7	2	3.4
Overall score	**2**	**3.7**	**3**	**6.4**

For the last benefit (carbon storage) 1 point is attributed to the lowest carbon stock value (Scenario 1 →4 tonnes/ha → 1 point) and the remaining scores are calculated proportionately for Scenario 2 (7 tonnes/ha → 1.8 points), Scenario 3 (8 tonnes/ha → 2 points) and for Scenario 4 (13.4 tonnes/ha → 3.4 points).

By reducing the number of thinnings in the forest GHG emissions decrease and disturbances due to forest works are also less frequent. Moreover, extending the rotation period provides wood products of larger dimensions that keep carbon stored for longer periods of time compared to firewood or paper. These benefits come with the price of reduced financial revenue for prolonged periods of time which range from 15 to 30 years, based on the proposed scenarios.

[2] Based on the maximum storage value at age class IV