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Afforestation of bad lands financed through Joint Implementation Projects

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ABSTRACT

Financing afforestation works is relatively difficult for the countries with economy in transition. The carbon financing may act as an incentive for national resource identification (both in terms of funds and lands to be afforested) and it generally improves significantly the economic return of the afforestation works. The paper shows some practical ways to address degraded land improvement and management through afforestation by financial synergies (multiple partners, co-financing), environmental gains (biodiversity, climate change and local environmental benefits), social and economic improvements (local energy supply, construction material, non timber forest products, alternative activities and temporary jobs). The analysis of an afforestation project place in the context of the national forestry and environmental issues in Romania is also undertaken.

Key words: badlands, afforestation, Kyoto protocol, carbon sequestration, biodiversity, environmental synergies, financial instruments

INTRODUCTION

Development of the flexible instruments under the Kyoto Protocol creates financing opportunities for the afforestation of badlands in transition countries, as specified in the articles 3.3 and 3.4 of the above-mentioned protocol. Afforestation is a valid option for the improvement of badlands in many cases, providing sustainable land uses in terms of forest resources, and appropriate long term management. Carbon financing may act as an incentive for national resource mobilization (both in terms of funds allocation and identification of lands to be afforested) and it could improve significantly the economic return of the afforestation works. Activities aiming at carbon sequestration are a challenge for a broad category of scientists as well as for many other social categories and they offer an opportunity for innovation in environmental services approach.

ENVIRONMENTAL SERVICES, CHALLENGES AND SYNERGIES

Practically, the degraded lands (with eroded soils) or the abandoned agricultural lands may be subject to different types of afforestation according to the planned land use: commercial or protection forests, belts, patches, corridors. The innovation regarding the afforestation under the joint implementation mechanism is associated with the financial efficiency of the activity itself, according to the rate of carbon sequestration in the ecosystem components (biomass, soil). Such a financing instrument may stimulate substantially the interest in land use improvement by afforestation of badlands, which are found in a large proportion in Eastern Europe.

Under the joint implementation mechanism approach, one of the environmental services provided by forest ecosystems, namely the sequestration of CO_2 (associated with its global atmospheric green house warming effect) could be satisfactorily quantified, compared to the difficulties in accurate quantification of other services (soil and water protection, biodiversity conservation, landscape improvement, communities and crops protection). Despite the apparent emphasis on carbon sequestration in afforestation projects (due to its importance as a financial instrument) the afforestation activity target several environmental and social benefits at local and global level.

Although the global effect of afforestation on climate is still subject to debate (due to long term processes involving carbon sequestration, unpredictable late effects, associated uncertainties and large risks) this is for the moment the only accessible and easy-quantifiable forest activity associated with carbon sequestration.

The abundance of the agricultural badlands available for afforestation may raise significantly the positive effect of this activity at global level. In the temperate area of Europe, the potential for carbon sequestration in stable pools, of young plantations established on low degraded soils over 15^{th} years of production cycle is presented in Table 1.

Table 1. Carbon sequestration in young plantations established in Romania

Species	C (Mg/ha) accumulation* in …					
	Biomass					Soils (including litter)
	Stems	Foliages	Branches	Roots	Total biomass	
Quercus sp.	6.0 – 8.0	0.5 –0.6	4.0 – 5.5	4.5 – 6.0	15.0 – 20.1	5.5 – 7.5
Populus sp.	19.0	1.2	3.0	8.2	31.4	10.0
Robinia sp.	5.0 – 22.0	0.3 – 1.4	5.5 – 11.3	2.2 - 9	12.5 – 43.7	4.0 – 15.0
Pinus sp.	2.2 – 6.0	0.4 – 0.9	0.5 – 1.3	0.7 – 3.5	3.8 – 11.7	1.0 – 2.3

* According to the CO2Fix parameterised according to the Romanian yield tables and other national data

During the young stages of stands, an important share of the total carbon allocation is in the biomass: 80-86 % in conifers and 73-76 % in broadleaved trees, compared to soils allocation: 14-20 % in conifers and respectively 24-27 % in broadleaved trees. Accordingly, some vulnerability is associated with stable pools of carbon on a long term, as above ground biomass may be exposed to different risks (fires, illegal cutting, grazing etc.).

Strategically the afforestation increases the wood resources not only for timber or rural construction, but it also supplies the "carbon neutral" combustible, an alternative to the present large use of fossil fuels. This is another important contribution of forest and its wood products to climate change mitigation in a sustainable pattern, associated with the promotion of tradition preservation in rural communities as appropriate alternative to the existing competing alternative forms of energy.

An optimisation of the local/regional communities' resources requires a balance between the land uses as well as the integration of the wide range of local activities. Improvement of degraded lands by afforestation is a way to establish a local-regional resource balance and to approach challenging environmental problems like desertification or social problems associated with poverty in rural areas. In this sense is recommended that the afforestation projects are located in such areas, where environmental-social and financial synergies are needed to address and such issues in a sustainable manner.

Afforestation activities under Kyoto protocol raise important questions and uncertainties related to biodiversity conservation. Large areas to be afforested may represent (stable?) agro-ecosystems where specific biodiversity assessment is required, although long-term intensive management via soil works and irrigation/fertilization have created large and uniform agro-ecosystems, where only crops may be different among parcels. A significant problem is represented by the afforestation of pastures or grazing lands, as relatively stable bio systems, which often are treasures of biodiversity in terms of species or ecosystem structures, even if they have been managed for a long time. In such cases the change of land use implies risks for biodiversity, while targeting multiple environmental benefits (including carbon sequestration) by changing the land use to forest plantations is not recommended. Still a decision of land use change would be taken according to the local circumstances and biodiversity impact assessment.

One major issue in biodiversity approach is represented by afforestation species. Generally, the afforestation work is considered as an "ecological reconstruction", which means the re-establishment of the type of forest specific to the local soil and climatic conditions. Local tree species and provenances are used for this action. In such cases the reconstruction focuses only on trees species, counting on natural migration of animals and micro-organisms (litter and soil fauna and flora). In the case of isolated plantations on former long term managed cropland and far from the natural (old) forests, the sources for micro-organism migration are lacking, and this almost always leads to high accumulation of necromasis in the top soil, which is associated with high amount of carbon stored; meanwhile the stable humus transformation is also reduced. Consequently appropriate measures should be taken via the artificial transfer of microorganisms or by appropriate spatial linkages to the existing forests. Particular biotopes may raise real problems in biodiversity approach (moving sand dunes, salty soils, heavily degraded soils, etc). Traditionally, certain forest species are known as successful for the afforestation of all types of such lands. Since the majority of these species are exotic ones, the problem of substituting them with local or at least improving the plantation composition with local species is of great concern. One of such examples is black locust (Robinia) which is very productive, stable and minimal management demanding on moving sand dunes, where option for forest structure improvement with other species seems to be limited. One option could be the use of indigenous poplar in the afforestation formula; this would also increase the associated fauna population, and offer significant chances for sustainable management.

Specific management of plantations on sandy dunes, over the very early stages of development (1^{st} and likely 2^{nd} growing season) may have side effects on GHG balance of the soils due to fertilization and irrigation of other associated crops (i.e. water melon) established between planted tree rows. The use of ammonia nitrate may be followed by nitrate release in the atmosphere, an effect that has to be quantified. Irrigation is not expected to create additional release of carbon from such soils since their former management type is continued, so a certain the soil-atmosphere carbon balance is established.

To address leakages, a relevant question is if the compensation measures (especially for the benefits of the local communities) which are taken to achieve the successful implementation of the afforestation projects are going to be quantified in terms of GHG emission / sequestration. An example of such a compensation measure could be the improvement of the quality of pastures or grazing land for communities adjacent to the planted areas, which include small patches of trees plantation as shelter for livestock. Associated to this, both an increase of the carbon stock in the soil and a certain increase of the livestock will occur. Since those activities are taking place outside the boundary of the project but in the vicinity and as a consequence of it, are they subject only to the general GHG inventory or the GHG effect must be quantified and included in the project carbon calculations?

FINANCIAL SERVICES

Carbon sequestration may act as a financial incentive for the improvement of land use, mostly in the case of medium and heavy degraded lands on slopes with eroded soils in dry areas, which otherwise would remained abandoned. The share of afforestation costs covered by the value of the carbon sequestered could represent about 20 % of the total cost of afforestation. In the case of abandoned agricultural land or low degraded lands (which need less site preparation work and maintenance) the income from carbon sequestration may cover circa 40 - 50 % of the total afforestation cost. Additional environmental benefits like biodiversity one should be reflected in the price of CO_2, as a “biodiversity incentive”. Spatial pattern of plantations related to the existing forests could be also taken into account for the carbon price for gene flow and genetic pollution consideration (see Table 2).

Table 2. Proposed comparative bonuses for carbon price

Tree species	Landscape approach	Bonus (1 = unit)
Local species	Isolated plantations - Small patches - Large areas	< 1
	Adjoined or connected to existing natural forests	1
Exotic species	Isolated plantations	< 1
	Adjoined or connected to existing natural forests	0

The patterns of biomass and consequently carbon accumulation in plantations on badlands largely depend on the specific biological features of the tree species that are used (Figure 1), as well as on the afforestation schedule, considering that early plantations will produce early accumulation and likely environmental associated effects.

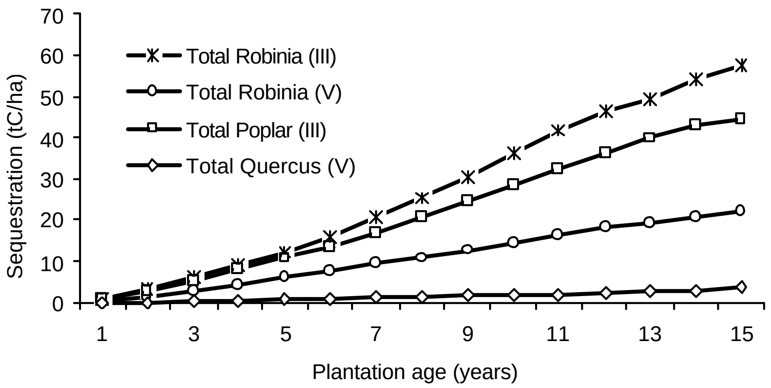

Figure 1. Cumulated soil and total biomass carbon sequestration in 15 year-old plantations of different species (pure stands, first rotation), generated by CO2Fix software in accordance with input data specific for Romania

Actually the type and the intensity of soil degradation, the climatic conditions and the management purposes determine the assortment of species to be used, usually from a limited number of options. The improvement of degraded land by afforestation is associated with a trade off between the management purposes and the limited available site resources for forest establishment and growth. Traditionally, on heavy and medium eroded soils some exotic species are recommended, while low degraded soils are suitable for local indigenous species (specific to the natural type of forest in that area). Sustainability of forest in such areas is related to a certain management type adapted to the local environment, which actually contributes to the selection of the most suitable species (e.g. sprouting species are preferred to non-sprouting ones or those yielding other economic advantages than wood). In this respect some exotic species naturalized in Romania, like *Robinia pseudoacacia*, are the only viable solution for certain types of site (sandy dunes), where any local indigenous species has no chance to reach a minimum level of productivity or even to survive. In such situations these species show very convenient carbon sequestration patterns compared to local tree species, and thus contributing significantly to the afforestation cost coverage.

AFFORESTATION JOINT IMPLEMENTATION PROJECTS IN THE NATIONAL FORESTRY CONTEXT

Afforestation of degraded lands is already a traditional practice based on an almost one century experience in Romanian forestry. Appropriate technologies have been developed and refined in order to ensure afforestation success for different kinds of degraded land. Related to forestry and land use change, the main requirement of the Kyoto protocol is to set additional demonstrable sequestration of carbon by forest activities. The resources allocated for an afforestation joint implementation project should not hamper other similar activities of the implementation agency or the national pattern of afforestation. Within their boundaries the afforestation projects should demonstrate carbon accumulation. In the national context, it is the responsibility of both the implementation agency and the national authority of forests to avoid leakages like deforestation, increased allowable cut and to allocate financial resources for the project sustainability.

In the last two years the state forest administration and the Prototype Carbon Fund have developed an afforestatio project under the JI mechanism. The project contributes to the expansion of forest areas in the low land of Romania, an area with limited forest resources and affected by excessive dry periods, desertification and increased poverty of the local communities.

Afforestation activities in such a project improve and strengthen significantly the cooperation between the scientists - philosophers of science, practitioners and environmentalists, in such a way that a basis for long-term partnership is established.

In the case of the above mentioned afforestation (which includes about 6,700 ha of degraded lands in south Romania) the project yields a without-carbon IRR of 2.04 % equivalent to a NPV of -$732/ha at 5 % discount rate, and a with-carbon IRR of 3.86 % equivalent to a NPV of -$272 /ha. Estimated IRR values without carbon for pure black locust stands are 6.1 %, 4.3% and 1.5% for site classes II, III and IV respectively. Site Class V does not yield an IRR as costs are greater than potential revenues. Still relatively low, the IRR values do not reflect the social and environmental benefits of the afforestation.

THE AFFORESTATION OF BAD LANDS AND CARBON SEQUESTRATION

The many benefits associated with the afforestation projects improve the integrity of actions targeting the climate change mitigation as well as the processes related to the Kyoto Protocol. Vegetation establishment on badlands is associated in many cases with low productivity of the established forests due to the site conditions, and this creates difficulties in predicting and quantifying the carbon accumulation.

Project baseline – carbon approach

To demonstrate scientifically the accumulation of carbon in an afforestation project, the actual carbon stock in the soils of the area to be afforested should be determined just before the afforestation work starts. This should address both scientific issues (in terms of replicable techniques laboratory, statistical frame and quality assurance) and practical approach (field actions and duties, level of precision, achievable targets etc.). A correct baseline survey implies the stratification of the land to be afforested in homogenous strata from the point of view of carbon in the soil, largely variable with the soil type and land use type. Recent history of lands in terms of soil works carried out is also important, and the same type of soil preparation over a long period creates a certain carbon balance with the atmosphere. In this respect the soils under agricultural crops may be considered in a steady carbon balance with the atmosphere and tillage of soil as part of the site preparation for the afforestation is not associated with an increase of carbon release from soils. In the case of pasture lands an increase of carbon release from soils is expected during the site/soil preparation works and consequent soil maintenance operations. The minimal area to be considered as a separate stratum in the baseline study and then in the carbon monitoring is still a matter of debate, but mainly the decision would be based on the differences between carbon stocks in various types of soils/sites included in the project.

Predicting and validation of the carbon accumulation

Several scenarios regarding the carbon accumulation in the project may be considered and accordingly several options would be available for the project negotiation and only one for the purchase agreement (Figure 2). According to the recent developments regarding the afforestation activities based on scientific achievements, there is a statistical evidence of carbon sequestration in the biomass (foliage, stems and branches, roots) and soil (litter and organic matter in the soils) over short time periods.

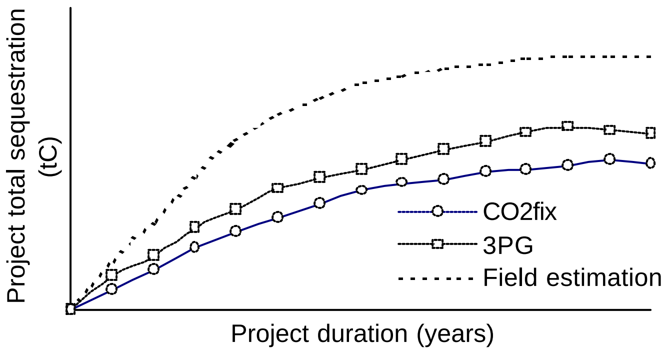

Figure 2. Scenarios for the total C accumulation in the afforestation project: CO2Fix (Nabuurs et al, 2001); Physiological Principles Predicting Growth (Landsberg, 1997); Field measurement in existing plantations (Baseline Study for the Romanian Afforestation Project, 2002)

All three scenarios presented in Figure 2 represent “bona fides” estimates of the accumulation of the carbon in the afforested area, as each approach is based on certain requested input data and computation pattern. Consequently large uncertainties are associated with simulation of carbon accumulation in afforested areas, which is actually a continuous challenge for the scientists. How to solve in a satisfactorily manner the very practical aspects of the project in relation to the tradable amount between partners still remain under discussion.

One available option is to choose the minimum predicted accumulation in the project, which allows both partners to be pretty sure about the achievability of the carbon target of the project. This would also allow the seller to get the market price at the moment of delivering for the extra-carbon sequestered in case of better performance of the project, if initial purchase contract did not state otherwise.

In the case of the Romanian afforestation project (Figure 2), the field measurements done in adjacent plantations to the project area showed a higher amount of carbon than predicted with CO2Fix, mainly due to specific ecosystem processes (low rate of decomposition of necromasis) and the higher growth rate of the stand than the initially predicted one. Field estimation of carbon requests an appropriate approach for ecosystem components (stems, branches, foliage, necromasis, soil) both in terms of the method and the statistical frame adopted. The maximum yield approach could as a basis for a carbon purchase agreement could be risky in terms of carbon availability in the initially predicted timeframe, but additional measures as "hot air" compensation for non-performance projects could guarantee the transaction amount initially planned. Still, in such cases the real success of the project is under high uncertainties both in terms of environmental/social issues at local/global level as well as the environmental integrity of the Kyoto Protocol.

Carbon monitoring

Once the project implementation starts, the amount of carbon sequestered have to be quantified (estimated) at certain intervals of time, with the purpose to assess the project performance and to balance the cash flow between partners. The monitoring activities are suppose to identify any change of the size of the afforested area included in the project, any major damage that may disturb significantly the carbon accumulation process and to quantify the carbon stock at the initially established monitoring periods.

The monitoring activity should be carefully considered in terms of costs and desired objectives to be reached, since an increase of precision imply a larger number of permanent monitoring plots, which leads to an increased cost. Due to current progress in the laboratory techniques it is expected that in the near future high performance devices will be used for carbon measurement.

Biomass and soil assessment have to be done. Due to high phenological stages in forests, the right moment for the biometrical and soil measurement should be the one showing stable accumulation of carbon in the ecosystem parts, which may be the end of the summer, just before the leaf fall.

Biodiversity monitoring

The biodiversity gains associated with the afforestation work should be also monitored. A simple and economically key parameter may be assessed over the project period; perhaps the biodiversity gains generated by land use change from degraded agricultural land to forest require a more careful and multilateral study approach, beyond the pragmatic monitoring purposes in order to fulfil the Kyoto requirements.

CONCLUSION

Afforestation of badlands may be financially supported via sequestered-carbon transactions specific to the joint implementation mechanism under the relevant articles of the Kyoto Protocol, which could also be an incentive for national resource mobilisation for the afforestation of the degraded agricultural lands. Multi-benefits of the afforestation work associated with local population and local environment remain important objectives as well as all the synergies between them. The improvement of land use by afforestation contributes substantially to the environmental integrity of the Kyoto Protocol and the mitigation of the climate change effects.

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