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## CARBON STOCK IN WOOD PRODUCTS: IMPLICATIONS FOR CARBON ACCOUNTING AT NATIONAL AND LOCAL SCALE IN ITALY

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*The international climate change adaptation strategies provide the opportunity to account for carbon sinks in forests through the Kyoto Protocol. Globally, forests and wood products are considered important carbon sinks. Harvested Wood Products (HWPs) are receiving growing attention, considering their potentialities to be included in national Greenhouse Gas Inventories with practical and economic implications for both carbon accounting and timber market. In Italy, understanding the contribution of HWPs to the total carbon budget may have a positive role to further improve forest management and planning approaches, as well as the timber production (i.e. wood-energy chain), specifically oriented to the climate change mitigation and ecosystem adaptation. This work aims to deeper assess the main barriers and drivers for the HWPs implementation within the carbon accounting framework in Italy. After a preliminary survey on how climate adaptation policies are currently implemented at global and national scale, this work specifically addresses the most important opportunities to include the HWPs in carbon accounting for the forestry sector at landscape scales. Finally, this work mainly outlines the following challenges for including HWPs in forest management and planning processes at local scale: (i) improving the assessment of forest carbon budget in different pools through using proper simulation tools, and environmental impact analysis; (ii) further developing robust policies and regulations that make the carbon accounting approach more explicit and economically relevant; and (iii) implementing adaptive approaches to effectively consider climate change mitigation strategies in decision-making processes at landscape scale.*

*Key words:* Kyoto Protocol; Harvested Wood Products; forest management and planning; carbon accounting; landscape scale.

*Parole chiave:* Protocollo di Kyoto; prodotti forestali legnosi; pianificazione e gestione forestale; contabilità del carbonio; scala di paesaggio.

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### 1. INTRODUCTION

The capacity of forest ecosystems to face global changes, through e.g., reducing the atmospheric concentrations of greenhouse gases (GHGs), has a central

role in international climate negotiations (Barbati *et al.*, 2014). In fact, forest ecosystems are able to absorb atmospheric carbon and accumulate it for relatively long periods, in both above- and below- ground biomass, deadwood, and soil (Lindner *et al.*, 2010; Pan *et al.*, 2011; Kolström *et al.*, 2011). According to the 2010 Global Forest Resources Assessment carried out by FAO (FAO, 2010), forests cover 31% of total land area; these lands offer a global contribution in terms of carbon stocks of about 527 billion m<sup>3</sup> C and absorb annually approximately 1.6 Gt C in woody biomass, soil and litter. In addition, the wood products obtainable with the forest utilization can retain a considerable amount of carbon for the duration of their life cycle (Kosir, 1999; Hillier and Murphy, 2000). Several studies demonstrate that they have a key role in the overall carbon budget, and climate mitigation options (Pingoud *et al.*, 1996; Flugsrud *et al.*, 2001; Poker *et al.*, 2002; Dias *et al.*, 2005; Hofer *et al.*, 2007; Canals Revilla; 2010, Pan *et al.*, 2011).

### 1.1. *The Kyoto Protocol and the international carbon policy until Paris 2015*

The most important agreement for the environmental protection worldwide is the Kyoto Protocol (KP) (Pettenella and Zanchi, 2006; Colletti 2012). KP was approved in 1997 with the main aim to reduce the GHGs emissions, in comparison with a common reference year. Through several meetings and the Conference of the Parties (COP), KP was implemented and the adoption of new commitments promoted. The recent agreement still ongoing for a second Commitment Period (CP; 2013-2020) was prepared during the COP17 in Durban in 2011. COP17 makes mandatory for all developed and developing countries the reduction of their emissions through implementing effective policies and adaptation measures in forest management, and as a consequence by rewarding those countries that increase forest carbon sequestration capacity (Perugini *et al.*, 2012, UNFCCC, 2011 a,b,c). Other important changes concerned the method of credits counting generated by forest management and in particular the inclusion in the count of the carbon stored in Harvested Wood Products (HWPs).

COP17 was interpreted as a transition scenario to the new international climate agreement, which was planned to be adopted at the COP21 in Paris in 2015 and entered into force in 2020 (Byrne and Maslin, 2015). The success of the outcomes from COP21 will depend crucially on the participation of the world's major economies, including the United States. A major weakness of KP has been its limited coverage (in terms of signatory countries), due both to the unwillingness of the United States to become a party and to the protocol's lack of new mitigation commitments for developing countries, which now account for the majority of global emissions from GHGs (Bodansky, 2015). Promising signs come from the joint announcement by the USA and China in Beijing in November 2014 to effectively take part to the climate change mitigation mandate. The Clean Power Plan for the USA announced by Barack Obama on August 3, 2015 and the recent decision of the European Council reaffirmed their commitment to domestic action on emissions. Considering that USA and China together account for around half of global emissions,

these decisions are important and substantive steps towards a more effective agreement in Paris in 2015, in comparison with the previous ones (Stern, 2014).

The EU has consistently pursued a global climate treaty and assumed a leadership role. This has strongly promoted the policy of engagement against climate negative effects, through developing a set of operational tools, such as e.g., the European Union's Emission Trading System (EU-ETS) (2003/87/EC) (Ronchi *et al.*, 2012). For the second CP, EU is committed to reduce its emissions by 2020 by at least 20% in comparison with 1990 levels, to increase to 20% the share of renewable energy in EU's gross final energy, and to save 20% of the EU's energy consumption through increasing the energy efficiency (European Council, 2009). To achieve these objectives, specific policies about the effective and sustainable use of resources are needful in Europe, and particularly for the forestry sector, to which a leading role in this context is attributed (Bucella, 2014). Accordingly, the new EU Forestry Strategy [(COM(2013) 659; SWD(2013) 343] supports the concept of the "cascade use" of wood (Ciccarese *et al.*, 2015).

The "cascade-use" of wood principle implies the use of wood material according to a priority based on the added value that can be potentially generated. As a consequence, raw material from forests should be preferably used for building, furniture and other products with long life span, while bioenergy should preferably derive from the use of waste wood, wood residues or recycled products (European Parliament, 2013).

### 1.2. *C storage in wood products*

To mitigate climate change, global forest ecosystems represent a key solution (Chakravarty *et al.*, 2015).

Wood products can be considered a valid tool for extending the storage of the forest C sink, as its role has been recognized only recently by KP. In the first CP (2008-2012), forest harvesting was treated as an instantaneous emission of carbon dioxide, and the carbon stock effect of HWPs ignored (Chakravarty *et al.*, 2015). In practice, wood-based materials may emit C over a long time frame (Pilli *et al.*, 2015). For this reason, for the second CP (2013-2020), the accounting rules have been changed to include explicitly C stock changes in the HWPs pool (UNFCCC, 2011a). However, the next commitment period from 2013 will be important for wood products, the carbon stock changes resulting from HWPs will be taken into account in the national inventories of GHGs (Tonosaki, 2009, Chakravarty *et al.*, 2015).

HWPs refer to the wood material that leaves the harvest area, and is used for producing commodities like furniture, doors, flooring, packaging, paper products, or others (Canals Revilla *et al.*, 2014). HWPs behave as temporal storage of C, because they lock the carbon from the wood of the forest, delaying its emission to the atmosphere depending on its lifetime and the decay process of the product (UNECE/FAO, 2008; Bowyer *et al.*, 2010).

Nevertheless, actions increasing the HWPs contribution need to be evaluated as a part of life-cycle evaluation that include wood-related carbon change in the

forest, energy, and manufacturing sectors (Skog, 2008). As a consequence, we need to search for proper solution that increase the sum of carbon offsets by forests, such as e.g., (i) the substitution of manufactured materials (for example steel and alloys) by wood (decreasing emissions of CO<sub>2</sub>, presence of pollutants and waste during the whole product life cycle; Petersen and Solberg 2005; Gustavsson *et al.*, 2006), and (ii) the substitution of fossil fuels by combustion of woody biomass that is not usable for wood products or from the combustion of wood waste (Marland and Schlamadinger, 1997). Although these examples show that the expanding use of HWPs can contribute to increase the carbon sinks and minimizing carbon emissions, questions still remain on how HWPs can be included in carbon accounting approaches (methods) to make adaptive measures more effective in the future from European to national scale (Tijardović, 2009). A key question is how to develop policy or market incentives to optimize this carbon offset additional contribution from forest resources. To study ways to optimize the sum of carbon offsets, the countries have to clarify their management goals and constraints (Skog, 2008).

### 1.3. HWPs in the carbon accounting: gaps and limitations

Efforts to recognize C storage in HWPs within international protocols have been ongoing for the past several years (Bowyer *et al.*, 2010). However, there is still no agreement regarding the potentialities for HWPs to be a more significant part of climate change mitigation options (Ingerson, 2011). Unfortunately, currently available C accounting approaches are difficult to be incorporated into national climate negotiations, mainly for technical reasons, regarding e.g., (i) how to assign carbon credits among countries, and to manage them at national scale; (ii) how to identify both emitting and mitigating countries; and (iii) how HWPs are used for carbon accounting. Considering the latter limitation, could the inclusion of HWPs in carbon accounting frameworks lead to more forest harvesting? Could the longevity of stored C in discarded products within landfills encourage waste and discourage durability and recycling? These questions may explain part of the reticence in dealing with the stored carbon issue (Bowyer *et al.*, 2008). In addition, understanding the opportunity for C storage in wood products still remains a difficult task, due to a complex reality of competing industries, and conflicting national agendas (Bowyer *et al.*, 2008). In fact, the national GHGs inventories reporting also the C stored in HWPs are inadequate to identify effective policy actions towards decreasing the emissions. One reason is that they do not identify the effect of changes in one element (e.g., HW carbon) on other elements like forest carbon stocks or emissions from energy and waste sectors (Ingerson, 2011).

Furthermore, the national account of HWPs still requires more detailed information. In this way, the IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006) provides three calculation methods (stock-change approach, production approach, and atmospheric-flow approach; Nabuurs *et al.*, 2003; Tonosaki, 2009). Countries can use these estimates to report the annual

contribution that HWPs make (Skog, 2008; Kloehn and Ciccacese, 2005, Pingoud *et al.*, 2006). The count should be made on the basis of the changes of carbon in wood products segment during the CP, through estimating each product category, and using the decay rates, as suggested by the IPCC Guidelines 2006 (equation 12.1 in IPCC, 2006) with the possibility, in case of lack of national data specific, to use a half-life of default of 2 years for the paper, 25 and 35 years for the panels and the sawn timber, respectively (Perugini *et al.*, 2012). These times refer to the number of years in correspondence of which assumes a loss of product equal to half of the initial one. However, incorporating HW carbon as a pool in forestry offset projects introduces technical complications that must be addressed to ensure accurate accounting and conservative crediting (Anonymous, 2006).

## 2. NATIONAL POLICIES

### 2.1. *The implementation of KP in Italy*

Italy ratified the KP with Law 1<sup>st</sup> June 2002, n. 120 (Ciccacese *et al.*, 2006). CIPE Resolution No. 123/2002 approved the National Plan for the reduction of GHGs emissions, a reference document for the implementation of the Kyoto Protocol. In this plan, particular attention is given to the agro-forestry sector and its potential contribution to the achievement of the national targets of reducing GHGs emissions (COP 12, Nairobi 2006). The reference levels for Italy correspond to a total of 465 Mt CO<sub>2</sub> emissions (ISPRA, 2014), assuming business-as-usual conditions for the second CP equal to -22.16 Mt CO<sub>2</sub> emissions. These levels are defined on the basis of projections simulating an intensification of forest exploitation of 20%, which is expected to decrease the C sink of 30%. Moreover, the target set for Italy to improve the use of renewable energy corresponds to 17%, in agreement with the European Climate-Energy Packages (EC, 2009a; EC, 2009b; Perugini *et al.*, 2012). The Italian forestry sector is expected to have a double role in this context. On one hand, future management practices have to increase carbon storage capacity in comparison with the current one. On the other hand, other future adaptive policy measures have to be implemented for supporting the production of renewable energy from biomass, in the frame of the EU Climate-Energy Packages (EC 2009a, EC 2009b, Perugini *et al.*, 2012).

### 2.2. *Wood storage policies and the anomalies of national system*

KP recognized forests as important ecosystems regulating the global carbon cycle and the GHGs atmospheric concentrations (Ciccacese, 2008; IPCC, 2014). Italian forests can play an important role as both sinks and sources of CO<sub>2</sub>, considering their average potential of carbon absorption of approximately 15 Mt CO<sub>2</sub> year<sup>-1</sup> (ISPRA, 2014).

### 2.2.1. Forest policy and management contexts

According to the above-mentioned issues, forest management in Italy can have a significant influence on the ability of forest ecosystems to remove carbon from the atmosphere, and as a consequence to improve forest ecosystem resilience and stability (Magnani and Matteucci, 2009).

In particular, the accounting of carbon storage in HWPs may have positive implications for forest management, and production chain (Aulí, 2002; Hansen, 2006; Voces *et al.*, 2008), especially for the Italian wood industry sector (Winjum *et al.*, 1998; Hashimoto *et al.*, 2002; Pingoud *et al.*, 2003; Kloehn and Ciccarese, 2005). Since 20<sup>s</sup>, the national forest area has more than tripled, bringing Italy to have a forest area index higher than in Germany and France (Gasparini and Tabacchi, 2011; Pettenella, 2009). In the last three years, the consumption of wood in Italy has increased of approximately 16% (Gardino, 2001). Although the significant and growing uses of wood, the Italian forests are used in a limited way (Jaegers *et al.*, 2013). Only one-third of annual increment of high forests is used, especially for the production of firewood (Romano *et al.*, 2014). This seems to be in conflict with the cascade principle promoted by the EU that biomass for energy should come from the reuse of products at the end of cycle and production waste (Pettenella and Romano, 2015), even considering that most of the domestic supply of raw material currently depends on foreign markets (Berti *et al.*, 2009). The Italian forests that can potentially be used to produce wood for building are ageing, abandoned, or poorly managed and valued (Pettenella, 2009). These difficulties require that a scientifically sound strategy and a locally-tailored sustainable management should be implemented, as in the case of the adaptive forest management that reconciles environmental protection with local development (e.g. Borghetti, 2012). From the owner/entrepreneur point of view, the forest sustainability is related to the possibility to obtain higher incomes from forest goods and services, which in turn could be invested to enhance future productivity. However, the implementation of sustainable forest management measures is influenced by the availability of suitable programming tools and incentives.

Italy has some difficulties to implement these measures. In Italy, there is a strong regime of regulations and restrictive political system to control and manage the resources produced or marketed (Pettenella *et al.*, 2005). Moreover, so far, several national and local policies did not promote a market structure ensuring a constant flow of raw materials from forest ecosystems to local communities. Even for the valuable and suitable size timber species, the forest owners are still not able to place such materials on the market. The lack of an adequate distribution network or collection points recognized by potential buyers actually prevents to supply on an ongoing basis our industries.

This approach discourages the investments that, on the contrary, are necessary to ensure the constancy of income over time. This has a direct impact on the land abandonment and the absence of active forest management, as well as originates an increasing erosion of forest ecosystem services (Berti *et al.*, 2009).

National government and business leaders can contribute to develop and promote processes that encourage and create incentives for the use of more wood products and the increasing of the market share of wood products. Some strategies and policy actions should regard: (i) the maximization of the achievable wood increment; and (ii) a further development of the wood products market, through promoting technical innovation and coherent policies encouraging the use of wood for buildings, or long-lived wood products manufactured using the timber harvested. These products may be recycled at the end of their lifetime and, finally, (end-) used to generate energy (Chakravarty *et al.*, 2015). These objectives can only be achieved by using all available “policy tools” (Berti *et al.*, 2009).

### 2.2.2. Wood chain and C accounting

Wood chain in Italy is considered unattractive by the industry, because the harvesting costs are always higher, according to possible revenues (Hippoliti, 2007). The lack of integration between domestic forest activities and the wood working industry is therefore one of the basic problem and, at the same time, one of the main challenges for the Italian forestry sector (Pettenella *et al.*, 2005). The harvesting systems and the limited organizational capacity of forest contractors are not sufficiently optimized (Berti *et al.*, 2009). This generates a loss of professionalism linked to the protection of land and opportunities for employment and entrepreneurship for many inland areas.

Furthermore, there is no standardized procedure for calculating the amount of wood potentially available for industrial production (Baskent and Keles, 2005; Kurttila, 2001) or energy purposes (Fiorese and Guariso, 2010; Gómez *et al.*, 2010; Sacchelli *et al.*, 2013; Tenerelli and Carver, 2012). The combination of the above-reported factors does not allow having accurate estimates of carbon fluxes useful for reporting to KP, as well as those related to the different forms of forest management. In fact, a method for accounting for carbon credits on a national level has not defined yet. In addition, the Italian forestry sector is cut off from any incentive instrument of targeted absorption of CO<sub>2</sub>. At national level, the development of payment mechanisms for environmental services is still a long way from being adopted (Berti *et al.*, 2009).

Nevertheless, the awareness that we have significant forest resources is expected to inspire industry operators towards identifying suitable strategies for the promotion of local timber markets. This aspect, in conjunction with the greater communication and comparison among the different public and private actors in order to identify shared lines of development and investment to focus future efforts, will allow a legitimate recovery of production activity (Berti *et al.*, 2009).

The Voluntary Carbon Market is a line of development to invest for local governments, companies, and forest managers. This makes the principle that “who provides an environmental service is paid”. In this way, forest managers (who provide several environmental services) can receive incomes from the sale of carbon credits obtained through their activities such as e.g., forest plantations, or the adoption of specific forestry techniques in the frame of sustainable forestry.

The Voluntary Carbon Market is therefore a great opportunity in the entrepreneurial sense and for promoting the land conservation, the sustainable management of forest ecosystems, and the production of incomes in marginal areas (Romano, 2010).

In addition, there is the interest of both farmers and foresters, and other land managers to diversify incomes through the establishment of tree plantations, according to the Common Agricultural Policies reform and the Rural Development Programme (RDP) post-2014 (Ciccarese, 2011).

In this way, the national policy should force the development of Voluntary agreements that can formally contribute to the commitments under KP.

### 3. POTENTIALS FOR FOREST PLANNING AND MANAGEMENT AT LOCAL SCALE

Given the above considerations, the adaptation to climate change goes throughout a rethinking of forestry policies. Accordingly, the local scale seems to be suitable for implementing climate policies in an easier way. Forest management is immediate and one of the most effective methods to curb the rate of increase in CO<sub>2</sub> in atmosphere, reorganization of the short wood chain and consequently less dependence on imports (Berti *et al.*, 2009). The local forest owners have the potential to manage the present and future forest C sequestration for different purposes, such as conservation, storage and substitution. The goal of conservation is to preserve the existing C pools in forests as much as possible in order to protect forests in natural reserves and control the impact of other anthropogenic disturbances. The goal of management for storage purposes is to increase the C sequestration in forest ecosystem through e.g., increasing the area of natural forest plantations or durable wood products. The substitution management aims at increasing the transfer of forest biomass C into products that can replace fossil fuel-based products (Brown *et al.*, 1996). Selecting and integrating these management approaches according to the characteristics of the territory, the forest and the ecosystem services provided, refer to realize adaptive and sustainable forest management. The implementation of sustainable forest management means higher costs for forest owners (Europe, Forest Resolution H1, 1993). In order to support the forestry sector, Regional Administrations could develop several initiatives to raise the forest-wood chain (D'Orlando *et al.*, 2009).

To support the forest-wood chain in the 2014-2020 period, RDP (Matthews, 2011) will provide specific support to forest managers for environmental services, even for developing wood-based energy supply chains (Cesaro *et al.*, 2013). During the RDP preparatory phase, regional and other local administrations had the opportunity to allocate resources and identify concrete actions to set up a real “forest-wood system”, thus contributing to the climate change mitigation. Other developmental instruments providing financial envelope for this kind of actions are the European Regional Development Fund (ERDF), the European Social Fund (ESF), and the “Supply Chain Contracts” promoted by the Ministry



of Agriculture and Forestry (*Ministero delle Politiche Agricole, Alimentari e Forestali - MIPAAF*) (Agro-energy Plan for Molise region, 2010). Moreover, modelling techniques and simulation tools (e.g., decision support systems for sustainable forest management) should be adopted to effectively support adaptive management strategies and wood supply chain from local to a broader scale (see e.g., Segura *et al.*, 2014).

In order to enable the recognition of wood products from the contribution of local level and improve the understanding on C stored in wood products, accurate and robust approaches have been developed. Scientific tools that provide the basic information must be adopted (Chakravarty *et al.*, 2015). Accordingly, it is necessary to have scientific recognised methods to be used to calculate the amount of CO<sub>2</sub> fixed (AA.VV., 2008). This is also useful to develop a voluntary C credit market. For example, CO2FIX is a stand-level simulation model that quantifies the C stocks and fluxes in and between the different biomass compartments (Schelhaas *et al.*, 2004). This tool is very easy-to-use, in terms of input parameters required, and harvesting activities to be set up (Masera *et al.*, 2003). The adoption of the CO2FIX model would overcome the problem of C credits accounting, thus quantifying the C flow variations according to different Forest Management activities. The use of the model would provide a detailed information base, seen as a starting point to develop management and planning strategies appropriate to reinforce the wood supply chain and contribute to face climate change. Strengthening the supply chain may improve the knowledge about how much resource is available and less dependent on wood imports. This is demonstrated by Scarfò e Mercurio (2009) in a beech forest in Southern Italy, Cattoi *et al.* (2002) in Trentino, and ISPRA in 2011 (Ciccarese *et al.*, 2011) in the Acerno municipality. These studies also provided indications to local policy makers about forest carbon storage and how changes in forest management decisions modify the carbon content across space and time.

In this context, the introduction of mechanisms for assessing the sustainability of a process or a product such as certification or Life Cycle Assessment (LCA) is important to increase the value of products and services and communicate to consumers the importance and complexity of the sector (Cappellaro and Scalbi, 2011). For example, LCA is the most reliable methodology for evidencing and analysing the environmental impacts along the detailed life cycle for wood product, productive process and wood chain to supply (ISO 14040, 2006; ISO 14044, 2006; Bauman and Tillman, 2004). LCA is also useful to identify key critical elements and best practices that can be implemented (Mirabella *et al.*, 2014) and information about the net impact on atmospheric GHGs concentration. If applied to the product, LCA can be used to assess the substitution effect of using wood in place of other more fossil fuel intensive material (Lippke *et al.*, 2010; Pingoud *et al.*, 2010; Ingerson, 2011), in order to unravel the most suitable environmental profiles that the increased use of wood may have if compared to products from other materials with the same function has (e.g. Werner and Richter, 2007; Glover *et al.*, 2002). These valuations may be taken as a guide for planning and support

the implementation of policies at local and regional level. In addition, LCA has the advantage to identify several action plans and related achievable targets. This makes it a great tool for policy-makers (Iraldo and Testa, 2014).

An important phase in all these process is the continue dialogue between, as well as the crucial role of the professional associations, the institutions, the organizations and the agencies, as well as the universities, which are specifically called to impart more scientific teachings, training and guidelines. In addition, the activation of Local Action Groups (LAG) is important for disseminating the effective opportunity that the wood forestry sector offers, both for the animation of companies and interest groups in the area ( Agro-energy Plan for Molise region, 2010). The research and development projects that can arise from these collaborations create opportunities and new perspectives for forest owners (D'orlando *et al.*, 2009).

#### 4. CONCLUSIONS

It is clear that forest policies are strongly influenced by many agreements and commitments, as carried out both at global and national level, in Italy (Cesaro, 2010). The opportunity of the new global climate agreement forces the Italian forestry sector to update the related national policy and gives finally the priority to the development of an important resource for Italy, such as e.g., the wood-related benefit. In fact, as previously stated, the Italian forestry sector has a strategic potential for climate change mitigation policies.

This implies the adoption of specific measures in forest planning and management, with the primary purpose to meet the requirements of climate adaptation strategies. If properly managed and maintained, in terms of their resilience and adaptation, forest ecosystems in Italy can represent not only natural carbon reservoirs, but also fundamental basins for the investments in the related productive sector. In this way, the socio-economic development, and the maintenance of ecological features, are guaranteed, especially in rural and marginal areas.

Obviously, a landscape scale approach makes the land protection, the policies for climate mitigation, and the industry revitalization easier. Close cooperation between forest technicians and universities should be the basis for technical, scientific and programme activities. Moreover, the use of technical support, such as e.g., the land modelling at local scale, is a great opportunity to reach specific programmatic action. It is useful to have a specific trend in land use, or land technically and actually available for C conservation and sequestration projects; possible interventions and their direct and indirect effects on future land uses and key barriers that may be encountered in attempting to implement forestry options for mitigation.

This will provide to local policy makers the necessary knowledge about the opportunities related to carbon stock of their forests, in order to integrate the carbon fixation component in the management objectives and as a consequence

to “internalize”, with an economic benefit, the ecosystem services that local forests provide for climate change mitigation.

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#### RIASSUNTO

*Il sequestro di carbonio nei prodotti legnosi: conseguenze per la contabilità a scala nazionale e locale in Italia*

Le strategie internazionali di adattamento ai cambiamenti climatici forniscono l’opportunità di contabilizzare i serbatoi forestali di carbonio, al momento ancora attraverso il Protocollo di Kyoto. Su scala globale, i boschi e i prodotti forestali legnosi sono considerati importanti serbatoi di carbonio. I prodotti forestali legnosi (*Harvested Wood Products*, HWP) ricevono attenzione e sono inseriti negli Inventari Nazionali dei Gas Effetto-Serra, con conseguenze pratiche ed economiche anche per il mercato del legno. In Italia, comprendere il contributo degli HWP al budget locale del carbonio potrebbe avere un ruolo positivo per migliorare ulteriormente gli approcci alla gestione e pianificazione forestali, in particolare per la filiera legno-energia, orientando le scelte verso la mitigazione dei cambiamenti e l’adattamento ecosistemico. Questo lavoro si propone di valutare in modo più approfondito i principali *drivers* e le limitazioni per l’adozione degli HWP all’interno dei meccanismi di contabilità del carbonio in Italia. Dopo uno studio preliminare su come le politiche di adattamento ai cambiamenti climatici sono attualmente adottate sia a scala globale che nazionale, si descrivono le opportunità per il settore forestale nazionale. Infine, le seguenti sfide per la gestione e la pianificazione forestali nell’integrare gli HWP sono ampiamente descritte: (i) migliorare la valutazione del bilancio forestale del carbonio nei diversi serbatoi mediante l’uso di adeguati strumenti di simulazione, nonché l’analisi dell’impatto ambientale; (ii) sviluppare forti politiche e regolamentazioni che rendano il conteggio del carbonio più esplicito ed economicamente rilevante; (iii) adottare approcci adattivi per tener conto in modo più efficace delle strategie di mitigazione dei cambiamenti climatici nei processi decisionali a scala di paesaggio.

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