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ACCOUNTING FOR CHANGES IN BIODIVERSITY AND ECOSYSTEM SERVICES FROM A BUSINESS PERSPECTIVE

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Abstract: Biodiversity refers to the dynamics of interactions between organisms in changing environments. Within the context of accelerating biodiversity loss worldwide, firms are under increasing pressures from stakeholders to develop appropriate tools to account for the nature and consequences of their actions, inclusive of their influences on ecosystem services used by other agents. This paper presents a two-pronged approach towards accounting for changes in biodiversity and ecosystem services from a business perspective. First, we seek to analyze how Environmental Management Accounting (EMA) may be used by firms to identify and account for the interactions between their activities and biodiversity and ecosystem services (BES). To that end, we use dairy farming as a case study and propose general recommendations regarding accounting for changes in biodiversity and ecosystem services from a management accounting perspective. Secondly, after discussing the corporate reporting implications of the main environmental accounting approaches, we propose the underlying principles and structural components of a Biodiversity Accountability Framework (BAF) which would combine both financial and BES data sets; hence, suggesting the need for changes in business accounting and reporting standards. Because this would imply significant changes in business information systems and corporate rating practices, we also underline the importance of making the associated technological, organizational and institutional innovations financially viable. The BAF should be designed as an information base, co-constructed with stakeholders, for setting up and managing new modes of regulation combining tools for mitigating BES loss and remunerating BES supply.

Keywords ***:*** Accounting, business, biodiversity, ecosystem services, indicators, management accounting, financial accounting, reporting, corporate social responsibility, standards, biodiversity accountability framework.

JEL classification M20, M40, Q20

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List of abbreviations:
BAF: Biodiversity Accountability Framework
BBII: Business and Biodiversity Interdependence Indicator
BES: biodiversity and ecosystem services
CBD: Convention on Biological Diversity
CSR: Corporate Social Responsibility
EMA: Environmental Management Accounting
ES: ecosystem services
EDS: ecosystem dis-services

1 - INTRODUCTION

During the past few decades, firms have been under increasing pressures from stakeholders to reduce their impacts on the environment. Ecological issues have become key strategic variables for them, notably in terms of disclosures (Cho and Patten, 2007; Cormier et al., 1993) now mandatory in many countries. Since decision VIII/17 was taken in Curitiba in March 2006 at COP 8 of the Convention on Biological Diversity (CBD), the business community has been asked, through the launch of the 'Business and Biodiversity' initiative, to contribute actively to the objectives of the CBD. Supported by the European Commission, this initiative calls for the adoption of best practices to reduce the impacts of businesses on biodiversity and promote its conservation. Within the context of the associated environment – competitiveness debate, biodiversity is usually understood as a new, additional form of external environmental constraint on business activity (Houdet et al., 2009). It is linked essentially to regulatory frameworks overseeing where and how businesses can operate, chiefly through the appraisal of new industrial projects. Businesses make use of cost-benefit analyses so as to capture the marginal economic value of biodiversity (inclusive of ecosystem services) for trade-offs purposes: this allows them and their stakeholders to account for biodiversity and ecosystem services (BES) loss or gain from an economic perspective. Yet, despite numerous efforts, BES may not easily be translated into a monetary proxy for market internalization[2], hence some stakeholders arguing that the total economic value of biodiversity, though useful, is not sufficient for arbitrage (i.e. the value of 'remarquable biodiversity' cannot rigorously be approximated in monetary terms; Chevassus-au-Louis et al., 2009). Accordingly, conventional business strategy amounts essentially at identifying, assessing, monitoring and mitigating the impacts of business activities on (noticed) biodiversity, especially on its components protected by law or those important to legitimate stakeholders. For preexisting business activities on the one hand, this would involve at best a cost-effectiveness approach with respect to negotiated or mandatory ecological goals linked to changes in business practices. For new business projects on the other hand, mitigation mechanisms - hybrid tools involving both markets and state regulation, based on a 'no net loss' five-stage approach[3], are actively being promoted worldwide, whilst various studies highlight the importance of ecological equivalencies between areas degraded and areas restored given the difficulties associated with the economic valuation of damages for trade-off purposes (e.g. Llewellyn 2008; Strange et al., 2002).

Though impact mitigation mechanisms are necessary for the internalization of certain biodiversity externalities, they fall short of the goal of fully integrating biodiversity into business strategies and practices. Impact mitigation mechanisms restrict business perceptions of its interactions with living systems to the management of their negative impacts on BES (Houdet et al., 2009). Nonetheless, business attitudes, behaviors and strategies regarding biodiversity are progressively changing. Previous work on the Business and Biodiversity Interdependence Indicator (BBII) has shown that firms' perceptions of their interdependences with biodiversity are highly diverse, regarding to technologies, sales and the management of

[2] Concerns are associated with the use of non-market valuation (e.g. contingent valuation) and benefit-transfer techniques, including their underlying assumptions, the reproduction of protocols and the comparative analysis of results across time and space (Bonnieux 1998; Kumar and Kumar, 2008; Nelson et al., 2009; Weber 2002).

[3] It involves (a) avoiding irreversible losses of biodiversity (prevention), (b) seeking alternative solutions to minimize losses, (c) using mitigation to restore biodiversity, (d) compensating for residual, unavoidable loss by providing substitutes of at least similar biodiversity value, and (e) seeking opportunities for enhancement (BBOP 2009; IAIA 2005).

supply chains among many other issues (Houdet 2008). This suggests the emergence of business strategies and practices which could go beyond impact mitigation and the search of a compromise between development and conservation. Combining strategies for mitigating BES loss (Polluter Pays Principle) and remunerating BES supply (Beneficiary Pays Principle) opens the door to new forms of arbitrage with respect to land use and development (Aretino et al., 200; Iftikhar et al., 2007; Trommetter et al., 2008), as well as business management and production processes (Houdet et al., 2009). This approach may see BES maintenance or provision becoming an integral part of the business plan of the firm, as a core variable among others for decision-making and management and as a source of new assets, liabilities, skills, technological and organizational innovations (Houdet et al., 2009).

Yet, a real awareness of the links between business and biodiversity is still of concern mainly to large corporations and multinationals, the firms most visible to the general public and those directly involved with living systems such as agribusiness (Houdet 2008; MA 2005). These are the corporations most likely to be subject to pressure from stakeholders, including non-governmental organizations, local communities and Corporate Social Responsibility (CSR) rating agencies. Currently available methodologies and tools which aim to go beyond impact mitigation either follow an approach based on the analysis of risks and opportunities with respect to ecosystem services (e.g. Ecosystem Services Review - Hanson et al., 2008, which is appropriate from an investor perspective), or one which seeks to assess firms' perceptions of their interdependence with biodiversity (Business and Biodiversity Interdependence Indicator; Houdet 2008). We posit that these are not sufficient to ensure rigorous understanding and assessment of the nature and dynamics of interactions between firm(s) and biodiversity. How may strategies combining mitigating BES loss and remunerating BES 'supply' be fully appropriated by all firms then?

This paper hopes to contribute to the challenge of reconciling business with biodiversity. To that end, we posit that (a) tools are needed so as to account for business interactions with BES and that these need to be integrated into (b) (internal) management information systems so as to guide decision-making and (c) (external) reporting tools for institutional purposes (e.g. in reference to norms or statutory targets), notably stakeholders' needs of a corporate responsibility framework inclusive of biodiversity and of ecosystem services used by others. Accordingly, the aim of this paper is to propose guidelines so as to account for business interactions with living systems, towards an operational Biodiversity Accountability Framework (BAF). We first analyze how a management or cost accounting approach (section 2) may help firms account for biodiversity and ecosystem services (BES), from the perspective of the business manager who seeks to achieve organizational targets. Then, we discuss how accounting for BES from a Corporate Social Responsibility (CSR) perspective may influence business accounting and reporting standards (section 3).

2 - ACCOUNTING FOR BIODIVERSITY AND ECOSYSTEM SERVICES FROM A MANAGEMENT ACCOUNTING PERSPECTIVE

In section 2, we seek to analyze how Environmental Management Accounting (EMA) may be used by firms to identify and account for the interactions between their activities and biodiversity and ecosystem services (BES). After synthesizing the conceptual foundations of EMA (2.1) and providing a general framework of interactions between business and biodiversity (2.2.1), we use dairy farming as a case study (2.2.2) and propose general recommendations regarding accounting for material flows of biodiversity (2.2.3), ecosystem services and benefits to business (2.2.4), biodiversity gains and losses caused by business activities (2.2.5) and interactions between firms and other agents with respect to changes in BES (2.2.6).

2.1 Environmental Management Accounting (EMA)

2.1.1 General principles

Cost or management accounting constitutes the central tool for internal management decisions, such as product pricing, and is not regulated by law. This internal information system deals with questions typically pertaining to the production costs for different products and their selling prices. The main stakeholders in cost accounting are members of different management positions within a company (Jasch 2003). There is a growing consensus that conventional accounting practices do not provide adequate information for properly supporting decision-making in terms of environmental stakes. To fill in this gap, Environmental Management Accounting (EMA) has been receiving increasing attention (Jasch 2008; Gale 2006). EMA is broadly defined to be the identification, collection, analysis and use of two types of information for internal decision making (UNDSD 2001; Savage and Jasch, 2005), namely (a) monetary information on environment-related costs, earnings and savings and (b) physical information on the use, flows and destinies of energy, water and materials (including waste). EMA may be particularly valuable for internal management initiatives with a specific environmental focus, such as environmental management systems, product or service eco-design, cleaner production and supply chain management.

2.1.1 Typology of environmental costs and revenues

Identifying and categorizing environmental costs and revenues can be done in various ways in order to guide action plans and decision-making. These may be associated with environmental media groups (e.g. air / climate, waste, noise and vibration; SEEA 2003), and can be 'sourced' from different cost and revenue (or earning) categories (de Beer and Friend, 2006; Jasch 2003; Jasch and Lavicka, 2006; UNSD 2001). While revenues comprise sales of by-products, subsidies, R&D investment grants, and sales of goods and services with an 'environmental' purpose (e.g. waste disposal and recycling), the US Environmental Protection Agency (1995; 1996) distinguishes internal costs from external ones:

- On the one hand, internal environmental costs comprise (a) conventional costs such as raw materials and capital equipments; (b) potentially hidden costs which result from assigning environmental costs to overhead pools or overlooking future and contingent costs; (c) contingent costs, which depend on uncertain future events; and (d) intangible costs, such as image and 'relationship' / public relations costs (e.g. annual environmental reports)[4].

- On the other hand, external environmental costs may include (a) environmental impacts or damages for which firms are not legally liable and (b) adverse impacts on human beings, their property and / or their welfare which cannot always be compensated through legal means (de Beer and Friend, 2006). These costs relate to environmental externalities because there is a legal vacuum (Huglo 2007) or no clearly established property rights, as the Coase Theorem (1960) states. Accounting for such costs is difficult (towards full-cost accounting; Bebbington et al., 2001; Canadian Institute of Chartered Accountants 1997) and results are often contested (too arbitrary or partial, not rigorous); though some firms have attempted to do so (e.g. the environmental report of BSO/Origin includes essentially externalities linked to GHG; Huizing and Dekker, 1992).

2.1.2 Standard typology of 'Input – Output' flows

Table 1: general input-output chart of accounts (UNSD 2001)[5]

INPUT in kg/kWh	OUTPUT in kg
Raw materials	**Product**
Auxiliary materials	Main Product
Packaging	By Products
Operating materials	**Waste**
Merchandise	Municipal waste
Energy	Recycled waste
Gas	Hazardous waste
Coal	**Waste Water**
Fuel Oil	Amount
Other Fuels	Heavy metals
District heat	COD
Renewables (Biomass, Wood)	BOD
Solar, Wind, Water	**Air-Emissions**
Externally produced electricity	CO_2
Internally produced electricity	CO
Water	NO_x
Municipal Water	SO_2
Ground water	Dust
Spring water	FCKWs, NH_4, VOCs
Rain/ Surface Water	Ozone depleting substances

To assess costs fittingly, an organization must collect both monetary and non-monetary data regarding materials use, labor hours and other cost drivers. Physical accounting information is hence critical to the understanding of many environment-related costs. EMA places a particular emphasis on materials and materials-driven costs because (1) use of energy, water and materials, as well as the generation of waste and emissions, are directly related to many of the impacts organizations have on their environment and (2) materials purchase costs are a major cost driver in many organizations (UNSD 2001). The 'input side' of material flow accounts (Table 1) typically includes raw materials, auxiliary materials, packaging, operating materials, merchandise, energy (gas, coal, biomass, etc.) and water. For the 'output side' of material flow accounts (Table 1), one usually finds products (core products and by-products) and non-product outputs (waste, waste water and air emissions),

[4] Image and relationship costs are not intangible in themselves, but the direct benefits that result from such expenses often are: e.g. difficulty of assessing the satisfaction of clients or employees.

[5] One could argue that recent European directives (e.g. REACH) could significantly enlarge the scope of input-output flows of an environmental nature that firms could monitor.

which may or may not be sold. On both cases, information is recorded in kilograms, litters or kilowatt hours, as appropriate.

2.1.3 A limited understanding of 'environmental' performance or an underdeveloped tool?

Based on cost-efficient compliance with environmental regulation and self-imposed environmental policies, EMA is argued to support environmental protection by purposely targeting the simultaneous reduction of costs and environmental impacts (Savage and Jasch, 2005). To that end, EMA allows firms to develop and use environmental performance indicators (EPIs) which may be based solely on physical data sets or may combine monetary and physical data sets to create hybrid EPIs called eco-efficiency indicators[6]. In practice, the most tangible and important implications for firms implementing this tool are two-pronged:

1. Quantifying the monetary impact that external environmental pressures (taxes, norms, quotas, stakeholders' demands) have on the business, by differentiating transactions of an 'environmental' nature from others (e.g. end-of-pipe / waste and emissions control costs, including handling, treatment and disposal, and control-related regulatory compliance costs).
2. Putting a 'price' on non-product output (waste) by highlighting the purchase costs of materials converted into waste and emissions.

However, while a cost-control approach to environmental issues is legitimate from a business perspective, current EMA does neither fully quantify (a) business influence on BES, nor (b) BES influence on its activities and production processes. Given the difficulties of assessing most external costs (see aforementioned typology in sub-section 2.1.1), focus is on more efficient use of energy, water and materials in business processes. Costs and earnings pertaining to biodiversity and ecosystem services (BES) are either recorded as impact mitigation expenses (e.g. remediation / compensation costs related to offsetting damages with no or limited information in terms of ecological efficiency) or merely ignored (no identified transactions); though some important drivers of ecosystem change are increasingly recorded by environmental management systems (e.g. GHG and toxic gas emissions recorded as physical outputs). How far may EMA - *and its cost-control rationale* - be expanded so as to account for the nature and consequences of interactions between business and BES?

2.2 Using EMA to account for the interactions between firms and biodiversity: dairy farming as a case study

2.2.1 Defining biodiversity and ecosystem services: what interactions with businesses?

Biodiversity refers to the dynamics of interactions between organisms in environments subject to change. We speak of the fabric of the living world whose component parts are interdependent and co-evolving. Biodiversity constitutes the engine which drives the ecosystems of the biosphere and from which humans and firms derive 'free' ecosystem

[6] The concept of eco-efficiency links monetary and physical EMA for decision making in a systematic manner. An eco-efficiency indicator relates 'product or service value' in terms of turnover or profit to 'environmental influence' in terms of energy, materials and water consumption, as well as waste and emission in terms of volumes (Verfaillie and Bidwell, 2000).

service benefits[7]. It refers specifically to (a) the genetic diversity and variability within each species[8], (b) the diversity and variability of species and their forms of life and (c) the diversity, heterogeneity and variability of interactions between species and of the ecosystem structures, functions and processes directly or indirectly generated by living organisms.

As explained by Alain Pavé (2007), "*one of the fundamental characteristics of living systems is their capacity to organize themselves into increasingly complex nested structures: genomes, cells, organs, organisms, populations, communities and ecosystems*". Their connections and interactions can be presented as a hierarchy of living systems, with a qualitative shift as we move from biological systems to ecological ones, since components of ecological systems do not exhibit genetic coherence. While living systems are diversified, self-regulating and adaptive, randomness-generating mechanisms (e.g. genetic mixing, genomic sequence modifications, random gene expression during cell differentiation, finding a sexual partner and sexual reproduction for many species) are necessary for their survival and evolution.

The scientific issues around biodiversity are also economic, social and political issues, each stakeholder having its own perceptions and agenda with respect to (some) BES aspects. For an environmental NGO, biodiversity may relate to priceless life-forms that need to be protected, especially those which are rare, endangered or 'useful' (e.g. charismatic species for hunting, fishing or eco-tourism). From a business perspective, BES may be (Houdet 2008):

- A going concern issue (e.g. operational or image risks),
- A source of raw materials, assets, technologies and products,
- A source of revenues (e.g. sales of food products),
- Linked to private production costs (e.g. farming production costs), and
- Linked to social costs and business liabilities, both in terms of (possible) damages to BES and additional costs incurred by impacted human communities.

In other words, the interactions between business and BES are complex and evolving, as are business perceptions of them (Houdet et al., 2009). Figure 1 shows a simplified, general framework of interactions between BES and businesses, from the perspective of the business community. It comprises three interacting interfaces:

(Interface 1) The firm seeks to avoid biodiversity and ecosystem dis-services (e.g. weeds in farms – Zhang et al., 2007; pathogens for the meat-processing industry) and secure specific / tailored BES benefits (e.g. raw materials, water quantity and quality) by managing their source(s), delivery channel(s), and / or timing of delivery. To do so, there are various options available, including (a) securing property rights over uses of and / or access to BES (e.g. buying parts of a watershed to secure water supply and quality; Déprés et al., 2008), (b) entering into contractual agreements with other economic agents influencing BES benefiting it (e.g. payments for doing or not doing something such as paying farmers for specific agricultural practices; Déprés et al., 2008) and / or (c) purchasing imported 'artificial' alternatives (e.g. replacing ES linked to soil 'quality' by fertilizers bought from agri-business). These strategic and investment choices may generate BES externalities. For instance, option (c) often leads to biodiversity loss (*link with interface 3*).

(Interface 2) What is the business responsibility towards BES? Changing business perceptions, strategies, policies, routines, production processes, skills, extra- and intra-organizational norms, development and investment choices, as well as associated institutional

[7] Various definitions and typologies of ecosystem services have been proposed and no compromise has yet been reached (Fisher et al., 2009; MA 2005; Ruhl et al., 2007).

[8] Though humans, in all our cultural, linguistic and organizational diversity, belong to biodiversity (UNESCO 2008), we decide to exclude them from the scope of this article.

frameworks among other variables, all influence firms' choices and practices regarding BES (Houdet et al., 2009; *link with both interfaces 1 & 3*). How, to what extent and under what rationale can business account for the nature and consequences of their interactions with BES?

(Interface 3) The business has numerous direct and indirect influences on BES which may or may not contribute to its revenues (*link with interface 1*), notably externalities with respect to other economic agents, whether these influences relate to core business processes and modes of BES appropriation, changes in land use, land assets controlled, owned or managed, adjacent properties or livelihoods, the end-of-life of goods and services sold, or the strategic choices made which may influence the behavior of its suppliers (e.g. purchasing policy).

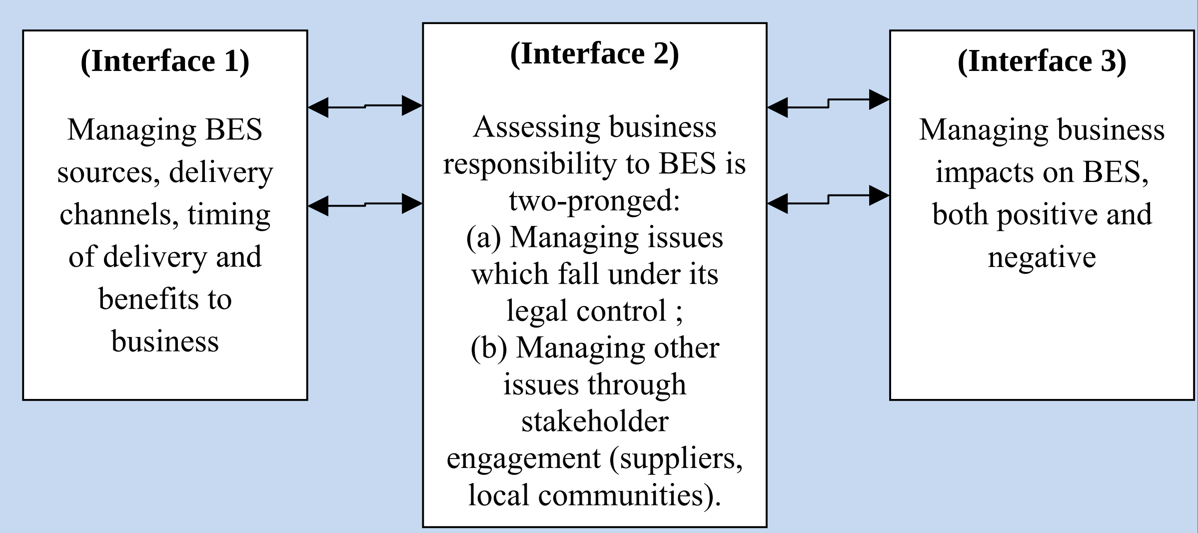

Figure 1: a simplified and general framework of interactions between businesses and BES.

2.2.2 Methodology and aims

In section 2, we attempt to assess whether (and how) EMA can help firms identify and account for the interactions between their business activities and biodiversity and ecosystem services (BES). This means asking questions such as:

- What influences BES have on business activity, whether positive or negative?
- Reciprocally, what influences, whether positive or negative, the business has on BES?
- What would be the appropriate indicators characterizing such interactions?
- What types of monetary information are involved for decision-making (costs and revenues)?

While attempting to address these, we choose to focus on the activities of a hypothetical dairy farm, an agro-ecosystem which produces 'raw milk'. There is a great diversity of modes of production linked to this type of business activity. Various management options are available to the farmer, notably in terms of stocking rate, cattle race selection, forage budgeting and crop rotation system, grazing patterns, use of fertilizers and waste management (FAO 2005). Previous environmental accounting studies involving farming activities have essentially focused on material (inorganic nutrients, pesticides), water and energy flows (e.g. Bechini and Castoldi, 2009; Breembroek et al., 1995; Lamberton 2000), besides expenses of an environmental nature (e.g. input expenses, waste and energy-related costs). We arbitrarily choose a simple production system:

- Livestock grazing on permanent pastures during a significant part of the year;
- Cattle feed resources during winter provided in part by forage produced on-farm;
- All cattle feed supplements are bought / imported;
- No hydroponic / greenhouse cropping is involved and no milk processing occurs on-farm.

By making use of this theoretical case study, we aim to provide preliminary conceptual elements of an accounting framework to be used by any type of business. Current limitations, challenges and research needs are also underlined. Given the nature of BES, we choose to break-down our analysis into four complementary stages that attempt to account for:

(a) Material flows of biodiversity (sub-section 2.2.3),
(b) Ecosystem services and benefits to business (sub-section 2.2.4),
(c) BES gain(s) and loss(es) caused by business activities (sub-section 2.2.5)and
(d) Interactions between firms and other agents with respect to BES change (sub-section 2.2.6).

2.2.3 Accounting for material flows of biodiversity

By material flows of biodiversity we mean all inputs and outputs linked to living systems which may be quantified in kilograms (kg), cubic meter (m^3) or similar 'physical' units, whether transformed or untransformed by human activities, resulting from present and past (e.g. petrol, gas, peat) ecosystem processes. Though they might be composed of biological elements (e.g. wood, leather), the component parts of machinery, buildings, vehicles and all similar assets are excluded from the analysis. We classify material flows of biodiversity into 4 categories, differentiated on the basis that they are either inputs or outputs and free or purchased: (1) purchased inputs, (2) 'free' inputs, (3) sold outputs, (4) unsold outputs / residues.

(1) **Purchased biodiversity inputs** may comprise (Table 2):

- **Untransformed biological materials (renewable resources)**: these purchased goods may be cultivated or harvested, may comprise a single or many species, and may include any bio-molecule (i.e. organic molecule produced by living organisms). Though they may be modified in appearance, their composition or component parts remain essentially the same.
- **Living organisms**: these relate to species which bear certain functional characteristics and which have been selected for specific business outcomes within the agro-ecosystem.
- **Transformed biological materials**: these purchased goods are produced by industrial processes and include biological materials (*both untransformed and engineered / synthetic bio-molecules as well as genetically modified organisms and component parts or extracts*) among various other ecosystem components (e.g. inorganic and mineral components). For instance, so-called 'natural products' of the pharmaceutical industry often belong to this category (EFPIA 2007).
- **Materials derived from transformed biological, non-renewable fossil resources**: these purchased goods are produced by industrial processes involving fossil materials derived from long-term biogeochemical processes, chiefly products derived from the transformation of crude oil.

Table 2: a typology of purchased biodiversity inputs for a dairy farm

Types of flow	Units	Data availability	Cost category
Purchased biodiversity inputs			
Untransformed biological materials (renewable resources) - Forage and supplementary feed: hay, silage, press cakes... - Untransformed fertilizers: composts, animal / plant manures, humic substances… - Seeds	Kg, ton or m^3, as appropriate, species name and geographic origin	Purchasing documents ; 'raw' materials for which most information should be readily available	Operating supplies and materials expenses
Living organisms - Auxiliary insects and micro-organisms (e.g. - Genetically unmodified seeds - Livestock	Kg, number of individuals, as appropriate, species name and geographic origin	Purchasing documents ; 'raw' materials for which most information should be readily available	Operating supplies and materials expenses
Materials derived from transformed biological, non-renewable fossil resources - Artificial fertilizers - Pesticides - Fuel	L, m^3 or kg, as appropriate for each component part, species name and geographic origin	Purchasing documents ; complete information may not be communicated by suppliers	Operating supplies and materials expenses
Transformed biological materials - Fertilizers including ingredients derived from living organisms (e.g. waste-water sludge transformed into pellets) - Pesticides including biological ingredients, derived from living organisms (e.g. plant oils, insect pheromones) - Transformed cattle feed: composite feed, proteins... - Pharmaceutical products, such anthelmintics, and vaccines (inoculated pathogens) - Genetically modified (GM) organisms, including livestock feed and crop seeds - Products containing GM ingredients	L / ml, kg / µg, or %, m^3 as appropriate for each component part, species name and geographic origin	Purchasing documents ; complete information may not be communicated by suppliers	Operating supplies and materials expenses

(2) '**Free' biodiversity inputs** comprise 2 major components: (a) **biological resources cultivated within the farm's agro-ecosystem** and (b) **auxiliary biodiversity co-evolving with the business activity**. These may be difficult to differentiate as auxiliary biodiversity is actively selected for by business routines and practices, *whether intentionally or not* and *whether consciously or not*; depending on the farmer's knowledge and perceptions (e.g. some key micro-organisms may be ignored or unknown).

- **Biological resources cultivated within the farm's agro-ecosystem** (Table 3): these material flows relate to biological products intentionally produced by the farm manager. They are critical to milk production processes but may not all be precisely traced and quantified (e.g. permanent pasture grasses eaten by livestock, though models may be used to estimate overall biomass production, especially for cultivated crops; FAO 2005).

Table 3: a typology of biological resources cultivated on a dairy farm

Types of flow	Units	Data availability	Cost category
Untransformed biological materials - Livestock raised for milk production - Forage crops, pasture (mix of species) - Organic fertilizers: manures, crop residues, composts... - Seeds produced for next year's harvest *Transformed biological materials* - Genetically modified species (seeds, crops)	Kg / ton (t), t / ha, number of units, as appropriate; species name	Should be quantified by the farmer (silage managed via GIS, CAP documents)	No direct costs ; farming practices influence their production (indirect costs such as wages and machinery capital / operating expenses)

- **Auxiliary / associated biodiversity co-evolving with the business activity**: this category relates to all biodiversity components living within the farm's agro-ecosystem and positively contributing to revenue generation (raw milk production in this case). Auxiliary biodiversity is directly linked to farm management practices and, hence, to most production costs. Complex interactions between organisms and their inorganic environments preclude us from determining any specific types of flows at the stage (*what would be the relevant flow units?*), though they may involve soil micro, meso and macro-organisms, birds, pollinators among others. On the other hand, not all biodiversity present within or adjacent to the dairy farm contributes positively to its production processes. ***This opens the door to questions pertaining to functional groups, ecosystem processes, (dis-)services and benefits, which will be analyzed in the next sub-section (2.2.4).***

(3) **Sold biodiversity outputs** (Table 4) for a dairy farm are relatively straightforward: various categories of raw milk and, potentially, some by-products of farming activity (e.g. forage surplus sold to other farmers). Though milk is classified as an untransformed product according to the EEC rule n°1898/87, it is noteworthy to mention that milk is a 'product' resulting from complex agro-ecosystem processes which involve a wide variety of transformed (e.g. fertilizers developed by the chemical industry, genetically modified ingredients) and untransformed (e.g. substances generated by interactions between auxiliary organisms), purchased and free biodiversity inputs. Accordingly, we argue that the classification of milk products should depend on what has been consumed to produce it (see recent development with respect to food labeling regarding genetically-modified organisms). This underlines the difficulty of quantifying all the ecosystem components of any product throughout their life-cycles. Ideally, accounting for material flows of biodiversity for each sold output would require data for each of the 'consumed' biodiversity inputs involved in its production, use and disposal (see sub-section 2.2.6 for further analysis).

Table 4: a typology of biodiversity outputs sold by a dairy farm

Types of flow	Units	Data availability	Revenue category
Transformed or untransformed biological materials, depending on what has been consumed to produce them - Principal product: raw milk (of varying quality for diverse purposes) - Co-product: forage	L, kg, and / or species name as appropriate; % weight / litter for each component parts	Sale and traceability documents	Sales
Living organisms as byproducts ; may be genetically modified or classified as transformed biological outputs if fed with transformed biological materials - Livestock - Seeds	Number of individuals; species name and geographic origin	Sale and traceability documents	Sales

(4) **Biodiversity residues** (unsold outputs; Table 5): residues may be classified into various types. According to the SEEA (2003), there may be solid and liquid waste, air emissions and water emissions (soluble chemical inputs). For this case study, we look at residues which are derived from the use, consumption and waste of material flows of biodiversity, including erosion-associated residues. These flows are readily associated with environmental impacts by public authorities (FAO 2005), so that farm environmental management systems are increasingly focusing on their control and reduction (statutory norms, Common Agricultural Policy - CAP, labeling for food – Moretto 2008; Tucker 2008; Gilbert and Bruszik, 2005). Quantifying them in physical terms is not always straightforward. A standard EMA approach would attempt to quantify the share of purchase materials converted into various types of residues and account for them as non-product outputs (NPO) at purchase value[9]. To minimize costs, assessments are often based on indirect measurements, results extrapolated from theoretical yields or punctual direct measurements (e.g. conversion factors for carbon accounting methodologies). For instance, nitrogen (N), phosphate (P) and potassium (K) concentrations are often used as indicators of the end-of-life of various types of inputs (fertilizers, compound feed; Breembroek et al., 1995).

[9] For instance, the FAO (2005) proposes the valuation of nutrient loss using the replacement cost method, arguing that depleted nutrients should be replaced as a means of conserving or restoring the quality or value of the soil to its former condition for future generations. Nutrients are considered to have an economic value equal to the market value of an equivalent amount of fertilizer. This economic value is then accounted for within integrated accounts as depreciation expenses of nutrients / allowance for nutrient replacement.

Table 5: identifying biodiversity resides of dairy farming

Types of flow	Units	Data availability	Cost category
Solid waste - Plant and animal residues, chemical waste	Kg	Highly variable, depending on legislation and environmental management system in place	Material purchase value of NPO, linked to operating expenses (waste management and disposal)
Liquid waste - Lost milk - Fertilizers and pesticides as dissipated inputs	L, kg / ha / year, % loss / concentration indicators, as appropriate	Highly variable, depending on legislation and environmental management system in place	Material purchase value of NPO, waste management and disposal costs
Air emissions - CO_2 - Acid substances (e.g. NH3) - Metallic (e.g. Ni) - Organic compounds (e.g. methane from livestock and biological decay)	Kg / ha / year, % loss / concentration indicators, as appropriate	Highly variable, depending on legislation and environmental management system in place	Management and disposal costs and taxes potentially, material purchase value of NPO
Water emissions - Remains and residues of fertilizers and pesticides used as inputs	Kg / ha / year, % loss / concentration indicators, as appropriate	Highly variable, depending on legislation and environmental management system in place	Management and disposal costs and taxes potentially, Material purchase value of NPO

This theoretical case study shows that a business can readily account for various material flows of biodiversity, especially purchased and sold biodiversity outputs[10]. This approach allows business to assess its **material dependence on material flows of biodiversity** (MFB)[11]. It falls within a standard cost-management approach to their use (i.e. minimizing non-product output). It also allows for differentiation between MFB which are under its direct legal control or responsibility and those managed through its supply chains and customers[12]: this provides some useful information regarding how the business secures MFB necessary to its production processes, whether using what is *produced within* / *derived from its land / ecosystem assets* or *importing* outputs *derived from* / *produced in outer-ecosystems*.

Our proposed typology of MFB could be tested on real case studies and be fine-tuned by applying it to other types of business activities within the same industry (i.e. agribusiness) or other industrial sectors (e.g. cosmetics, pharmaceuticals, retailing, building). Combining this MFB typology with the general input-output chart of accounts (Table 1) may constitute an important step towards accounting for all material ecosystem benefits to business (*Box 1*

[10] This is readily done by some organisations due to the nature of their business (e.g. close links between biological goods / ingredients and marketing), though other classification typologies may be used according to stakeholders' needs (e.g. cosmetics, food retailing).

[11] This would include biotechnologies and genetic resources in other business activities.

[12] Sold outputs may generate further consumption of material flows of biodiversity by their users (e.g. car engine conception predetermines user needs in terms of fuel consumption). This relates to a life-cycle approach to product conception and design.

presents a conventional approach to accounting for MFB loss at the cost of replacement of non-product output). To reach that aim, the challenge is two-pronged at this stage:

- Accounting for **material flows of biodiversity 'consumed' by production processes** for both **purchased inputs** – *i.e. materials consumed outside the dairy farm* - and **sold outputs** - *i.e. materials consumed within the dairy farm*. This means identifying and quantifying each input / output at each stage of co-evolving production and ecosystem processes (further analysis in sub-section 2.2.6).
- Accounting for **auxiliary / associated biodiversity co-evolving with the business activity** and for which there is **no direct cost** (i.e. no purchase; further analysis in sub-sections 2.2.4 and 2.2.5)[13].

Box 1: business account divisions and entities for material flows of biodiversity (MFB) using a conventional EMA approach focused on non-product output management
(modified from FAO 2005)

OPTION 1: INTEGRATED ACCOUNTING BY ADDING SATELLITE ACCOUNTS

Conventional business accounts
- Material input-output statement
- Balance sheet
- Operating statement (budget)
- Cash flow statement

Material flow accounts as satellite accounts
- Material accounts in physical terms, including MFB
- Material accounts in monetary terms, including MFB

OPTION 2: INTEGRATED ACCOUNTING BY NEW LINES ENTRIES *(e.g. depreciation expenses / allowance for replacements of non-product outputs, including that of MFB)*

Main accounts
- Material input-output statement, including MFB
- Integrated balance sheet
- Integrated operating statement (Budget)

Intermediate accounts
- Material flow asset accounts
- Conventional monetary accounts

NB: As previously argued, external environmental pressures with financial impacts on business activity, such as taxes and waste management costs, are included in conventional business accounts and can be differentiated from other transactions.

Though this work provides methodological clues to identify (a) what 'types' of MFB a dairy farm directly consumes, (b) how much of each it does consume (weight, volume) and

[13] This may be highly difficult for most business activities, except perhaps for ones which rely on individual species: e.g. accounting for the bacteria biomass on which a waste-water treatment plant relies for "free" water purification.

(c) at what cost[14], it fails to fully account for business interactions with ecosystems (next 2 sub-sections), notably its impacts on biodiversity and ecosystem services used by others (sub-section 2.2.5). Indeed, conventional EMA focuses on material residues of production processes, irrespective of whether derived from biodiversity inputs or not. Though waste and emissions are drivers of ecosystem change, they may or may not lead to BES loss. For instance, this may depend on whether nutrient concentration goes beyond specific thresholds (e.g. nitrogen in water bodies). Providing information about the component parts of a fertilizer (e.g. percentage of nitrogen) - *though highly useful for policy and management purposes* - does not tell us much about their geographical origin, the materials consumed to produce them and the consequences of their modes of production and / or appropriation, including the resulting direct and indirect biodiversity gain(s) or loss(es).

2.2.4 Accounting for ecosystem services and their benefits to business

The previous sub-section underlines that biodiversity plays a critical role in the production processes of a dairy farm: it influences agro-ecosystem processes, notably as components of material inputs (purchased biodiversity inputs), cultivated organisms and auxiliary / associated biodiversity. In addition, dairy farmers derive ecosystem service (ES) benefits from interacting organisms, ecosystem structures, functions and processes. A business accounting system which only accounts for the material flows of biodiversity[15] would fail to fully account for the interactions between business and ecosystems, hence this partial[16] attempt which aims to formalize a preliminary understanding of what an **accounting framework for ES *useful* to a business activity** (a dairy farm) would look like. To that end, the challenge is two-pronged:

- *How can business quantify the contribution of ES to their revenues?*
- *And reciprocally, how can business quantify their influence on desired ES?*

Figure 2 proposes a general understanding of interactions between farming practices, agro-biodiversity, ecosystem structures, functions, services and benefits to the dairy farmer. Farming practices directly influence agro-biodiversity (i.e. active selection processes which favors co-evolutionary dynamics with specific species), which encompasses both biodiversity components planned by the dairy farmer (e.g. livestock, crops ; depending on management of purchased inputs and spatial / temporal arrangements) and biodiversity components associated with the latter (Vandermeer and Perfecto, 1995), whether auxiliary to the business activity (e.g. crop pollinators) or not (e.g. pathogens, biological invasions; concept of ecosystem disservices or 'EDS'[17] - Zhang et al., 2007). Agro-biodiversity contributes to ecosystem functions (i.e. builds and maintains ecosystem structure: e.g. mosaic of habitats) and enables ecosystem dynamics (e.g. predator-prey relationships, growth and reproduction cycles) both of which, in turn, influence ES sources, provision timing, delivery channels, distance delivery, and delivery timing (Ruhl et al., 2007); and this positively or negatively from the farmer's

[14] If purchased or linked to indirect costs such as wages and capital expenses, as is the case for biological outputs cultivated within the farm's agro-ecosystem.
[15] A type of ES benefits: i.e. 'provision services' according to the Millennium Ecosystem Assessment (2005).
[16] Business' influences on biodiversity and ecosystem services will be discussed in the next sub-section 2.2.5.
[17] Ecosystem dis-services may be generated locally (e.g. crop loss due to pathogens / pests or competition between species for the same resources – weeds; Stoller et al., 1987) or regionally / globally (ES loss at the landscape level due to activities by other agents such as forest plantation programs that diminish water runoff / availability to downstream users). We may speak of a continuum of ecosystem services – disservices, contingent to the differentiated needs of users and associated thresholds between alternative states (e.g. Carpenter et al., 2002).

perspective[18]. Furthermore, according to Lavorel et al. (2008), ES linked to agricultural activities may be classified into three categories:

1. Input services, which include: (a) **resource input services** contributing to resource production and to physicochemical supports of agricultural production (e.g. soil structure and fertility) and (b) **input services of biotic regulation** which ensure the regulation of interactions between organisms, whether positive or negative to agriculture (e.g. pollination, protection of livestock's health, control of pathogens).
2. **Production services contributing to agricultural revenue**[19], which relate essentially to biomass production (vegetal, animal) generating sold outputs (e.g. milk) and co-products, in terms of *quantities*, *spatial* and *temporal variability / stability* as well as of *quality* of the outputs / products.
3. **Services produced outside of agricultural revenue** which include, for instance, the control of water quality, carbon sequestration or landscape aesthetical values (tourism).

ES may be *used directly (dynamics-based)* or *indirectly (structure-based)* by the dairy farmer (Costanza et al., 1997; Ruhl et al., 2007), who hence derives various *benefits* contributing to its business activities and revenue (category 1 and 2). In addition, services produced outside of agricultural revenue may benefit other economic agents (category 3), for instance local / adjacent communities or society at large (i.e. positive externalities).

According to Levin (1998), ecosystems are "*prototypical examples of complex adaptive systems*". Costanza (1996) explains that such systems are characterized by "(*1) strong, usually non-linear interactions among the parts, (2) complex feedbacks loops that make it difficult to distinguish cause from effect, (3) significant time and space lags; discontinuities, thresholds and limits, all resulting in (4) the inability to simply 'add up' or aggregate small-scale behaviors to arrive at large-scale results*". In other words, there are no direct, linear relationships between ecosystem functions, services and benefits, biodiversity and farming practices: these relationships are many-to-many, which renders complex the task of precisely understanding the role(s) played by biodiversity, whether favorable or unfavorable (e.g. weeds, pathogens) to the business activity. For instance, in the case of our theoretical dairy farm, soil fertility is an essential resource input ES critical to both permanent pastures and cultivated crops needed by livestock. More precisely, the diversity, abundance, assemblages and interactions of plant species, mycorrhizae, and other soil organisms influence organic matter (mineralization, decay) and nutrient (elementary transformation, solubilisation) dynamics (i.e. availability for plant uptake), which in turn influences both the quantity and quality of produced milk (Lavorel et al., 2008). Accordingly, biodiversity may be beneficial to soil fertility (and to other categories of agro-ecosystem services), but some of its components may also generate damages (e.g. unpalatable species invasion and their ensuing competition with palatable ones) or may not currently have any significant effect on a specific ES (i.e. highly uncommon and / or functionally redundant species).

The framework proposed in Figure 2 could be applied and adapted to other types of businesses (e.g. cosmetics, retailing). In the present context, it may help the dairy farmer assess (or better formalize its understanding of) the ecosystem services and associated biodiversity on which its operations (dairy farming) and sales (milk) directly and indirectly depend, including the delivery mechanisms from source(s) to final use(s) / benefit(s). Though benefits of some production services contributing to agricultural revenue may be readily accounted for by the dairy farmer (i.e. material inputs / outputs discussed in the previous sub-

[18] Off-farm functional (option / insurance value) and associated biodiversity may also play a role in ES benefits secured by the dairy farmer (Pascual and Perrings, 2007).

[19] These would include material flows of biodiversity, also classified as "provision services" by the Millennium Ecosystem Assessment (2005).

section), the assessment of the contribution of other types of ecosystem services to the farmer's revenue is far from straightforward. This requires the development and use of appropriate sets of indicators, including structural (indirect), taxonomic (direct), composite and / or single-parameter indicators (Levrel 2007). For each ecosystem service benefit, one would identify (and use) indicators of the ecosystem services, functions and structures involved, as well as of biodiversity components which build and enable them. Yet, such information is often unavailable and / or costly to obtain, or we may not know exactly what to look for. Even if beneficial effects of biodiversity are brought to the fore, these are rarely formulated in terms of *amplitude*, which would be more than necessary for an assessment of their usefulness to agricultural production (Lavorel et al., 2008). Lastly, ***off-farm biodiversity*** and ***sources of ES*** (e.g. water purification and flood mitigation ; Goldman et al., 2007) would play a major role in ***securing on-farm ES delivery***, hence the probable need for a landscape and regional approach for their management (i.e. an individual farm is situated within a matrix of interconnected ES 'providers' and users[20]; Ruhl et al., 2007).

From an EMA perspective, several important points need to be emphasized:

- First, we must emphasize the fact that **business benefits derived from ecosystem services are *not* based on monetary transactions[21]**. Indeed, no one pays ecosystems (or its component parts) for harvested fish species or the air humans breathe. We may pay other humans (*sole exception to our argument in the previous sentence*), whether individuals or groups of individuals represented by 'legal persons' (e.g. companies, partnerships, states), for the various rights attached directly or indirectly to the use of such ES benefits (e.g. markets for tradable CO_2 emission quotas, user fees for collecting firewood or for opening and running an open-pit mine and hence 'gaining access' to minerals derived from ecosystem processes over geologic time scales). With respect to dairy farming, purchased inputs - whether biological or not - merely refer to transactions meant to secure the use of *material ES benefits delivered elsewhere* and *imported* through *contractual agreements* with other economic agents. The monetary units associated with such transactions would correspond to the *costs borne by the contracting party* so as to make them available for sale – *in addition to a profit margin*. Otherwise, ES benefits derived from the agro-ecosystem managed by the dairy farmer are secured though *farming choices* and *practices,* and their *associated expenses*; including those linked to the purchase, use and management of farming inputs and those due to the management of the temporal and spatial arrangements of agro-biodiversity, both planned and associated.

[20] The delivery of ES benefits may be contingent on other ES whose maintenance depends on both (a) the practices of other agents and (b) the interactions between these agents and other ES.

[21] The focus is not on capturing the economic value of BES: EMA may help differentiate costs and revenues according to their 'environmental' nature or aim, in this case the nature and consequences of the underlying transactions and associated practices.

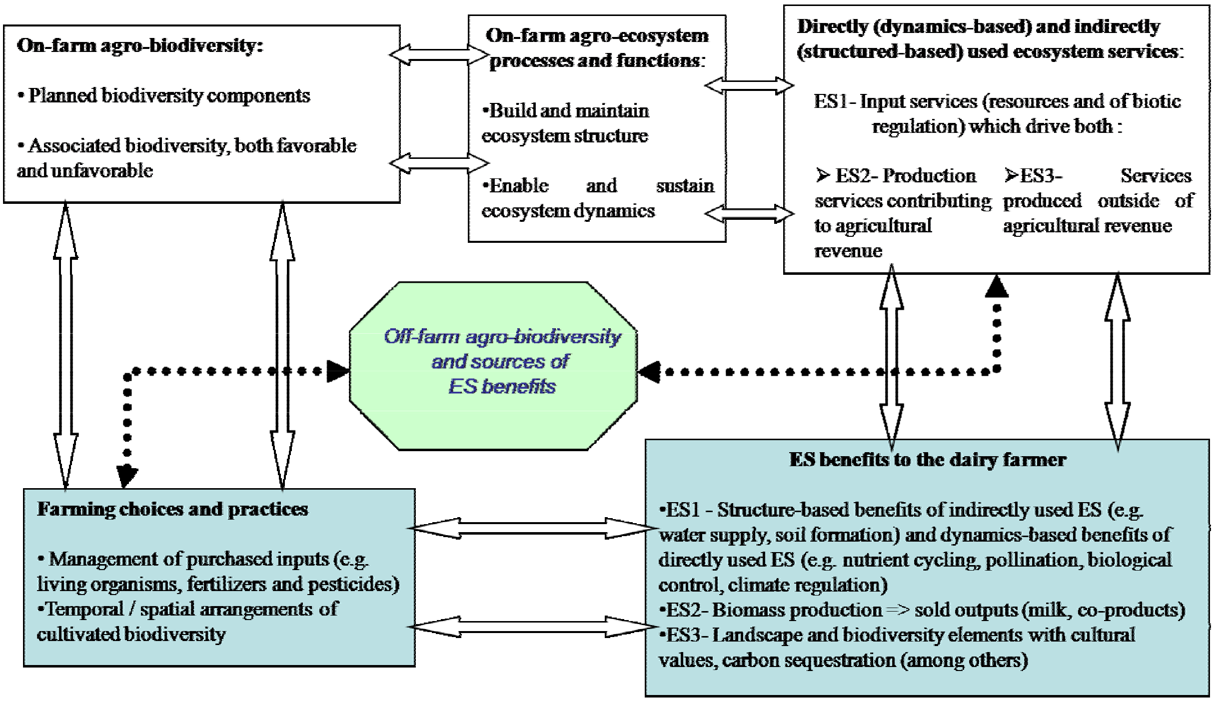

Figure 2: linking dairy farming practices with on-farm / off-farm agro-biodiversity, ecosystem structure, functions and processes, ecosystem services and ES benefits (modified from Costanza et al., 1997; Lavorel et al, 2008 ; Ruhl et al, 2007; Zhang et al., 2007). Note that arrows are bi-directional. For instance, agro-biodiversity of a specific agro-ecosystem is contingent to agro-ecosystem structures and dynamics (which they simultaneously build and enable) and will also influence farmer's choices and practices. Similarly, the latter are contingent, at least partially, to last year's and to forecasted ecosystem services benefits. Dotted lines exhibit bidirectional influences over which the farmer has no direct interest, control and / or responsibility.

- Secondly, land-use spatial and temporal patterns, production models (e.g. projected outputs, valuation), nutrient management, operating expenditures (materials, labor use, hire and maintenance of equipment, depreciation of dairy farming related assets), and investment choices (e.g. land 'improvement', equipment, construction) and sales / subsidies are **directly** and **indirectly linked** to the **management of ES benefits**, whether derived from the farm's agro-biodiversity, ecosystem functions and processes (*direct relationship with ecosystem services*), purchased from elsewhere (*indirect relationship; ES benefits - e.g. 'natural' fertilizers - delivered to other agents who chose to trade them with the dairy farmer*) and / or both. The second option is sought when the first is too costly and uncertain given production aims; the latter being 'chosen' and organized according to legal and financial incentive frameworks in place (e.g. Common Agricultural Policy's subsidy system in the EU)[22]. *Such trade-offs may fall within a standard EMA framework for assessing which costs and revenues are related to biodiversity and ecosystem services.* Using cost accounting techniques, one may able to *differentiate* the *direct* and *indirect costs* of *arbitrages* with respect to *alternative modes of ES benefit appropriation*, including *spatial / temporal trade-offs* (Box 2). Assigning cost categories to the management of a single ES may be relatively straightforward (e.g. Gonzalez and Houdet, 2009). However, expenses may influence various ES simultaneously, hence the need for multi-criteria accounting data differentiation.
- Thirdly, dairy farmers would logically gear their farm management towards choices and practices which **secure important ES benefits at the lowest possible costs**, while satisfying requirements for obtaining subsidies (e.g. conditionality of the CAP in the EU ;

[22] In fact, buying inputs produced elsewhere is actively promoted by most institutional frameworks governing farming activities worldwide (FAO 2005; Roger-Estrade et al., 2008).

Trommetter et al., 2008), and gaining access to markets for their agricultural production (i.e. milk quality standards / terms of reference). This may or may not favor biodiversity and local ES sources (within the agro-ecosystem or within its vicinity), as well as their provision timing, delivery channels and delivery timing. This will depend essentially on whether farmers have chosen or choose to replace diverse sets of interacting organisms, which are responsible for the delivery of on-farm production ES contributing to agricultural revenue, by purchased artificial inputs (i.e. biodiversity-poor intensive agricultural systems[23]; Pascual and Perrings, 2007). If they choose to favor on-farm functional diversity and their associated ecosystem services, these could be argued to become '*usual' functions* or *factors of farm production*.

- Fourthly, because they are few or no real opportunities for paid contractual agreements regarding farming practices already or potentially leading to ecosystem service delivery to other economic agents, dairy farmers would have **few (if no) incentive(s) to promote the agro-biodiversity linked to services produced outside of agricultural revenue**[24]. As argued by Roger-Estrade et al. (2008), factors playing a role in adopting farming practices favorable to biodiversity are numerous, variable and contextual to the business activity and to the socio-ecological system in which the latter takes place: they relate to *technical*, *economic*, *institutional* and ***psychological*** issues.
- Lastly, by combining the assessment of the functional roles played by agro-biodiversity with that of the influence of farming practices on the latter, farmers may readily compare alternative production choices or models with respect to functional agro-biodiversity (spatial and temporal ES trade-offs). This means developing an **integrated management information system** based on **indicators of interactions** (Levrel 2007), which would combine **monetary and physical accounting data** (sub-section 2.2.3) with **quantitative and qualitative indicators** of important variables identified at each step of framework proposed in Figure 2 (e.g. temporal and spatial information regarding diversity and abundance of functional biodiversity). Such sets of indicators may help farmers fine-tune their farm management system, notably helping them to evaluate the **costs of reaching chosen levels of ecosystem services *derived from his managed agro-ecosystem*** and / or ***neighbouring ones***[25], depending on the ES in question**,** whether voluntarily, in response to customers' demands (e.g. labels) and / or to satisfy potential public policies, regulations and / or incentive schemes. Though expected cost savings may be an attractive motive for reducing purchases of artificial inputs, the transactional basis (revenue structure) for agricultural revenue generation may need to evolve so as to compensate for possible concomitant reductions in agricultural production (livestock biomass, milk) and hence 'normal' revenues (sales, subsidies). Box 2 underlines accounting data requirements of a possible step-by-step process for managing ES benefits to a dairy-farming business.

[23] Intensifying some farming practices (e.g. use of fertilizers and pesticides, stocking rate) is correlated to reduced species richness and increased uniformity of species present for various groups of organisms as well as major changes in functional characteristics of remaining species (Lavorel et al., 2008).

[24] Natura 2000 contractual agreements in Europe can be, in some ways, an exception to this rule (Trommetter et al., 2008). Indeed, the influence of farming practices on agro-biodiversity is contingent to institutional frameworks (incentives, subsidies, regulations; Roger-Estrade et al., 2008).

[25] This will require cooperating with other landowners and users and possibly the participation of both independent organizations and governmental ones.

Box 2: managing ES benefits to business – the case of dairy farming: step-by-step approach and associated accounting data requirements

STEP 1 - Identifying / quantifying the relevant ecosystem service (ES) benefit(s) to business, in terms of desired:

As appropriate:
- 'Quality';
- 'Quantity';
- Provision / delivery channel(s), distance and timing.

STEP 2 - Developing an accounting / information management system for ecosystem service benefit(s):

Based on three possible modes of ES benefit(s) appropriation:
(a) If ES benefit derived on-farm, indicators would need to be developed for managing:
- The ecosystem service(s) contributing to this benefit : e.g. soil fertility contributes to the 'grazing quality' of permanent pastures and to the biomass / nutritive quality of cultivated crop outputs ;
- The associated agro-biodiversity (functional groups), agro-ecosystem structures, functions and processes / dynamics.

(b) If ES benefit(s) derived from surrounding ecosystems, the farmer may need to engage with land (ES sources) owners, managers and users to:
- Develop collective tools / indicators for managing them;
- Sign contractual / informal agreements to secure, share and / or pay the contracting party to manage ES benefits as desired.

(c) If ES benefit(s) secured through purchased artificial inputs, information should be easier to record; though this may go beyond the legal control or responsibility of the farmer (see sub-section 2.2.6)

STEP 3 – For each mode of ES benefit appropriation (step 2), assessing the associated:
- Agricultural production models and practices, including land-use pattern as well as fertilizer, pesticide, nutrient and sanitary management;
- Operating expenditures, and investments;
- Revenues (sales, subsidies).

STEP 4 - Data analysis for assessing the mode(s) of ES benefit appropriation and associated transactions:
- Expenses linked to each mode of benefit appropriation (see step 3);
- Revenues contingent to each mode of benefit appropriation.

Developing appropriate performance indicators (ratios) for **qualifying the type of business activity** based on its **mode of ES benefit(s) appropriation**: *e.g. expenses linked to ES benefit(s) derived on-farm / total expenses, subsidies linked to ES benefit(s) secured through purchased artificial inputs / total subsidies or total revenues.*

STEP 5 – Reframing business strategy (going back to step 1):

Based on current cost and revenue structure and its associated mode of ES benefit(s) appropriation, develop a short-to-long term business strategy with respect to the appropriation of ES benefit(s).

Through this theoretical case study, we seek to provide a clearer understanding of business arbitrages and associated information requirements with respect to ecosystem services that are useful to its production processes. This could be tested on other types of business activities which would imply varying modes of appropriation of ES benefits. Applying it to operating dairy farms may (a) raise farmers' awareness of the roles played by on-farm associated biodiversity in terms of ecosystem structures, functions and processes sustaining ES and (b) highlight alternative options for practices which favor them instead of relying on purchased artificial inputs usually correlated with the '*loss' of both on-farm input services* and *services produced outside of farming revenue*. To that end, we emphasize the need for more research into the mapping of ES (Goldman et al., 2007; Nelson et al., 2009; Ruhl et al., 2007; i.e. sources, delivery distance / channels and uses / users, their associated timing) and the development of operational sets of ES indicators (benefit quantitative / qualitative description, agro-biodiversity, ecosystem structures and dynamics involved), as part of a comprehensive agro-ecosystem management accounting system.

2.2.5 Accounting for BES gain(s) and loss(es)

In this sub-section, we attempt to discuss accounting for biodiversity and ecosystem services gain(s) and loss(es) linked to a business activity, from the perspectives of both ***direct*** and ***indirect impacts*** associated with (a) **material flows of biodiversity (MFB)** and (b) **business interactions with biodiversity and ecosystem services (BES)**. We do not seek to be comprehensive in our analysis of each approach but seek to underline their principles, advantages, complementarities and limitations. This partially falls within a *critical approach to EMA* (Cullen and Whelan, 2006; Milne 1996), as opposed to a conventional or 'private cost' approach used for sub-sections 2.2.3 and 2.2.4.

(a) Direct and indirect impacts associated with material flows of biodiversity (MFB)

EMA is highly useful to identify and quantify what MFB and other material flows (including residue outputs which may provide indirect measures of ecosystem change) are consumed by production processes. It provides the accounting data structure necessary to inform management and may be used to develop various indicators of:

- **Dependence on biodiversity material resources**: e.g. ratios of purchases for different categories of MFB over total purchases (measured in monetary and non-monetary units); purchases costs of MFB (globaly or for each type) consumed to produce a good over its selling price (per unit of goods sold or global sales) [26];
- **MFB use efficiency** (standard EMA performance indicators), which can be useful if (comparable) data sets are compared over time: these will help managers assess the efficiency of the production processes involving MFB.

Yet, these indicators will provide limited information to data users regarding the biodiversity loss(es) or gain(s) associated with consumed MFB. Various complimentary approaches need to be underlined:

- Managing **non-renewable biological / fossil resources** (e.g. fossil fuels) relates essentially to extracting / exploiting an *exhaustible resource* (optimal extraction rate; Hotelling 1931) and the direct and indirect (e.g. leakage) ecosystem impacts (positive and

[26] This type of information may be critical to access-and-benefit sharing issues which are currently relevant to several industries making use of genetic materials.

negative) associated with firms' modes of appropriation and production (e.g. spatial footprint of assets, including the loss of habitats / populations on-site and ecological connectedness at the landscape scale). With respect to the latter, various programs worldwide are ongoing so as to develop standards and markets for mitigating / offsetting biodiversity loss associated with *new development projects* or *changes in land-use* (e.g. BBOP 2009), with ecological equivalency methods at the heart of challenges and controversies (Chevassus-au-Louis et al., 2009; Dunford et al., 2004; Faber-Langendoen et al., 2008; Fennessy et al., 2007; Trommetter et al., 2008; US NOAA 1995).

- For **renewable biological resources**, including **living organisms**, challenges are associated with the management of their modes of appropriation (e.g. access and benefit sharing issues) and production (e.g. agricultural techniques) and their associated impacts on biodiversity and ecosystems, whether positive or negative. This may require the use of multiple, complementary tools. For instance, various standards (checklists, norms, labels) are dedicated, wholly or in part, to the 'sustainable' management or use of such resources. Firms may screen goods sold and suppliers according to the standards to which they adhere or which they respect. This may lead to better stewardship of ecosystems from which businesses derive MFB. For instance, purchased inputs may be labeled (e.g. FSC - forest management label promoted by the Forest Stewardship Council, MSC - Fishery management label promoted by the Marine Stewardship Council), or excluded from the portfolio of supplies on the basis that concerned species are red-listed by IUCN. Various organizations are also working towards the development of best practices standard for access and benefit-sharing for biotechnologies and genetic resources (SECO 2007). Changes in land-use so as to produce renewal biological resources may generate biodiversity loss, especially if it involves monocultures and artificial or impermeable infrastructures, and should theoretically be subject to environmental impact assessments combined with appropriate offset measures; similarly to what is required for the exploitation of non-renewable biological / fossil resources. A 'no net loss' approach is being promoted, notably by the International Association for Impact Assessment (IAIA 2005) and Business and Biodiversity Offset Program (BBOP 2009). IAIA's five-stage approach involves (a) avoiding irreversible losses of biodiversity (prevention), (b) seeking alternative solutions to minimize losses, (c) using mitigation to restore biodiversity, (d) compensating for residual, unavoidable loss by providing substitutes of at least similar biodiversity value, and (e) seeking opportunities for enhancement.

From this perspective, firms would be able ***to assess*** and ***differentiate the various costs of managing impacts on biodiversity which relate to their dependence on MFB*** (e.g. towards ratios of mitigation expenses over sales revenue contingent to MFB and / or purchase costs of MFB). These costs could be associated to the direct and indirect impacts on biodiversity, including that of MFB derived from species harvested from ecosystems (e.g. fisheries, medicinal plant components), and may involve strategic thinking with respect to modes of appropriation, production and innovation (Houdet 2008; Houdet et al., 2009). However, *(non-monetary) indicators of changes in biodiversity are still mostly lacking*. Those available often target indirect drivers of ecosystem change, or are merely incomplete in their coverage of business and biodiversity interactions. For instance, organic food labels prevent farmers from using 'artificial' fertilizers and pesticides. This may have positive impacts on some functional groups, including organisms auxiliary to farming activities (Burel et al., 2008). However, landscape heterogeneity (e.g. high densities of heterogeneous hedges), an aspect currently omitted by such labels, is the key to ensuring the viability of numerous species, especially which are mobile or require a diversity of habitats for their life-cycles (Burel et al., 2008; Holzschuh et al., 2007; van Elsen 2000). What's more, *a MFB approach tends to focus business attention on single species rather than on biodiversity* – that is the interactions between organisms within changing environments, hence the need to look more closely at the interactions between business and BES.

(b) Direct and indirect impacts of business interactions with biodiversity and ecosystem services

MFB relate to benefits derived from production services contributing to business revenue. How can we account for business interactions with other biodiversity elements and ecosystems services? Three complementary approaches, which may overlap in certain circumstances, are proposed[27]:

1. Direct and indirect, positive or negative impacts on biodiversity and ecosystem services (BES) associated with the modes of appropriation of ES benefits, including those of all (un)purchased inputs.
2. Direct and indirect, positive or negative impacts on BES associated with the use and management of controlled / owned land assets (and access to marine renewable and non-renewable resources), including changes in ecosystem use (e.g. from one form of land use to another).
3. Direct and indirect impacts on ***other biodiversity and ecosystem services (BES) users***, linked to business modes of appropriation, production and innovation, and thus to both preceding approaches.

For the **first approach**, major issues have already been partially underlined through the direct and indirect impacts of MFB. Besides, suppliers which produce / extract / exploit ecosystems and their resources will also be concerned by the other two levels of analysis. Implications from a product life cycle perspective will be addressed in the sub-section 2.2.6. Using the example of a theoretical dairy farm once more (Figure 3), the **second approach** would relate to the assessment of changes in BES on land assets managed by the business. This would involve developing sets of indicators for assessing the impacts of farming activities on agro-biodiversity, including functional biodiversity contributing to various ES and species and associations of organisms which do not play a significant functional role. This means data collecting and management that is relevant both spatially[28] and across time; the latter being particularly important for accounting for the biodiversity impacts of changes in farming models and associated patterns of land-use. Lastly, with respect to the **third approach**, the challenge is to develop indicators for the impacts that farming practices would have on ES used by other agents[29], for instance adjacent landowners or water users downstream of a river going though the dairy farm. In other words, approach 3 targets interactions between agents with respect to differing and potentially competing uses of biodiversity and ecosystem services. Potential agreements between them will be contingent on their legitimacy, negotiating capacity and their influence on / responsibility over variables determining ES benefit(s) delivery (e.g. ES source, delivery distance, channel and timing). From the perspective of the other agents, ES benefits they need or choose to secure may be favored or threatened by dairy farming practices, and may relate to production ES both

[27] This builds upon the simplified, general framework of interactions between BES and businesses, from the perspective of the business community, proposed in Figure 1.

[28] A landscape or regional approach may be necessary for many species with low-densities and / or with large and changing home-ranges, which means cooperation with economic agents, such as NGOs, for the use of appropriate sets of indicators.

[29] These agents may have direct and / or indirect interactions with the dairy farm. For instance, an agent which aims to secure specific ES benefits may be influenced by the changes in practices (with respect to associated ES) of a landowner, adjacent to the dairy farm, who is influenced himself by the actions of the latter with respect to other ES.

contributing to, and outside of, their *revenue structure*. For agents concerned by ES benefits such as landscape and biodiversity elements with cultural value(s), or specific levels of water quality, farming practices may have direct and indirect consequences which may or may not be easy to quantify.

According to the bibliographical review by Burel et al. (2008), intensifying agricultural practices can be correlated with both negative effects on species diversity for a large number of groups of organisms and significant modifications on functional characteristics of remaining species. Conversely, moderate levels of farming management can promote associated biodiversity. As previously argued, various factors may play a role in the adoption of farming practices favorable to biodiversity. From an EMA perspective, this would imply ***quantifying the farming practices*** and ***associated costs / revenues*** which lead to *biodiversity gain(s) or loss(es)*, which may lead to questions such as:

- At what costs can the dairy farmer achieve (a) differentiated biodiversity and (b) ecosystem services targets or levels, (c) for itself and (d) for identified stakeholders?
- Will cost savings in terms of concomitant reductions in purchases of inputs mitigate potential loss of 'normal' agricultural revenue?
- If not, how can the business secure other sources of revenue with respect to production ecosystem services out of conventional business revenue (e.g. contractual agreements between farmers and Vittel which involved both monetary transactions and in-kind payments; Déprés et al., 2008)?
- How can it secure concomitant insurance mechanisms (e.g. monetary or in-kind compensation measures) against failure during the transition from one system of practices to alternative one (e.g. agro-environmental measures; Richard and Trommetter, 2000)?

Accordingly, biodiversity loss(es) and gain(s) (change) may start to become part of the business plan of the dairy farmer. The key question is not whether firms consume too much of MFB but rather how do modes of appropriation, production and consumption directly and indirectly generate changes in BES, whether positive or negative. While accounting for MFB and ES benefits to business demonstrates business direct and indirect dependence on living systems (i.e. this amounts to **revenue generation based on specific components of biodiversity**), the nature of this dependence is likely to change rapidly (e.g. exhaustion of fossil fuels and its implications for all industries which depend on them). Indeed, we will be more than ever relying on biological renewable resources (e.g. agro-fuels based on crops or algae), which, as previously argued, have different implications in terms of BES management. While minimizing MFB consumption may be appropriate in some situations (e.g. reducing business dependence on fossil fuels, or crops that necessitate high levels of artificial inputs for growth), in others the challenge lies in *investing* in the *viable management of biodiversity and ecosystem services* (e.g. an ecosystem management approach to managing fisheries; Cury and Christensen, 2005) while *securing production outcomes* (e.g. agricultural commodities) and finding ***new sources of revenue*** **for practices favorable to biodiversity and ecosystem services used by others, locally, regionally and / or globally** (Pascual and Perrings, 2007; Swinton et al., 2007). Within the context of a dairy farm, this challenge[30] may be formulated as follows:

- Making use of ecosystem processes and biodiversity on the land assets the dairy farmer directly controls or owns, so as to minimize ES benefits secured through purchased inputs;
- Developing farming practices which minimize BES loss, which implies *playing with*

[30] Risk aversion may prevent changes in perceptions and practices, hence the need for sustained education and the development of 'appropriate' institutional and financing mechanisms (Trommetter et al., 2008).

the diversity, variability and heterogeneity of living systems (Houdet 2008; Houdet et al., 2009), and *securing remuneration for such practices*; for which various options have been proposed in the literature, including direct compensation payments, subsidies and payments for ecosystem services (Boody et al., 2005; Hackl 2007; Pascual and Perrings, 2007; Swinton et al., 2007). To be effective, the latter must be more lucrative than income sources linked to conventional practices (i.e. it may involve loosing traditional income sources, such as subsidies linked to high levels of agricultural outputs). Concomitant mechanisms making practices which generate negative BES outcomes more expansive should be considered.

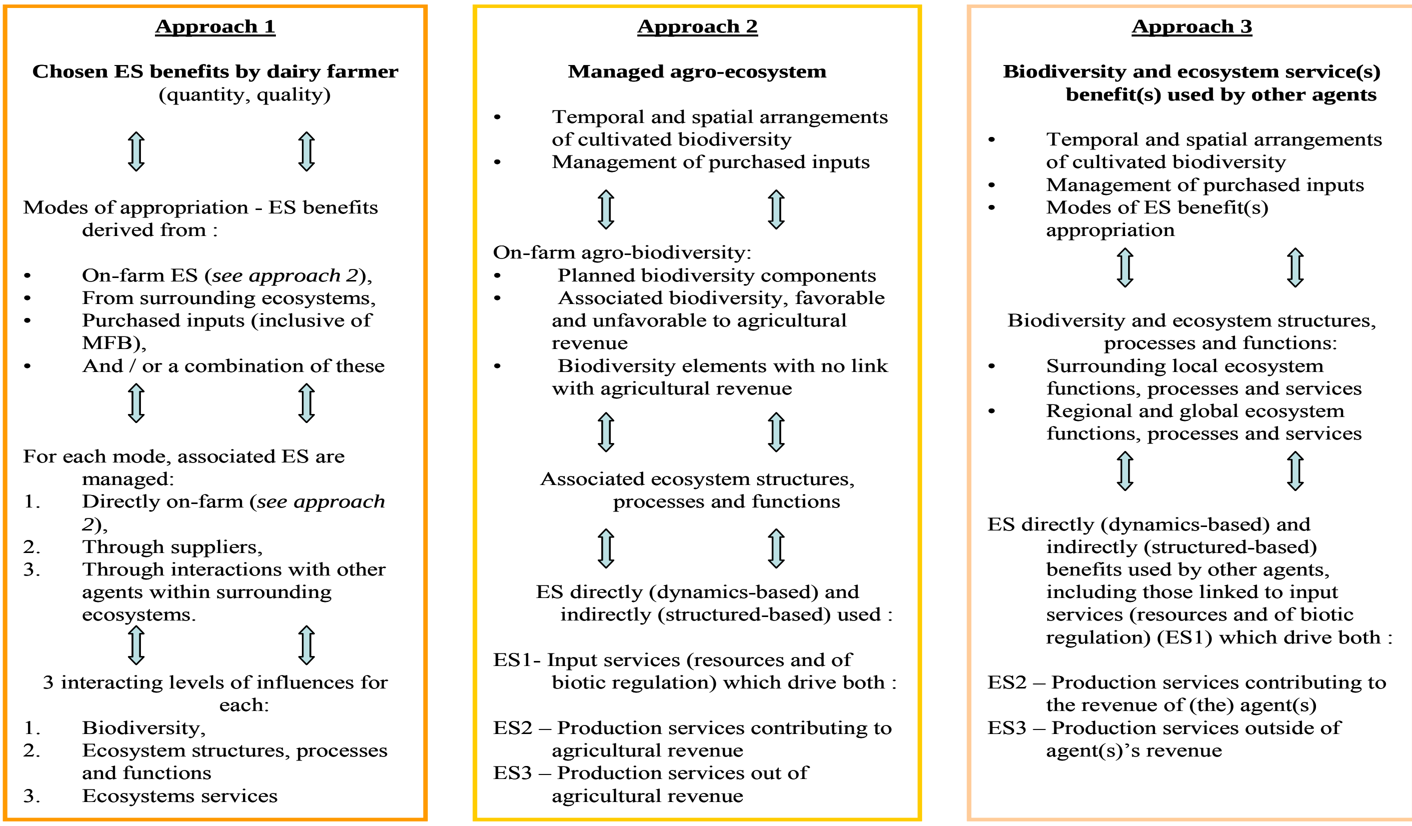

Figure 3: direct and indirect impacts of a dairy farmer's choices, contingent to revenue structure and associated institutional frameworks. Building upon the framework proposed in Figure 1, three complimentary approaches are proposed and may overlap at some points, which underlines the need for an integrated BES management accounting system. Arrows indicate bi-directional influences, which comprise both positive and negative impacts.

2.2.6 Accounting for interactions between firms and other agents with respect to changes in BES

The previous sub-section opens the door for further discussion with respect to business influence on and responsibility over biodiversity and ecosystem services at large, in other words beyond what the company needs for current production purposes; though new business opportunities may be linked to such issues (Bishop et al., 2008; Houdet 2008; Houdet et al., 2009). If we take the life-cycle of a dairy product such as cheese (Figure 4), accounting for BES loss(es) and gain(s) (or rather *changes in BES*) would require compiling data for each step of the product life-cycle, from the dairy farmer (and its suppliers) to the retailer. This builds upon the standard approach to Environmental Management Accounting (i.e. focused on a single organization and its environmental performance) towards fully accounting for changes in BES linked to the life-cycle of goods, services and (even) firms by means of standardized information exchanges between agents. Though suppliers / producers may be reluctant to provide detailed information on composition, origin and - especially - modes of appropriation and production linked to BES necessary to the production of their products, this life-cycle approach supports the need for a BES accounting system that agents can use throughout supply chains. This highlights the *interdependence of firms (e.g. between a major retailer or producer and its suppliers)* with respect to both *business dependence* and *business impacts on BES.*. This may lead firms to develop, collectively, **inter-firm accounting information systems** so as to address BES issues across the supply chain(s) involved.

Furthermore, complex interactions between economic agents arise from the diversity of (and potentially competing) uses of BES. These inevitably generate consequences on BES in return, in the form of both positive and negative externalities. Relationships between firms might hence pertain to **negotiations** regarding alternative uses and management of biodiversity and ecosystem services as well as alternative modes of securing ES benefits (aforementioned trade-offs); in other words unilateral and / or co-**arbitrages** with respect to the **destruction versus** the **creation / increased supply of ES** (Houdet et al., 2009). Beyond attempts to seek or secure paid contractual agreements for business practices already or potentially leading to specific ES benefits delivery, forward-thinking companies may work, both individually and collectively, on: (1) assessing the BES on which their operations and sales directly and indirectly depend, (2) finding the delivery mechanism(s) from source(s) to final benefit(s) / use(s), and (3) securing the latter, either by (a) directly negotiating with concerned agents, (b) lobbying for the development of 'appropriate' institutional and financing mechanisms or (c) searching for a cheaper artificial alternative (e.g. replacing ES linked to soil quality by fertilizers bought from agri-business). Within this context, there is limited incentive to develop inter-firm accounting information system: only option (b) would provide the legal basis for setting markets for BES and their associated accounting data sets (i.e. records of transactions such as ES involved, units used, amounts traded, associated property rights). Although its links with BES are most likely inconspicuous to firms, option (c) is commonplace nowadays and is linked to BES loss (from a 'green revolution' to a 'doubly green revolution'; Griffon 2006; Griffon and Weber, 1996), so that means may need to be found to reverse such trends, for instance through disclosure in annual reports and hybrid incentive – disincentive mechanisms.

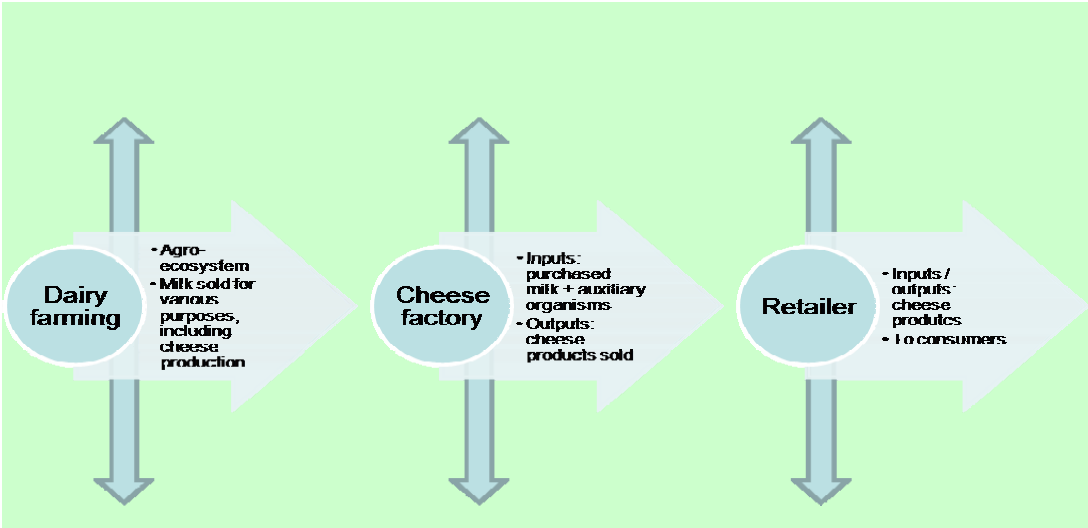

Figure 4: a product life-cycle approach to accounting for BES gain and loss for cheese products. Interactions with biodiversity and ecosystem services take place at each step of the supply chain. For instance, the cheese factory may derive ES benefits from various species of micro-organisms, including some involved in the control of pathogens and others which play key roles in the transformation of milk (Baroiller and Schmidt, 1990; Richard and Zadi, 1983). Arrows indicate interactions with BES and associated stakeholders for each business unit along the supply chain, highlighting the critical importance of Business – BES interaction indicators that are relevant from a landscape perspective. However, we emphasize that this case study is rather simple: for most agricultural commodities nowadays, most inputs at the farm level are imported goods produced elsewhere, each type of commodity with its own interaction dynamics with BES throughout its life-cycle.

This further suggests that, in terms of its structure, components and aims, a fully operational accounting system for BES needs to be both *adaptable to any business activity* and *compatible with the needs of users and stakeholders along supply chains*, for instance in terms of information system required to trace consumptions of MFB throughout the product life-cycle and that of its component parts[31]. This may have implications for product labeling, as well as the management of supply chains (e.g. car manufacturers, retailers), subsidiaries (from the perspective of a parent company) and / or asset portfolios (from the perspective of global finance, including portfolio managers, banks and insurance companies). Moreover, from an institutional perspective, such information systems may provide the basis for new arrangements combining the Polluter Pays Principle with the Beneficiary Pays Principle (Aretino et al., 2001; Houdet et al., 2009; Iftikhar et al., 2007; Trommetter et al., 2008).

[31] Considering the changes in the nature of MFB (e.g. milk transformed into cheese) and the complexity of interactions between businesses and BES across supply chains, individual transactions between firms may be an interesting cut-off point for accounting for such information.

3 – ACCOUNTING FOR BIODIVERSITY AND ECOSYSTEM SERVICES FOR REPORTING PURPOSES

In this section, we seek to account for changes in biodiversity and ecosystem services from a Corporate Social Responsibility (CSR) perspective. We shift our attention to the accounting information that firms provide to stakeholders, whether voluntarily or according to statutory standards. After introducing emerging corporate responsibilities with respect to BES (3.1.1) and presenting our methodology and aims (3.1.2), we discuss current environmental approaches to reporting (3.1.3), present our recommendations towards a Biodiversity Accountability Framework negotiated with stakeholders (3.1.4) and explore possible mechanisms for making the changes in accounting and reporting standards we call for financially viable for society (3.1.5).

3.1.1 Corporate Social Responsibility: emerging responsibilities with respect to BES

The corporate world has witnessed a proliferation of initiatives on responsible practices, ranging from specific managerial practices and systems to reporting standards, and falling within the scope of Corporate Social Responsibility (CSR) (Friedman and Miles, 2001; Heal 2008; The Economist 2008). Research into strategy and economics has long been interested on firms' responses to social and institutional pressures (Freeman, 1984; Schuman, 1995) and complementary theories have been put forward. Capron and Quairel-Lanoizelée (2007) argue that CSR initially falls within the framework of the Resource Dependency Theory initially developed by Pfeffer and Salancik (1978). A company needs to manage the requirements and claims of interest groups on which it relies for access to the resources necessary for carrying out its operations. Though Agency Theory enlarged to managers – stakeholders relationships[32] has allowed the re-conceptualization of corporate governance (Hill and Jones, 1982), Capron and Quairel-Lanoizelée (2007) further argue that at the heart of CSR lies Stakeholder Theory (Freeman 1984; Carroll 1989): stakeholders' perceptions of business activities underpin their legitimacy, CSR initiatives acting as brand insurance for instance (Wherther and Chandler, 2005).

Yet, CSR has no single commonly accepted definition that has implications for standards setting and governance (Moir 2001). It generally refers to business practices based on ethical values, notably with respect for social and ecological issues relevant to key stakeholders. McWilliams and Siegel (2001) posit that "*with so many conflicting goals and objectives, the definition of CSR is not always clear. (…) we define CSR as actions that appear to further some social good, beyond the interests of the firm and that which is required by law. This definition underscores that (…) CSR means going beyond obeying the law*." From a managerial perspective, this leads to risk management based on differentiated stakeholder engagement, according notably to their capacity to negotiate - which is linked to the degree of legitimacy of their criticism (e.g. in terms of expertise), to the nature of the problem or conflict (e.g. a crisis, which is media or emotionally driven), and to their economic and / or institutional power.

Though the literature suggests that good corporate governance is associated with increased transparency and lucid financial disclosures (Mallin 2002), the broad range of stakeholders that might be impacted by a company's activities makes the task of developing CSR standards fairly daunting (Bhimani and Soonawalla, 2005). Financial reporting has traditionally been the domain of national standard setting agencies, with the International

[32] Pressures on managers may emerge from customers, employees, suppliers, community groups, governments, and some stockholders, especially institutional shareholders. These groups are not mutually exclusive.

Accounting Standards Board (IASB) providing guidelines and standards that are adopted by a growing number of countries[33]. Yet, corporate responsibilities in terms of compliance with external financial reporting standards represent only one part of the spectrum of broader organizational reporting concerns. Bhimani and Soonawalla (2005) hence posit that there is a "*notional continuum for locating corporate financial reporting (CFR) and corporate governance (CG) responsibilities alongside potential corporate social responsibility (CSR) reporting and stakeholder value creation (SVC) requirements*". One may question whether ongoing changes in stakeholders' needs and ensuing pressures will reduce the gap between the two ends of the continuum, for instance with institutional mechanisms (new modes of regulation) in place to ensure that corporate performance assessments, inclusive of BES issues, rely on a diversity of values shared by all stakeholders.

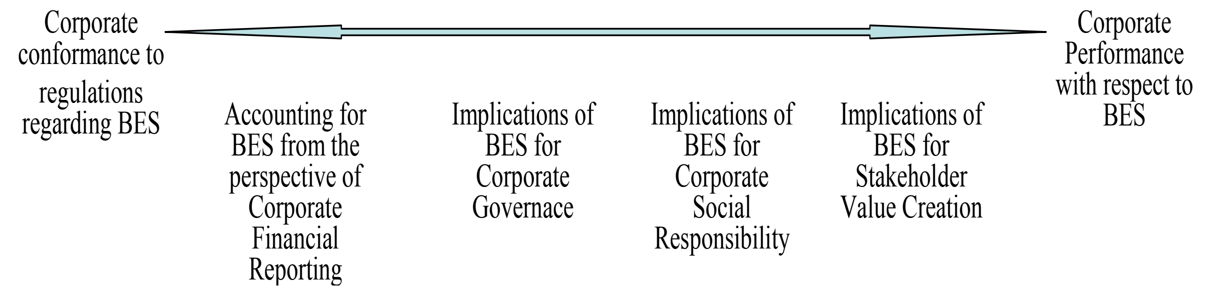

Figure 5*: the Corporate Responsibilities Continuum with respect to biodiversity and ecosystems services (adapted from Bhimani and Soonawalla, 2005). The interactions between business and BES are particularly diverse and complex (Houdet 2008; MA 2005). Each step along this continuum covers, by itself, an increasing range of issues regarding the interactions of the business entity with its stakeholders.*

Ecological issues have become prominent CSR issues: they are of increasing concern to citizens, employees, governmental and non-profit organizations and leaders, among other stakeholders, in most countries around the world. Often defined as the duty to take into account the ecological implications of the company's operations, products and facilities, corporate environmental responsibility is no longer a luxury but a requirement for many companies (some aspects of it at least)[34]. Historically, the focus has been on minimizing waste and pollutants, maximizing the efficiency and productivity of resources purchased or used, and minimizing practices that might adversely affect the 'natural environment'; the latter concept often being unclear in both its nature and scope for business (Bazin 2009; Houdet 2008). As argued previously (see sub-section 2.2.1 and Figure 1), this has significantly evolved with recent increases in social and institutional pressures relating to interactions between businesses and BES (Grant et al., 2008; Hanson et al., 2008; Houdet 2008; Houdet et al., 2009; MA 2005). Figure 5 (see above) presents a Corporate Responsibilities Continuum with respect to biodiversity and ecosystems services, from conformance to regulations to

[33] International Financial Reporting Standards (IFRS) are under increasing criticism with respect to their focus on 'fair value' (Capron et al., 2006; Colasse 2007), which discards a fundamental principle underlying accounting: the principle of prudence, which forbids statements of potential profits and prescribes disclosures of potential losses (Richard and Collette, 2008).

[34] For instance, for public companies listed on the Paris stock exchange, the New Economic Regulation (NRE) law of 2001 states, among other requirements, that measures put in place so as to limit damages or threats to biological equilibrium, natural habitats, and protected species must be disclosed (Art. 148-3).

corporate performance. From the viewpoint of corporate responsibility to stakeholders, it highlights the diversity of approaches that could be explored towards fully integrating biodiversity and ecosystem services (BES) into business strategies and practices.

3.1.2 Methodology and aims

> ''*A society's system of Values is its system for ordering the universe, the world, objects, beings and the relationships between beings and objects. This overarching typology, unique to each culture, provides the reference system governing the views and attitudes of individuals and groups in the society. Honesty, honour, fidelity, homeland, compassion, as well as the flag and the constitution, are Values in this anthropological sense. These Values cannot be sold, given away, lent, or exchanged: they can only be shared. Values in this sense cannot be expressed in terms of willingness-to-pay: these Values are priceless.*" Jacques Weber 2002, p.10.

In this section, we seek to analyze how our approach to accounting for BES from a managerial perspective (section 2) may be used for reporting purposes. We do not attempt to investigate all the possibilities of analysis offered by the Corporate Responsibilities Continuum with respect to biodiversity and ecosystems services presented in Figure 5 but choose to focus on the implications of our work presented in the previous section for corporate performance assessment (though it has inevitable implications for each step along this continuum). We posit, as an underlying rationale, that corporate performance assessments, *inclusive of BES issues*, must reflect *values 'shared'*[35] *by all stakeholders of the reporting entity*, especially those most affected by changes in BES. Yet, 'tools' used by different communities of practice, from management and financial accounting to CSR reporting and ecosystem accounting, do not seem to converge. How might we rigorously assess corporate performance with respect to BES? We first analyze (sub-section 3.1.3) the reporting implications of existing environmental accounting approaches. Though we refer to various 'green accounting' methodologies, we do not provide a comprehensive review of available tools[36], whether monetary or non-monetary in nature. By subsequently presenting (sub-section 3.1.4) the underlying principles and structural components of a Biodiversity Accountability Framework (BAF; Houdet 2008), we suggest the need for changes in corporate accounting and reporting standards towards integrating both financial and BES data sets. The accelerating biodiversity crisis, associated with the deep changes in stakeholders' informational needs[37], calls for questioning both the scope and the nature of the information reporting tools convey to stakeholders. Since implications for firms would go beyond changes in business information systems and accounting practices, we also suggest (sub-section 3.1.5) possible avenues so as to make the associated technological, organizational and institutional innovations financially viable.

[35] Our understanding of this term may be understood by referring to the citation at the beginning of this sub-section.
[36] See Richard (2009) for a classification of 'green accounting' methodologies and Milne (1996) for an analysis of the links between the concept of sustainability and (management) accounting.
[37] Partially in response to the current financial, economic and social crisis.

3.1.3 Environmental reporting: from financial data differentiation to the inclusion of ecological externalities?

As argued by Jasch (2003), in contrast to cost (or management) accounting, financial accounting is "*mainly designed to satisfy the information needs of external shareholders and financial authorities, both of whom have a strong economic interest in standardized comparable data and in receiving 'true' and 'fair' information about the actual economic performance of the company. Therefore, financial accounting and reporting are being dealt with in national laws and international accounting standards*". The aim is arguably to reduce the principal-agent problem by measuring and monitoring corporate performance and reporting the results to financial information users (Jensen and Meckling, 1976). As argued by Colasse (2007), financial accounting is simultaneously (a) an information system, (b) an instrument of business modeling (e.g. the basis for differentiated business performance assessments according to the needs of stakeholders) and (c) a social and organizational practice, contingent notably to (changes in) accounting standards and the dynamics of interactions between the reporting entity and its stakeholders.

In modern accrual accounting, assets can be defined as the future economic benefits controlled by a legal entity, resulting from past transactions or events (Deegan 2005; Trotman and Gibbins, 2003). They correspond to the various 'uses' of business 'resources' (liabilities + owner's equity) so as to sell goods and / or provide services, and are usually ranked in descending order of liquidity on balance sheets. Current assets, such as cash, receivables and inventory, are distinguished from fixed or long-term assets, such as buildings, financial holdings and intangibles. An asset is (supposedly) recognized only if the financial entity has control over the item in question, if its value can be accurately estimated and if its future economic benefits are likely to materialize. Liabilities, in turn, can be defined as sacrifices of future economic benefits (cash payments, transfer or use of assets, provisions) which the business is obliged to make to others in the present, as a result of past transactions or events (Deegan 2005; Trotman and Gibbins, 2003). Like assets, liabilities may be current or long-term, depending mainly on the repayment schedule of these future sacrifices (payables, loans, provisions). A liability is (supposedly) recognized only if its value can be accurately estimated and if its future economic sacrifices are likely to materialize (though provisions, by definition, are only *probable*). Along with its liabilities, the business has other types of 'resources' in the form of share capital issued, reserves (cumulated earnings) and earnings (obtained from the annual Profit & Loss Statement or Statement of Financial Performance: earnings = net income - dividends). These constitute the shareholders' or owner's equity, in other words the obligations to third parties which may or may not require an outflow of resources. Liabilities and owner's equity make up the 'resources' necessary for the acquisition of assets[38].

Conventional environmental financial accounting falls within the framework of modern accrual accounting and its associated financial reports. It deals with *differentiating* financial accounting information relating to environmental issues: i.e. accounting entries with a direct (present or future) financial 'impact' on the reporting entity ('environmental' expenses, liabilities, revenues and assets). While environmental revenues and expenses[39] fall, undifferentiated, within Statements of Financial Performance, environmental assets and liabilities are logically included, undifferentiated, within the Statement of Financial Position:

[38] By convention, on a Balance Sheet or Statement of Financial Position, assets = liabilities + owner's equity.

[39] This draws upon environmental management (EAM) accounting tools and providing performance indicators of eco-efficiency– see sub-section 2.1.3.

both *may be clearly identified* within notes to the financial statements (or within extra-financial or CSR reports). Beyond common environmental expenses and liabilities (e.g. pollution prevention, recycling, energy usage, cleaning-up of polluted sites, management and disposal of waste and hazardous materials, management of time-limited facilities whose renewal requires governmental authorization, or liability for goods and materials which have reached their end-of-life; Crédit Agricole Chevreux 2006), relatively innovative (and recent) financial accounting entries of an 'environmental nature' may involve (a) a loss or gain in asset value (e.g. loss in land value due to a pollution event) and (b) new types of assets (e.g. GHG emissions quotas as immaterial assets).

Because it is only concerned with 'internal'[40] environmental costs / revenues, conventional environmental financial accounting[41] fails to account for corporate ecological externalities (Milne 1996), whether positive or negative. Merely disclosing environmental expenditures gives neither indication of the efficiency of the company's environmental performance nor evidence of the benefits accruing to society (Huizing and Dekker, 1992; Richard 2009). This amounts to "*false environmental accounting*" in the words of Richard and Collette (2008; p.250). According to Milne (1996), the narrow focus on market-based transactions of financial accounting is due to both the lack of social and environmental information relevant to decision makers and the choices of the latter to exclude (or not to seek out) such information because they consider it too costly to gather and process and / or because they do not perceive its relevance to decision-making. Given new stakeholders' informational needs however, as aforementioned, several authors have proposed to foster the inclusion of externalities (inclusive of those involving BES) into financial statements (and / or their associated notes), for instance those associated with material expenses, tangible assets and intangible ones; towards assessing the full costs of business activities, in reference notably to 'total impact accounting' by Mathews (1984) and the use of non-market valuation techniques[42] to capture corporate environmental impacts (Milne 1991).

Increasing reporting of contingent liabilities is, at best, a first step from this perspective. According to Milne (1996; p.145), "*much more radical departures from the traditional accounting model are required if the full costs of resource consumption, as opposed to the costs of purchasing resources, are to be recorded*". Accountants would require *legitimate*[43] results from relevant cost-benefit analyses (CBA) involving the direct and indirect externalities associated with business activities (e.g. fixed assets); the full costs of resource consumption being only one part of the 'big picture'. For instance, the 1990 environmental report of the Dutch computer software company BSO/Origin provides some clues of what might be done using this approach. Chosen environmental accounts cover several types of residual (water, air and waste) emissions[44] (CO_2, NO_x, SO_2), as well various

[40] External costs (externalities) are excluded from conventional financial accounting because they involve sacrifices of future economic benefits the reporting entity is not obliged to make to others in the present (see sub-section 2.1.1).

[41] According to Jacques Richard's environmental accounting classification system (Richard 2009), conventional environmental financial accounting belongs to the 'traditional private accounting' category.

[42] According to de Groot et al. (2002), valuation techniques may be grouped into four types: (a) direct market valuation, (b) indirect market valuation (avoided cost, replacement cost, factor income, travel cost, hedonic pricing), (c) contingent valuation and (d) group valuation. Non-market valuation techniques comprise the last three types.

[43] The use of study results needs to be based on consensus with stakeholders, including scientists and local communities.

[44] BSO/Origin has discriminated between the direct and indirect impacts of its activities, the latter including both upstream (impacts of suppliers) and downstream (impacts linked to the uses and disposal of goods sold) effects if we take the perspective of the life cycle of goods sold. Only direct impacts are accounted for (direct pollution

aspects of the business activity (energy consumption, pollution generated by cars, incineration plants, sewage treatments) (Huizing and Dekker, 1992): the challenge was to convert 'physical' measurements – *which may be particularly difficult in itself given the nature of externalities and the spatial / temporal scope of analysis* – into monetary units using non-market valuation tools. What's more, these environmental monetary accounts have been used to calculate a 'net value added' (i.e. the difference between value added and value lost)[45] so as to represent "*BSO/Origin's net return after taking into account its ecological effects*" (Huizing and Dekker, 1992). According to Richard (2009), this amounts to a concept of business performance targeting stakeholders, beyond the interests of stockholders. Yet, one may question the practical implications of such an approach. Alternatively, what if 'value lost' was deduced from conventional net profit as proposed by Richard and Collette (2008)? This would have influenced the dividend-payout ratio[46] and, most likely, next year's environmental expenditures and investments (e.g. so as to mitigate future 'value lost' from a shareholders' perspective). Though no real transactions are underlying BSO/Origin's 'value lost', this may change as soon as the associated accounting entry - a form of 'debt to nature' - suits the definition criteria of a liability (e.g. liability contingent to future collective decision-making with respect to the externality at stake), though one question would remain unanswered: "*To whom should the firm pay for its externalities?*" (Richard and Collette, 2008). Provided 'double counting' issues are addressed, these alternative approaches to valuing (and accounting for) business direct and indirect externalities, applied to all transactions between firms, nationally and across international borders, would provide a completely different picture of financial reports[47] (Richard 2009; Weber and Erhard, 2009); with direct links with initiatives aiming at 'greening' national accounts (O'Connor and Steurer, 2006; O'Connor et al., 2001), notably the System of Environmental and Economic Accounts or SEEA (Hecht 2005; SEEA 2003; Smith 2007; Weber 2007).

Yet, despite their increasing recognition that present accounting systems need to change (Milne 1996; Houdet 2008), why have firms and professional accountancy bodies been so reluctant to internalize externalities into financial statements through non-market valuation techniques? As argued by Norgaard (1992; p.94), "*while internalizing externalities certainly increases efficiency, it need not increase sustainability*". We may mention several reasons for this inertia (non-exhaustive list):

- The *selection of environmental financial data* is often *arbitrary*, both in terms of the scope of externalities covered (what about indirect impacts?) and the choice of valuation techniques used (Huizing and Dekker, 1992; Milne 1996; Richard 2009).
- The *lack* of *reliable estimates of externalities* due to a combination of factors, including (a) methodological challenges, especially in terms of the valuation of biodiversity and ecosystem services, (b) controversies with respect to the underlying assumptions of valuation techniques used for CBA (discount rate, sample representativeness, neutrality of questions asked) and (c) prohibitive costs of undertaking appropriate assessments; this despite

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and consequences of its energy consumption), except from some upstream effects of the firm's energy consumption.

[45] For BSO/Origin, net value added amounts to the difference between value added and value lost (Huizing and Dekker, 1992). Value added is usually defined as the sum of personal costs, depreciation, changes in provision, financial expenses, taxes and net income. Value lost comprises the costs of the firm's externalities less its expenses on mitigating its impacts.

[46] Dividend Payout Ratio = Dividend per Equity Share / Earnings per Share.

[47] Efforts up to now have largely focused on negative externalities. One could argue that positive externalities, notably business practices that favor ecosystem services used by others, and which are not remunerated, could also be included for a more 'complete' approach to accounting within the scope of CSR. This opens the door to payments for ecosystem services associated with new revenues and assets (Houdet et al., 2009).

numerous attempts, based on complementary valuation methodologies, to quantify financially ('monetarize') known externalities during the past decades (Braat and ten Brick, 2008; Chevassus-au-Louis et al., 2009; Houdet et al., 2009; Milne 1996; Nelson et al., 2009).

- The *lack* of *independent verification mechanisms* (veracity of information communicated?) and *consensual* (collectively-agreed by all) *standards of ecological performance* against which the firm may compare its results. Several authors emphasize the importance of non-financial compliance-with-standards (Gray et al., 1987; Huizing and Dekker 1992; Mile 1996; Richard 2009). Because they are defined outside of the reporting entity (partly from law and partly from other sources), such standards may be legitimately used as 'yardsticks' to judge the results of the organization's activities; though this leaves unanswered the question of the most 'appropriate' combination of institutions that would be authoritative over the issues at stake.
- The ***impossibility*** of ***financially quantifying*** *all the company's ecological effects* is due to what O'Connor et al. (2001) call the *monetization frontier*. This latter concept refers to the variation in our capacity to put monetary values on non-marketed ecosystem functions and services according to the importance or scale of the issue at stake[48] and the type of values involved[49]. This calls for assessing relevant constraints on economic activities based on socio-ecological information from long-term and systematic ecosystem monitoring at all relevant spatial and temporal scales (Milne 1996; Weber 2007), which, consequently, seriously questions the validity of project-based assessments to account for sustainability (assumption of independence of economic activities or projects, inappropriate time and space boundaries - Cocklin et al., 1992; Odum's "*tyranny of small decisions*" – Odum 1982).
- Last, but not least, the *lack of coherent and replicable framework to account for the interactions between business and ecosystems* (Houdet 2008), with up to recently an almost exclusive *accounting focus* on *negative* impacts of *past events* or *activities* (Houdet et al., 2009; Milne 1996; Stone 1994), hence discarding firms' dependence on BES (Hanson et al., 2008; MA 2005) and the *nature* of *their dynamics of interactions with living systems* (Houdet 2008; Houdet et al., 2009). We hope to have contributed, as modestly as it may be, to the resolution of this ongoing issue via section 2 of this article.

Arguably partly in response to these limitations and challenges, alternative non-monetary 'green accounting' methodologies have been developed, independently and with no direct link with conventional financial accounting standards and practices. One major stream is based on principles of strong sustainability which refuse any substitutability between different forms of capital (e.g. incommensurability of biodiversity and ecosystems; Daily 1991; Godard 1995; Pearce et al., 1990; Rees and Wackernagel, 1999): we may notably mention works pertaining to the concepts of ecological footprints - bio-capacity accounts[50]

[48] Underlying this argument is the recognition of cumulative ecological damages as well as ecosystem responses which may be non-linear, discontinuous, synergistic and subject to thresholds (Costanza, 1996; Holling and Gunderson, 2002; Ruhl et al., 2007).

[49] The total economic value of biodiversity, inclusive of ecosystem services, is traditionally divided into its use values (direct use value, indirect use value, option value) and non-use values (existence value and bequest value), with a gradient of decreasing tangibility as one moves from direct use values to existence values (Barbier, 1989; Chevassus-au-Louis et al., 2009; Freeman, 1993; O'Connor and Steurer, 2006; Pearce and Turner, 1989). Chevassus-au-Louis et al. (2009) further argue that capturing the economic value of biodiversity is only rigorous for 'ordinary biodiversity', and this through the economic evaluation of ecosystem services.

[50] Ecological Footprint accounts document how much of the annual regenerative capacity of the biosphere, expressed in mutually exclusive hectares of biologically productive land or sea area, is required to renew the resource throughput of a defined population in a given year; with the prevailing technology and resource management of that year (Wackernagel et al., 2005). This approach has been criticized for several reasons with respect to the units, weightings, calculation methods, scope and scales used (Bergh et al., 1999; Piguet et al.,

(Monfreda et al., 2004; Wackernagel et al., 2005) and of Critical Natural Capital[51] (Brand 2009; Chiesura and de Groot, 2003; Deutsch et al., 2003; Douguet and O'Connor, 2003; Ekins et al., 2003); with the first one having been applied to organizations (i.e. number of hectares needed to sustain its activities) and the second one targeting a broader regional / national approach to ecosystem and socio-economic planning (from the perspective of various interest groups in interaction, especially public authorities). On the other hand, a *statistical stream* is focused heavily on very specific performance (percentage of business units with an operational environmental management system) and 'physical' indicators (e.g. carbon footprint, waste, energy and water consumption, air and water emissions) (Richard 2009). Linked to firms' extra-financial reporting, it falls under a broader CSR agenda (inclusive of social issues and ethics) which seeks to legitimate management decisions and actions through a concise set of core Key Performance Indicators (KPI) targeting stakeholders (Bebbington et al., 2004). Implemented essentially on the basis of standards produced by the Global Reporting Initiative (GRI 2006), this approach has been criticized for various reasons (Moneva et al., 2006), notably because it is tailored to the needs of 'Global Finance' and major business lobbies (Larrinaga and Bebbington, 2001; Owen et al., 1997) and for the lack of proof of stakeholder value creation, especially from a global performance perspective (some indicators may reveal significant improvements while others may underline sustained failures or mere inaction; Richard 2009).

Though highly useful to broaden perspectives, these latter approaches provide no clear guidance for assessing corporate BES performance. This monetary - non-monetary divide even seems to lead to an increasing gap between the various business accounting approaches to ecological issues. As far as we are aware, a single article has attempted to develop an accounting methodology specifically targeting biodiversity from an organizational perspective. Jones (1996) has integrated both monetary (amenity valuation) and non-monetary data sets for 'natural inventories' graded according to the ecological worth of the wildlife and wildlife habitats recorded on land assets owned by a public organization. The author argued that this fell within the scope of the "*direct accountability (and thus measurability) of an organization's stewardship of its wildlife resources*" (Jones 1996; p. 248). Through promising, we argue that this work remains too restrictive in terms of its scope or, in other words, its underlying understanding of the interactions between business and BES. Accordingly, how might firms report, precisely, in response to stakeholders' needs, the nature and consequences of their interaction dynamics with biodiversity (Houdet 2008)? How could business accounting information systems, standards, reporting frameworks and practices help socio-economic systems - *which now promote the globalization of biological homogenization* - find dynamics of co-viability with the diversity of living systems? We will attempt to address these questions within the next sub-section.

2007). Besides, its neo-Malthusian understanding of ecosystem change is unrealistic (flawed concept of unchanging carrying capacity through time). It is grounded on a view of sustainable development which sees 'nature' as a 'stock' to be managed optimally, at equilibrium, leading inexorably to hair-splitting distinctions between 'strong' and 'weak' sustainability, depending on which discount rate is adopted (Godard 1995).

[51] The concept of critical natural capital emerged as a trade-off between two extreme positions: *weak* versus *strong* sustainability (Brand 2009). It refers to the components parts of natural capital that performs important and irreplaceable environmental functions and, hence, that cannot be substituted by other types of capital.

3.1.4 Towards a Biodiversity Accountability Framework: changing accounting and reporting standards to integrate both financial and BES data

Katherine Farrell (2007) views the environmental valuation system as a recursively co-evolving system where articulated values influence future choice of valuation methods and vice versa. Her work has powerful implications in terms of environmental valuation discourse (and hence environmental accounting for business), notably with respect to (i) **preferences**, (ii) **incommensurability** and (iii) **the use of monetary valuation for expressing the economic worth of living systems phenomena**. First, it questions the presumption that *preferences for one outcome or object over another* are endogenous (originating within the individual): these are *strongly influenced*, inexorably, by *institutional* (hence social) *contexts*, including methods of value articulation. Secondly, it supports the argument that *incommensurability* of *living systems phenomena* should be viewed as a form of *competition between alternative adaptive responses* within the social evolutionary landscape of environmental valuation (of which firms are stakeholders among others): the *challenge of "distinguishing between frames* is not one of better or worse, of right or wrong, but rather of *fitness for purpose"*. Thirdly, it explains that the "*surprising tendency to continue representing environmental preferences in terms of monetary values, regardless of a scientific consensus that these data are not accurate, may be understood as an adaptive response to an institutional context that encourages monetary valuation*" (Farrell 2007). In other words, this "*reduces the likelihood that preferences will be expressed in non-monetary units in future*." Her "*co-evolutionary perspective hence reveals the pragmatic choice to 'scream now and then in dollars' as not merely incorrect but counter-productive to its own purpose of 'taking the environment into account', because continuing reliance upon this inappropriate method may be understood to favour the future adoption of environmental value articulation methods that are also incapable of taking living systems data into account*".

As further explained by Farrell (2007), "*by focusing on the design of new methods for articulating the economic worth of priceless living system factors of production, we can foster new social practices. These practices would contribute new value data. The environmental valuation system reference frame would begin to include priceless data and the structure of our knowledge about the objects of valuation would change."* With respect to corporate performance assessments inclusive of BES issues, this strongly suggests that we cannot rely on mere monetary aggregates but on appropriate combinations of financial and BES data sets (Houdet 2008). In this sub-section, we seek to analyze the reporting implications of our approach to accounting for the interactions between business and BES. This requires us to revisit our proposed management accounting frameworks which aim to account for (a) material flows of biodiversity (sub-section 2.2.3), (b) ecosystem services and benefits to business (i.e. the management of alternative modes of ES benefits appropriation; sub-section 2.2.4), (c) changes in BES due to the business activity (sub-section 2.2.5) and (d) interactions between firms and other economic agents with respect to changes in BES (sub-section 2.2.6). While the first two approaches seek to identify accounting journal entries (monetary data) linked to the BES useful to the reporting entity[52], the third one calls for complementary non-monetary information systems so as to fully account for the consequences of its interactions

[52] This is consistent with Boyd's argument that part of nature's value is already captured in GDP (Boyd 2007). "*Whenever ecosystem goods and services are inputs to goods and services measured by GDP (marketed goods and services), part of their value is captured in GDP. The value of housing embodies the value of visual amenities enjoyed by residential owners, for example. Likewise, the value of commercial fish, crop, and timber harvests partially 'captures' the value of goods and services used to produce the harvests. In other words some of the value of marine fish stocks, irrigation water, and forests is already captured in GDP"*.

with living systems. These are constitutive of our proposed Biodiversity Accountability Framework (BAF; Houdet 2008), an interdisciplinary instrument designed to institutionalize the responsibility of organizations to biodiversity and ecosystem services used by other agents. By highlighting some of the fundamental principles and aims of the BAF, the last approach stresses the need for new corporate accounting and reporting standards.

(I) Linking financial accounting data to material flows of biodiversity (MFB)

Our approach to accounting for material flows of biodiversity provides *methodological clues to* ***differentiate*** *which* ***accounting journal entries*** *directly* ***relate*** *or are* ***contingent to*** *the* ***different categories of MFB*** we propose. As previously argued (sub-section 2.2.5), MFB relate to benefits derived from production services contributing to business revenue, in other words biological material benefits businesses secure from ecosystem functioning (provision services according to the MA, 2005). Thanks to the proposed typology, these MFB may easily be traced across supply chains, even if transformed by production processes (categories 'transformed biological materials' and 'materials derived from transformed biological, non-renewable fossil resources'). Accountants could assess the *share* of each relevant type of accounting journal entries which is contingent to different types of MFB and propose *differentiated financial statements highlighting the '****financial dependence'*** *of the* ***reporting entity*** *on* ***MFB***; hence providing users of financial reports with much-needed information regarding the links between MFB and financial accounting[53]. The accounting journal entries involved represent the double-entry implications of monetary transactions between economic agents with respect to MFB, for instance changes in property rights attached to their use (purchase of a MFB: DR Stocks, CR expenses or CR Accounts payable; sale of a MFB: DR Accounts receivable or Cash at bank, CR Revenue). Therefore, these would include entries from both:

- The Statement of Financial Performance: sales, purchases, inventory value adjustments and associated taxes (tax on value-added, fees attached to the access to certain types of MFB);
- The Statement of Financial Position: assets (cash, inventory, accounts receivable, intangibles such as patents on biotechnologies), liabilities (accounts payable to suppliers and lenders) and shareholders' equity (earnings, reserves).

This approach significantly differs from the one in sub-section 2.2.3 and Box 1. Indeed, conventional environmental management accounting focuses on quantifying material flows and the monetary impacts of non-product outputs (loss / waste of MFB priced at their replacement costs). Furthermore, accounting for MFB may be combined with accounting for other types of non-biological material flows and emissions (minerals, water, GHG), which could be argued to fall within the scope of an *enlarged material and energy flow cost accounting* framework[54] (combining MEFA and EMA; e.g. Eder and Narodoslawsky, 1999; Haberl et al., 2004; Jasch's material flow cost accounting – MFCA, Jasch 2008). By doing so, we would be able to differentiate the financial dependence of the reporting entity on ***all material ecosystem benefits***, whether extracted or obtained from directly-controlled ecosystems or purchased from other economic agents; which should be feasible given firms' increasing knowledge of their material consumption (e.g. food labelling, REACH, D3E).

[53] This may include providing information relative to value-added creation at each step of supply chain, notably from an access-and-benefits perspective going beyond genetic materials.

[54] This would mean further differentiating the standard input-output chart of accounts presented in Table 1.

(II) The benefits of ecosystem services to business: highlighting chosen modes of ES benefits appropriation through financial accounting data differentiation

As previously shown in sub-section 2.2.4, accounting for ecosystem services and benefits to business activities aims to provide a clearer understanding of business arbitrages and associated information requirements with respect to ecosystem services that are useful to its production processes. In our case study, we argued that land-use spatial and temporal patterns, production models, nutrient management, operating expenditures, and investment choices and sales / subsidies are directly and indirectly linked to the management of ES benefits, whether derived from the farm's agro-biodiversity and ecosystem functions, processes and services, purchased from elsewhere (e.g. contractual agreements with other agents for the purchase of raw materials which are ES benefits secured elsewhere) and / or both. Using management accounting techniques and relevant non-monetary information regarding interactions between business and BES (interaction indicators; see sub-section 2.2.4), one may be able to **identify** the **direct** and **indirect transactions** linked to **chosen modes of ES benefit appropriation**, resulting from *spatial, temporal and beneficiary trade-offs*, for **any type of business activity**. From a financial accounting perspective, this means that a reporting entity would be able to ***differentiate the financial implications of their chosen modes of ES benefits appropriation***. In other words, any accounting entry may be differentiated, *quantitatively* and / or *qualitatively*, according (a) to the type(s) of ES benefit(s) to which it is linked (i.e. what ES benefit(s) the business wants to secure because it / they contribute to revenue) and (b) the means of achieving this mode of ES benefit(s) appropriation (e.g. either from the firm's assets, locally, regionally and /or through global trade).

Possible assessment criteria for chosen modes of BES appropriation would include: (1) perceptions of the dynamics of interactions between business activities and BES, (2) alternative uses of BES, (3) ways of accessing and controlling access to BES, (4) ways of transferring resources and profits derived from these BES, though not exclusively in monetary terms, and (5) ways of allocating or sharing BES and / or the products derived from them (adapted from Weber and Revéret, 1993). Businesses would hence be asked to explain the ecological and social consequences of (i) each of their property rights relative to BES (e.g. rights of access and use, land lease or ownership) and (ii) each of their modes of production, appropriation and innovation involving BES.

While approaches (1) and (2) are critical to assess the **dependence of the reporting entity on BES from a financial accounting perspective** (e.g. revenue and value-added contingent to BES[55]) and may give rise to *new financial reports* in terms of both *content* and *format* so as *to explain* the *reporting entity's choices* with respect to *alternative modes of ES benefits appropriation*, they fail to fully account for business interactions with ecosystems, notably its impacts on biodiversity and ecosystem services useful to other economic agents.

(III) Reporting changes in BES which are linked to the activities of the reporting entity

Current attempts to report changes in biodiversity which is due to the activities of a reporting entity are limited in both their nature and scope (Houdet 2008). First, the focus is on disclosing *biodiversity impacts* (essentially for new projects and ventures, without questioning

[55] Please refer back to footnote 21; by contrast with approaches seeking to include negative externalities within financial reports (which implies including the economic value of BES externalities), our focus is to differentiate accounting journal entries according to their 'ecological nature', in this case those that are made possible by the appropriation of ES benefits by the reporting entity.

past events[56]) and associated *mitigation measures*. Secondly, despite numerous studies showing that biodiversity is the driving force behind ecosystem processes[57], it is still understood and presented as an additional 'environmental issue'[58]. For instance, the GRI (2006) recommends disclosing information regarding: (i) the location and size of land owned, leased, managed in, or adjacent to, protected areas and areas of high biodiversity value outside protected areas (EN11); (ii) the description of significant impacts of activities, products, and services on biodiversity in protected areas and areas of high biodiversity value outside protected areas (EN12); and (iii) habitats protected or restored (EN13). Though such information is both important and relevant, it fails to cover the full spectrum of what is required to understand the dynamics between biodiversity and the activities of the reporting entity.

Alternatively, the 'no net loss' framework promoted (and being tested) by the Business and Biodiversity Offset Program (BBOP 2009) may provide a more rigorous framework for disclosing biodiversity impacts and mitigation measures for *new ventures* or *projects* linked to *changes in ecosystem-use*, towards an international standard which could be used by reporting entities so as to legitimate their decisions. Yet, because of its the current focus on shifts from so-called 'pristine' and 'natural' ecosystems to exploited socio-ecological systems (i.e. exclusively mining case studies at this stage), one may argue that, *from a land-use perspective*, it currently leaves out of its scope (a) ongoing ecosystem-uses, whether intensive / diversified or not, and (b) changes in ecosystem-uses taking place within exploited ecosystems (e.g. from a form of exploitation to an alternative one).

Given the restricted understanding of interactions between business and biodiversity underlying an 'impact mitigation' approach (Houdet et al., 2009) and the lack of both consensual disclosure methodology (e.g. what does *describing* a *significant impact* on biodiversity means and entails?[59]) and measures of ecological efficiency (e.g. does habitat protected ensures the viability of the biodiversity components it harbors?), notably in terms of ecological equivalencies between areas destroyed and areas restored[60], one could argue that it is probably critically important to also disclose (a) *what was not covered by the impact*

[56] For instance, article 8.4 of the European Directive 2004/35 on responsibility for the prevention and remediation of damage to the environment specifies that member states may introduce legislation to exempt business from the cost of remedial actions under either of two conditions: where it had a permit for the activity in question or where 'risk in development' arises. In the latter case, the operator must (a) demonstrate that it was not at fault or negligent and (b) that the environmental damage was caused by an emission, event or activity which either was authorized under applicable national laws - all of whose conditions have been complied with - or was not considered likely to cause environmental damage according to the state of scientific and technical knowledge at the time when the activity took place.

[57] GHG, water, energy are only non-living 'elements' which living systems use, absorb or emit. These interaction dynamics underpin ecosystem services from which human derive benefits.

[58] Weber and Baily (1993) define the environment as constituted of what belongs to nobody in particular. This explains why pollutions and GHG are typical environmental problems. Biodiversity, however, comprise some components which are private goods (food) while others are common-pool resources (certain grasslands and fish stocks) or pure public goods (existence values attached to it in general, or to some of its component parts), hence the difficulties encountered when attempting to classify biodiversity issues with other typical environmental problems. In this paper, we choose to adopt an ecosystem approach to interactions between business and biodiversity, which implies that typical environmental issues (water consumption, waste and emissions) are nothing more than drivers of ecosystem change: they fall within a broader framework for assessing changes in BES, as indirect indicators of 'pressures' on the latter.

[59] This would be contingent on the elements of biodiversity involved, and, especially, associated stakeholders' perceptions and agendas which are likely to vary across time and space.

[60] Faber-Langendoen et al. (2008) present current possibilities and future challenges with respect to the use of complementary remote-sensing, rapid and intensive field-based metrics for ecological integrity assessments for wetland mitigation programs.

assessments on which decision-making was based and (b) *what has been* or *is being lost,* through the business *direct spatial footprint* and *cumulatively* within the ecosystems the business operates[61] or from which it draws the resources (ES benefits) it needs. Therefore we propose to adapt our accounting framework outlined in sub-section 2.2.5 to reporting purposes, which means disclosing the **direct** and **indirect impacts on biodiversity and ecosystem services**, both ***positive*** and / or ***negative***, associated with:

- The **use** and **management of controlled** and **owned land assets** (and access to marine renewable and non-renewable resources), including changes in ecosystem-use[62];
- The **modes of appropriation of ES benefits**, including those of all purchased inputs (inclusive of material flows of biodiversity);
- **Other BES users**, linked to business *modes of appropriation, production and innovation* (e.g. ecological consequences of new technologies, inclusive of biotechnologies), and thus to *both preceding approaches.*

This approach presents the opportunity to identify, assess, monitor and report on the real business drivers of changes in BES. It calls for significant investments in research towards the development of information systems adaptable to all types of businesses, *based on indicators of interactions between business activities and ecosystem dynamics.* It notably requires that such information systems (1) ***reflect ongoing ecosystem dynamics*** (it may involve 'real-time' indicators[63], with daily or monthly records, which may influence reporting tools, notably in terms of formats[64]), (2) ***be spatially and contextually relevant***[65], and (3) ***be grounded on principles of data co-production, use and interpretation***, *in partnership with all stakeholders* – especially *the weakest*, so that they may express data uncontested or accepted by all (i.e. underlying values being 'shared' by all, that is negotiated value frames based on consensual agreements).

To that end, works by the European Environment Agency on ecosystem accounting[66] (Weber 2007; 2008) and that of the GEO Biodiversity Observation Network provide some important clues regarding how ecosystems and biodiversity may be monitored using a variety of complementary tools, including remote sensing technologies (Turner et al., 2003) and on-ground verification. The key challenge will be to adapt such information systems to the business community's aforementioned accounting and reporting needs and challenges with

[61] This involves, for instance, consequences of interactions between economics agents within a watershed, though assessing its share of responsibility regarding the latter may be problematic (see approach IV).

[62] This means going much further than what Jones (1996) has advocated in terms of accounting for 'natural inventories' occurring on land assets owned by organizations.

[63] In addition to standard performance indicators indicating, for instance, the percentage of facilities implementing such customized information systems.

[64] For instance, websites may publish regular reports of key data sets concerning various business facilities within an ecosystem (involving different reporting entities) or, alternatively, all relevant interactions with BES for a single reporting entity.

[65] This means not choosing indicators such as ecological footprints which produce aggregates that do not reflect any 'real' ecosystem trends but theoretical 'consumption' data (i.e. hectares needed to sustain the business activities). The focus is therefore on the **spatial monitoring of ecosystem dynamics**. Biophysical ranking methods, such as that used for case studies undertaken by the European Environment Agency on ecosystem accounting for Mediterranean wetlands (Weber et al., 2008) and the mapping of ecological networks in Rhône-Alpes (Guillot et al., 2009), provide some useful insights to that end. Such data sets will need to be combined with those concerning modes of appropriation (e.g. land assets owned or leased by firms; data often in the hands of local authorities or statistical agencies, such as the Institute Géographique National in France).

[66] Ecosystem accounting is based on collective decision-making and long-term policies for the integrity and health of ecosystems world-wide, drawing in particular on the goals of the Convention on Biological Diversity.

respect to BES: this will likely require several types of complementary quantitative and / or qualitative data sets, including some *directly managed by the reporting entity* (e.g. indicators monitored linked to its assets) and others *involving regional or global ecosystem dynamics*.

While approaches (1) and (2) aim to provide differentiated financial reports providing information regarding the dependence of reporting entities on BES (inclusive of MFB) and their choices with respect to alternative modes of ES benefits appropriation, this third approach aims to provide complementary information regarding changes in BES caused, partially (in reference to diffuse impacts of various firms with cumulative ecosystem effects) or entirely, directly and indirectly, by their activities. In addition, these three approaches combined may have significant implications beyond corporate performance assessments, notably in terms of the definition of 'environmental expenditures' from a national accounting perspective (SEEA 2003), the classification of eco-technologies and eco-activities (e.g. Poupat and Tachfint, 2009), and, more generally-speaking, the definitions of environmental costs and revenues used in environmental management accounting (Jasch 2008; Savage and Jasch, 2005). Similarly, further research will be needed before we may rigorously attempt to apply Ijiri and Lin's symmetric financial accounting (2006) with respect to possible accounting 'goods' and 'bads' our proposals may reveal.

(IV) Reporting changes in BES linked to interactions between firms and other economic agents: the call for changes in accounting and reporting standards

Sub-section 2.2.6 highlighted the interdependence of firms with respect to both business dependence and business impacts on BES and suggested that, in terms of its structure, components and aims, a fully operational business accounting system for BES needs to be both adaptable to any business activity and compatible with the needs of users and stakeholders across supply chains and networks of firms. Therefore we call for new **corporate accounting** and **reporting standards** which would (1) *disclose value frames*[67] *co-constructed with all stakeholders* and (2) **institutionalize** the **accountability of organizations** with respect to **biodiversity** and **ecosystem services used by others**. *Yet, is closing the gap between shareholder value creation and stakeholder value creation more than a mere 'useful fiction'?*

Levrel (2007) argues that we are now in a problematization phase for biodiversity, in which constructive criticism predominates and all indicators / approaches are competing, reflecting conflicting views and analyses of the issues in question: indicators of 'strong' sustainability such as the 'ecological footprint' are frequently opposed to 'weak' sustainability indicators such as those of the GRI (Richard 2009); thus the need for greater conceptual clarity and statistical robustness before any can be institutionalized with a clear conscience. It is in this context that the adaptive co-management of biodiversity, based on technological democracy, fits. As argued by Levrel (2007), we need to move on from (a) "*a system of expertise to a system of co-operation between various sources of knowledge*" and (b) "*the aggregation of individuals to the composition of a collective*" towards, in due course, the co-construction, institutionalization, appropriation and implementation of batteries of consensually formulated indicators of interaction dynamics between firms and BES. These will be essential for fostering dynamics of co-viability between them, as prerequisites for re-integrating business strategies and practices within the dynamics of living systems (Houdet 2008). Providing the constituting elements, methodologies and precise disclosure requirements of the changes in accounting and reporting standards we call for would thus go

[67] We use this term in reference to Farrell's aforementioned arguments (Farrell 2007).

beyond the scope of this article, so that we choose to conclude this sub-section by the following points, as what we argue to be *fundamental principles* underlying them towards *bridging the gap between shareholder value creation and stakeholder value creation*:

i. Accounting for ecological externalities, which implies capturing the monetary values of BES[68], is both reductionist and unreliable at best, and, in addition, highly likely to be counter-productive as previously argued. Therefore, the focus should not be on finding ways to integrate them into financial reports: (a) the double-entry involved has no underlying transaction attached to it (i.e. no payment to another agent is made, no payment from another agent is received), (b) it can neither satisfy the definition criteria of a liability (negative externality) nor those of an asset (positive externality), and, hence, (c) it has no practical implications for both 'nature' (in terms of ecological targets or standards) and the reporting entity (even if deduced from conventional net profits, because of the lack of contractual party). For the same reasons, we argue that accounting for consumption of renewable and non-renewable resources by adding a journal entry 'debt to nature', priced at their replacement costs, though useful from a management accounting perspective (sub-section 2.2.3, Box 1), is a pathway that should not be pursued from a reporting perspective.

ii. On the other hand, if an externality involving the reporting entity and another economic agent gives rise to a transaction between them, then this would fall within the scope of conventional financial accounting: accounting journal entries can 'serenely' be recorded. This is what '*internalizing an externality'* means from a financial accounting perspective[69]. This transaction will be contingent to the 'competing' evaluations of the externality by its interested parties and, hence, to the outcome of their negotiations. It would *never* represent a contractual agreement with 'BES' (as implied by a 'debt to nature'): it *necessarily* constitutes a transaction with another economic agent with respect to the (non)use or management of BES. This may involve a specific action or inaction so as to satisfy mutually agreed objectives and / or means (e.g. monetary payments and in-kind transfers made by Vittel to farmers for changes in farming practices, with a focus on means rather than on shared measurable targets; Déprés et al., 2008).

iii. In the previous paragraphs of this sub-section (first two approaches essentially), we drew attention to the fact that information readily in the hands of firms can be very useful in assessing their responsibility to BES: accounting journal entries may be differentiated with respect to the nature of the underlying interactions with BES, notably according to chosen modes of ES benefit appropriation (accounting data contingent to BES), and this without attempting to price externalities. Accounting and reporting standards should thus provide methodologies (1) for differentiating available financial accounting data according to their direct and indirect links with BES and (2) for building complementary non-monetary ecosystem (quantitative and / or qualitative) data sets which would account for the changes in BES caused by the business activities. The end-results would constitute **integrated reporting**

[68] Adding new journal entries (unrelated to conventional financial accounting entries) as some may propose for the 'free' consumption of BES would require using non-market economic valuation techniques. Yet, as argued by Chevassus-au-Louis et al. (2009), this would amount at putting a price on BES, something only possible for 'ordinary biodiversity', by capturing the economic value of ecosystem services.

[69] For GHG emissions in Europe, internalizing externalities from an accounting perspective required negotiating collectively (a) emission reduction targets, (b) quotas for each industry involved and (c) the associated regulatory mechanisms (markets for emission rights, taxes for GHG emitted beyond the specified quotas). This logically lead to financial accounting entries for firms involved in trading GHG emission rights (e.g. surplus GHG units as assets, sales / revenues for sales of emission rights, purchases / expenses for acquisitions of emission rights) and / or merely paying for surplus GHG emissions (taxation expenses). Note that this did not involve the economic valuation of GHG externalities, but economic models have been used to test the viability of alternative regulatory mechanisms.

statements, inclusive of (but not limited to) corporate annual statements, involving the use of *both financial* and *BES data sets*, and *representing the diversity of values co-produced with (and hence shared by) all stakeholders*.

iv. The information disclosed may then be used for (a) ***rating*** *the reporting entity with respect to its* ***interactions with BES*** and (b) *evaluating* ***its share*** *of the* ***unpaid costs*** *of the maintenance and (more likely)* ***restoration of ecosystems*** *with which it* ***has interacted*** *or* ***is interacting****,* ***directly*** *and* ***indirectly*** (Houdet, 2008). The latter should give rise to ***transactions targeting specific BES outcomes***, and hence new types of accounting entries, satisfying the recognition criteria of events recorded under accrual accounting, but with very different rating in terms of their underlying interactions with BES[70]. The monetary amounts of such transactions should be calculated on the basis of *cost-efficiency analyses* regarding *ambitious BES standards or aims*[71] institutionalized through various means, including international conventions (notably the Convention on Biological Diversity) and local consensual agreements between all stakeholders. To implement or reach such standards and 'manage' associated interactions between agents with respect to BES, new modes of regulation and governance models will need to be conceptualized, put in place and financed (see next sub-section).

v. **Independently-produced data sets of BES dynamics**, involving *transparent governance regimes* and *rigorous monitoring methodologies* (co-validated with scientists and data producers and users) will need to be used by reporting entities and this for two principal reasons. First, this may be the only rigorous way to secure the *legitimac*y of the reported data sets and, hence, ensure their *acceptabilit*y to all stakeholders. Secondly, it is not part of the reporting entity's business to monitor ecosystem dynamics over the spatial and temporal scales our Biodiversity Accountability Framework calls for. For instance, during and after a transfer of ownership of a land asset, who will monitor the relevant indicators regarding business-BES interactions? We believe one (or more) independent organization(s)[72], partially financed by firms according to their aforementioned 'BES rating' (i.e. which will be used to evaluate the share of unpaid costs for the maintenance or restoration of BES), would be best suited for this type of work.

vi. This opens the door to one last key question: what 'object of reference' should be the focus of the changes in accounting and reporting standards we call for? In accordance with the principles of financial accounting, we argue that it should be the **individual transaction** and its **associated accounting journal entries**. For each, the firm should be able to supply detailed information about: (a) all material / energy flows, consumed directly and indirectly (from the perspective of a comprehensive life-cycle analysis), inclusive of MFB, (b) the chosen modes of ES benefits appropriation, and (c) the associated dynamics of direct and indirect changes in BES. This implies that firms should be able to precisely *trace* these information across *space* (with GIS, it is already possible to record the precise geographic location of transactions underlying accounting entries; Kurt Ramin, oral presentation, EMAN

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[70] We posit that firm's bottom line is currently essentially structured to *make profit* on either the *destruction of BES*, the *globalization of biological homogenization* or *the remedial of past BES destruction by others* (curative rather than preventive approach); the three often acting in interaction. The new types of accounting entries suggested may for instance relate to payments to other agents for specific BES outcomes in response to institutionalized targets or standards.

[71] Such standards should include quantitative goals with respect to viable socio-ecological dynamics. Habitat Equivalency Analysis (HEA) (e.g. Dunford et al., 2004) may be appropriate under certain circumstances, for instance for restoring damaged areas. Questions regarding initial reference conditions and long-term ecological objectives would require collective decision-making processes and should be embedded within a logic of co-viability between business and BES.

[72] This would most likely depend on the issue or scale involved.

conference 2009) and *time* (cumulatively from one reporting period to another) and between *economic agents* (e.g. sales and purchases of goods from a supply chain perspective, sales of partially or fully-depreciated assets to another firm); with major implications in terms of integrated information systems from a managerial perspective[73].

3.1.5 Making changes financially viable by reforming modes of regulation

Three legitimate questions may be asked at this point:

(1) In **what ways** and **why** our proposals for **management accounting tools** (i.e. EMA; section 2.2) and **reporting standards** (3.1.4) would be **better than the current systems in place**?

(2) What would be the **costs of refining, institutionalizing and implementing** the changes in accounting and reporting standards we call for?

(3) How may these **costs be shared by concerned agents** (from suppliers to consumers, including financial institutions and shareholders)?

With respect to the question (1), we have attempted to show in this paper that current tools available to firms fail to fully account for the nature and consequences of their interactions with living systems: (a) standard Environmental Management Accounting can be very useful but needs to be significantly expanded by including non-monetary BES data (2.2), while (b) institutionalizing corporate accountability with respect to biodiversity and ecosystem services used by other agents calls for changes in accounting and reporting standards (3.1.4). By contrast with approaches seeking to include negative externalities within internal accounting information systems and financial reports (which implies including the economic value of BES externalities), our focus is to **differentiate accounting journal entries according to firms' interactions with BES** so as to **better understand how firms create value for its stakeholders**. Though more research and case studies need to be undertaken to test and refine our proposals, we argue that, provided the appropriate institutional framework is in place, accounting information systems integrating both monetary and BES data sets could become a *key tool for business strategy framing* with respect to, for instance, process and stakeholder management, investment choices and innovation policy.

On the other hand, questions (2) and (3) have not yet been addressed. Though it is not the purpose of this paper, this last sub-section aims to provide some elements so as to foster further discussion. The time frame is a key consideration for ensuring that the necessary changes be financially profitable. An innovation may be profitable for a business in the long term, but there is often no guarantee that it will be so in the short term. Business time (return on investment), the time needed to modify behaviors (in-house training, recruitment of new staff members provided desired competencies are available on the job market) and the time needed for the hoped-for feedback to occur within an ecosystem (achieving a 'desirable' BES target) do not take place on the same scale (Trommetter 2008). Costs of changes in practices will vary depending on the situation, particularly with respect to the specificity of the assets concerned and the firm's capacity to influence the practices of some of its key stakeholders, namely suppliers (product design and modes of production), customers (demands) and employees. A small or medium enterprise cannot dictate the practices of its suppliers. It will probably have to choose between the existing options available on the market, depending on its financial resources available. In the case of monopolies, oligopolies and vertically

[73] Rom and Rhode (2007) provide a useful literature review of research on management accounting and integrated information systems.

integrated industries, where a single company (or rather its main shareholders) controls all or much of the supply chain, firms involved would be supposed to have more freedom of action. Nonetheless, all situations would be *contingent to modes of regulation already in place*. Indeed, the world of business, including that of global finance, is particularly sensitive to the rules, incentives and disincentives (or their mere absence), which 'govern' markets. Business lobbies influence the latter on every possible occasion to ensure the viability of the operations of their clients or principals. *Orientated in a 'proper' way* and *provided* ***public-support policies*** *are in place in the* ***short term*** - during the transition phase from one system to another (e.g. agro-environmental measures; Richard and Trommetter, 2000), changes in modes of regulation that aim to maintain or increase ecosystem potential may *also* be **financially profitable in the medium to long term for those impacted** (firms, consumers). Issues of risk and guarantee against business failure should be addressed from this perspective.

Regulation Theory (Aglietta 1976; Boyer 1986) deals with the precise characterization of variables of the various regimes of accumulation (or different forms of capitalism) which can be observed through time and space. A mode of development is the conjunction of an accumulation regime, modes of regulation and institutional forms (Boyer 2004). Research in Regulation Theory makes use of the data sets provided by systems of national accounts (SNAs). Yet, a SNA is nothing but a "*global, detailed and quantitative representation of an economy within an accounting framework*" (Piriou 2006): "*to throw away the quantitative in favor of the monetary and the qualitative in favor of the quantitative is not a principle of national accounts, but the logical result of a commercial and monetary economy in which activities and their products necessarily need to be expressed in monetary terms in order to be socially validated*". Recent papers suggest that there a growing consensus of the need to account for major social and ecological phenomena which are currently ignored by national accounts (Jackson 2009; Stiglitz et al., 2009). What would our proposals regarding accounting and reporting standards imply for systems of national accounts? We suggest that, towards dynamics of co-viability between (different) accumulation regimes and biodiversity, two complimentary approaches should be explored: (a) findings ways to include the interactions between business and BES into SNAs and (b) shifting modes of regulation on the consumption, destructions – creations and mode of appropriation of BSE based on the information gathered in SNAs.

Somewhat paradoxically from an ecological standpoint, homogenizing ecosystems and living systems generates revenue, as do efforts to curb pollution and other commonly targeted externalities through artificial means (conventional waste-water treatment plants, waste storage sites), so that the underlying business performance (and macro-economic 'growth') indicators mostly discard the consequences of the nature of interactions between firms and BES. As previously argued (sub-section 2.2.4), unless (a significant share of) the revenue structure of firms and the associated legal footings (property rights attached to the access to and uses of BES) evolve, there is no reason for firms to change their business model and engage themselves with respect to BES not currently contributing to revenue generation (ES benefiting to other stakeholders, existence values attached to biodiversity). As a result, we called for institutional innovation with respect to corporate accounting and reporting standards (Biodiversity Accountability Framework - BAF), meant to foster significant technological and organizational innovations towards dynamics of co-viability between firms and biodiversity (Houdet 2008; Houdet et al., 2009). In this context, the *integrated accounting and reporting information systems* we now propose should be designed as an **information base, incorporated into systems of national accounts, for setting up and managing new modes**

of regulation *combining tools for **mitigating BES loss*** and ***remunerating BES supply***[74]. This should aim to make business practices favorable to BES profitable and would open the door to new forms of arbitrage with respect to models of land use, development and innovation, involving both pre-existing business processes and new business opportunities (Houdet et al., 2009)[75]. This will also contribute towards 'shortening the distance across' the two ends of Corporate Responsibilities Continuum with respect to BES (Figure 5), in other words bridging the current (massive) gap between conformance to regulations regarding (some components of) BES and corporate performance with respect to BES. To that end, we further underline that:

- The alternative combinations of complementary 'families' of economic tools, which may include taxes, subsidies (or suppression of perverse ones), quotas, prohibitions, norms, licenses to operate, rights markets and / or tradable permits, will need to be assessed according to the BES issue at stake[76] and the stakeholders concerned, towards securing social, ecological and economic efficacy simultaneously.
- We may need to move away from a taxation system based on human and manufacturing capital to a different system based on the interactions between economic agents and BES[77] (Grandjean et al., 2007; Houdet 2008; MA 2005; Weber, 2009). This may involve differentiated fiscal treatments (e.g. in terms of taxation or subsidy rates) according to (a) modes of appropriation of BES (an incentive – disincentive continuum with thresholds could be adopted) and (b) impacts on BES (e.g. reform of taxes associated to land-use and changes in land-use as suggested by Sainteny 1993; Cumming 2009), inclusive of those linked to the dissemination and appropriation of innovations (e.g. uses of biotechnologies in agriculture; Houdet 2008).
- Current modes of appropriation of ES benefits are commonly based on (total or partial) free access to BES: various ES may be imbedded within them and this often with few (if any) business contribution to the maintenance or restoration of the ecosystem dynamics which enable them; notwithstanding activities which negatively impact BES as well as modes of appropriation which target a single type of ES benefit while degrading other ES. Accordingly, property rights regimes associated with the interactions between businesses and BES need to be better understood and clarified (Houdet et al., 2009). A variety of property rights exist, from the traditional (private and public property rights) to the more complex (rights of access and use). Insofar as rights of access and use are independent of property rights on goods (resources), using markets for trading property rights may be highly flexible and adaptable, transaction costs being reduced by trading certain elements of property without laying a hand on property itself (Weber 2002b). When assessing alternative strategies for combining the mitigation of BES loss and the remuneration of BES supply, stakeholders should clearly aim at socially equitable governance regimes which explicitly (a) recognize very varied regimes of appropriation and (b) guarantee rights to temporary or permanent

[74] The term 'supply' is probably inappropriate: we refer to practices which favor BES or contribute positively to BES targets.
[75] New business opportunities may further involve new assets and liabilities (e.g. BES trading rights and / or contractual agreements), new skills or competencies (e.g. biodiversity skills in the Finnish forest industry; Wolf and Primmer, 2006), as well as technological (e.g. using living systems as ecosystem engineers; Byers et al., 2006; Hastings et al., 2006) and organizational innovations.
[76] According to Fisher and Turner (2009), BES can be characterized along a continuum from rival to non-rival and from excludable to non-excludable. This may change according to the intensity of use (fisheries, CO_2 storage).
[77] This could arguably constitute a very effective avenue for dynamics of co-viability between firms and biodiversity (Houdet 2008).

access and use to (the weakest[78]) local communities. This may see common property resource management (Ostrom 1990; Ostrom and Hess, 2007) becoming a key feature of future business strategy framing and operations management.

4- CONCLUSION

The aim of this paper is to propose guidelines so as to account for business interactions with living systems, towards an operational Biodiversity Accountability Framework (BAF). By successively discussing (1) how a management or cost accounting approach may help firms account for biodiversity and ecosystem services (BES) and (2) how accounting for BES from a Corporate Social Responsibility (CSR) perspective may influence business accounting and reporting standards (section 3), we have proposed methodologies so as to ensure a more rigorous understanding, monitoring and assessment of the consequences of dynamics of interactions between firms and biodiversity.

First, by making use of a theoretical case study, a dairy farm, we have proposed preliminary structural elements of a managerial accounting framework which could be tested on any other type of business. In doing so, we have chosen to break-down our analysis into four complementary steps that attempt to account for: (a) Material flows of biodiversity (MFB), (b) ecosystem services and their benefits to business, (c) BES gain(s) and loss(es) caused by business activities and (d) interactions between firms and other agents with respect to changes in BES. Developing these accounting approaches in partnership with operating dairy farms may (a) raise farmers' awareness of the roles played by on-farm associated biodiversity in terms of ecosystem structures, functions and processes sustaining ES useful to their activity (as well as those useful to others) and (b) highlight alternative options for practices which favor them instead of relying on purchased artificial inputs usually correlated with the 'loss' of both on-farm input services and services produced outside of farming revenue. To that end, we have emphasized the need for more research into the mapping of ES and the development of operational sets of ES indicators, as part of a comprehensive agro-ecosystem management accounting system. By applying this framework to other types of business activities, implying variable models of appropriation of ES benefits, we have further argued that firms will be able to quantify the business practices and associated costs / revenues which lead to biodiversity gain(s) or loss(es). This may lead to questions such as:

- At what costs can the business achieve (a) differentiated biodiversity and (b) ecosystem services targets or levels, (c) for itself and (d) for identified stakeholders?
- Will cost savings in terms of concomitant reductions in purchases of 'imported ES benefits' mitigate potential loss of 'normal' business revenue?
- If not, how can the business secure other sources of revenue with respect to production ecosystem services out of conventional business revenue? How can it secure concomitant insurance mechanisms against failure during the transition from one system of practices to alternative one?

From this perspective, BES loss(es) and gain(s) (or rather changes in BES) may start to become part of the firm's business plan. The key question is not whether firms consume too much of MFB but rather how do modes of appropriation, production and consumption generate, directly and indirectly, changes in BES, whether positive or negative. Accounting

[78] This is a prerequisite for local governance models which give them the opportunity to regain possession of their present and engage themselves in the future (Weber 2002b).

for MFB and ES benefits to business demonstrates business direct and indirect dependence on living systems – i.e. amounting to revenue generation based on specific components of biodiversity (which falls within a classical management accounting approach): the key challenge lies in investing in the viable management of biodiversity and ecosystem services while securing production outcomes; which means finding new sources of revenue for practices favorable to (A) biodiversity and (B) ecosystem services used by others, locally, regionally and / or globally.

Secondly, we have sought to analyze how our approach to accounting for BES from a managerial perspective may be used for reporting purposes, which implied working on corporate performance assessments with respect to BES. The accelerating biodiversity crisis, associated with the deep changes in stakeholders' informational needs - partially in response to the current financial, economic and social crisis, strongly calls for questioning both the scope and the nature of the information reporting tools convey to stakeholders. For reporting practices and end-results to be socially legitimate and ecologically effective, we argue that their underlying principles and associated standards must reflect values 'shared' by all, especially those most affected by changes in BES.

After analyzing the reporting implications of existing environmental accounting approaches, we have presented the underlying principles and structural elements of a Biodiversity Accountability Framework (BAF). The BAF calls for changes in corporate accounting and reporting standards towards disclosing value frames co-constructed with stakeholders and institutionalizing the accountability of organizations with respect to biodiversity and ecosystem services used by others. We have highlighted that accounting for ecological externalities, which implies capturing the monetary values of BES, is both reductionist and unreliable at best, and, in addition, highly likely to be counter-productive so that it should not be used for reporting purposes. On the other hand, we have drawn attention to the fact that information readily in the hands of firms can be very useful in assessing their responsibility to BES: accounting journal entries may be differentiated with respect to the nature of the underlying interactions with BES, notably according to chosen modes of ES benefit appropriation (accounting data contingent to BES), and this without attempting to price externalities. Accounting and reporting standards could thus provide methodologies (1) for differentiating available financial accounting data according to their direct and indirect links with BES and (2) for building complementary non-monetary ecosystem (quantitative and / or qualitative) data sets which would account for the changes in BES directly and indirectly caused by the business activities. The end-results would constitute integrated reporting statements, inclusive of but not limited to corporate annual statements, involving the use of both financial and BES data sets, and representing the diversity of values co-produced with (and hence shared by) stakeholders.

The information disclosed could then be used for (a) rating the reporting entity with respect to its interactions with BES and (b) assessing its share of the unpaid costs of the maintenance and (more likely) restoration of ecosystems with which it has interacted or is interacting, directly and indirectly. To that end, independently-produced data sets of BES dynamics, involving transparent governance regimes and rigorous monitoring methodologies (co-constructed with scientists and data producers and users) would need to be used by reporting entities. In accordance with the principles of financial accounting, we have further argued that the 'object of reference' for the required changes in accounting and reporting standards should be the individual transaction and its associated accounting journal entries. For each, the firm should be able to supply detailed information about: (A) all material ecosystem flows, consumed directly and indirectly (from the perspective of a comprehensive life-cycle analysis) - inclusive of material flows of biodiversity, (B) the chosen modes of ES benefits appropriation, and (C) the associated dynamics of direct and indirect changes in BES. This implies that firms should be able to precisely trace such information across space and time, and between economic agents.

Since the implications of our proposals for firms would go beyond changes in business information systems and accounting practices, we have also suggested avenues so as to make the associated technological, organizational and institutional innovations financially viable. The integrated accounting and reporting information systems we propose should not be designed as an additional constraint on business activity. Incorporated into systems of national accounts, it should become an information base, co-constructed with stakeholders, for setting up and managing new modes of regulation combining tools for mitigating BES loss and remunerating BES supply. This should aim to make business practices favorable to BES profitable and would open the door to new forms of arbitrage with respect to models of land use, development and innovation, involving both pre-existing business activities and new business opportunities. This would also contribute towards shortening the distance across the two ends of the Corporate Responsibilities Continuum with respect to BES, hence bridging the current massive gap between shareholder and stakeholder value creation.

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6- LIST OF FIGURES

7- LIST OF TABLES

8- LIST OF BOXES

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