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Agroforestry Accounting System environmental incomes compared with SNA and SEEA-EEA at corporation scale: applications to holm oak *dehesas* in Andalusia-Spain

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Highlights

The GVA of the Agroforestry Accounting System (AAS) is 1.8 times that of the SNA.
The amenity ecosystem services accounts for 34% of the total one for the *dehesa.*
The final economic water accounts for 43% of the environmental income of the *dehesa.*
The total ecosystem services in the rSEEA-EEA overvalues by 20% that of the sAAS.
The ecosystem service in the AAS is 2.5 times that of the System of National Accounts.

Abstract

Corporations and governments face the challenge of dealing with new demands from social actors to make visible their individual economic activity environmental incomes that they accrue from ecosystem service (ES) and changes in adjusted environmental net worth (CNWead). The System of National Accounts (SNA), the System of Environmental-Economic Accounting-Experimental Ecosystem Accounting (SEEA-EEA) and the experimental Agroforestry Accounting System (AAS) frameworks are the basis of their comparative refined applications in this research. Our objectives are to measure and aggregate, in a consistent way, the farmer and government individual activity ecosystem services, incomes and environmental assets measured in the same individual *dehesa (*farm) territorial units. We compare the results of the above three accounting frameworks in 16 large mixed holm oak *dehesas* (HODs) which are privately-owned by non-industrial landowners (famers) in Andalusia, Spain, and where farmers manage twelve economic activities and the Andalusian regional government manages seven economic activities. In these HODs the economic activities are valued at basic prices by the refined SNA and at social prices by the refined SEEA-EEA and the simplified AAS. Social price in this study is estimated by adding the farmer voluntary unitary opportunity cost twofold, as intermediate product and own intermediate consumption, to the individual activities valued at basic prices.

Keywords: total product consumption, farmer voluntary opportunity cost, ecosystem services, changes in environmental asset, adjusted environmental net worth.

List of contents

1. Introduction

Notable asymmetry exists between the implicit practices in informal[1] corporative accounting governed by the decisions of a private corporation and the System of National Accounts (SNA) with regard to the valuation of flows and non-financial stocks of a territorial unit. In a corporation it is the total capital income (CI) comprised of the operating profit (hereafter 'net operating margin') and the capital gain which guide the owner's decision making. In other words, the production accounts and the balance account are completed by corporations to avoid bias in the estimation of the total capital income from its investments in manufactured capital and environmental assets in a period.

The non-financial production and balance accounts of the SNA should not differ conceptually from the informal corporation accounts. The differences between these micro accounting frameworks of the corporations and that of the SNA are: (i) that the SNA ignore natural growth (NG) in the estimation of own account gross capital formation for the period and consider the intermediate consumption of intermediate products of work in progress used (WPeu), standing at the opening of the period, as a component of the net operating surplus (NOS); and (ii) that the SNA do not include changes in the environmental assets (CEA) and changes in environmental net worth (CNWe) in the balance account. Although both systems claim to measure the economic activities of the regional/national territory in the case of the SNA and those of the corporation territory in the case of corporate accounting, the latter differs from the SNA in that it explicitly or implicitly takes into account the changes in net worth adjusted to the market beyond the legal regulations. However, both accounting approaches ignore the environmental incomes and assets from public goods and services.

The point to be taken from the above, is that SNA practice should tend towards assuming the informal accounting practice of corporations and extend the same accounting rule to regulated public production and/or those managed by the government using the same territorial unit in which the corporation operates. Thus, the owners, government and consumers should have information at their disposal on the ecosystem services and environmental income in order to determine whether the consumption of products in the period for the territorial unit of a corporation assures that the future

[1] The term 'informal' is used here in the sense that it is not required by government legislation.

biophysical and economic productivity does not decrease and/or improves over the complete commercial/natural life cycle of the individual environmental assets of the private and public ecosystems present in the territorial unit of the individual corporation.

Environmental accounting integrated in social accounting is a challenge as yet to be resolved for numerous conceptual and instrumental reasons. As regards conceptual issues, the valuations of final product consumption without market price and the delimitation of the concept of social total income are those attracting most academic controversy. As for instrumental problems, these include the absence of government standardization of a glossary of terms to mitigate the current polysemic laberynth and the lack of a developed structure of the sequence of ecosystem accounts linked to the SNA. Henceforth in this study we use the terms 'ecosystem accounting' instead of environmental accounting, environmental asset as a synonym of ecosystem asset, ecosystem service instead of resource rent of the environmental asset, and environmental income as an equivalent of ecosystem total environmental income[2].

The standard System of Environmental Economic Accounting-Central Framework (SEEA-CF) and the still-in-process of development satellite Experimental Ecosystem Accounting (SEEA-EEA) constitute the current governmental conceptual developments of the ecosystem service and environmental asset measurements linked with the SNA (Atkinson and Obst, 2017; European Commission et al., 2009; FAO, 2017; Obst et al., 2019; ONS, 2017; United Nations et al., 2014a, 2014b; United Nations, 2017).

The absence of a legal framework for ecosystem accounts in standardized company accounting underlies the scarcity of published academic applications (Campos et al., 2017, 2019a, 1019b; Ovando et al., 2016; Oviedo et al., 2017) or those currently in progress (Obst, 2019), although there is a growing demand from private and public institutions which point to the need to include corporation scale in the SEEA-EEA protocols under development (Lammerant, 2019; Obst et. al., 2019). These authors

[2] The precedent for our choice in this instance is the use of the term environmental income in scientific literature (Angelsen et al., 2014; Cavendish, 2002; Sjaastad et al., 2005). However, if future government standardization of terms used in ecosystem accounting adopted the terms 'ecosystem service' and 'ecosystem asset', then we consider the terms 'ecosystem total income' would be more appropriate than 'total environmental income'.

advocate the valuation of total environmental income[3] of the ecosystems with reference to the territorial unit of individual corporations.

Economic valuation is characterized by the fact that it relates to a specific place and therefore the characterization of economic property rights over the products, the economic rationale of the producers, the government regulations and compensations, the behaviour of public gatherers-consumers and the types of market constitute a preliminary phase prior to classifying the specific products and costs in the production and capital balance accounts of ecosystem accounting. Hence, the type of property conditions (i) the presence or absence of producer auto-consumption of amenities and (ii) the state of conservation of the environmental assets determine the economic rationale of the public owners and the government.

The total product of an economic activity is given by a technical/economic function which depends on the local organization of the labour market and the property rights over the extraction and transmission of rights of use to third parties (Anderson and McChesney, 2003). For example self-employed direct producers tend to dissipate the environmental income and maximize the income from self-employed labour on the basis of relatively low productivity from the hourly remuneration (Campos et al., 2008, 2017). In contrast, corporations which only have paid employees aim to maximize incomes from manufactured and/or environmental capitals. These different economic rationales of the corporations of employees and self-employed workers give rise to the paradoxical, though not uncommon, situation of trade-off between manufactured and environmental incomes, whereby it would be possible that the maximum sustainable social total income could occur alongside the dissipation of the resource rent without the biological degradation of physical environmental assets, or in contrast, that a corporation with paid workers could have a lower social total income but greater ecosystem and environmental asset services (Campos et al., 2008). In other words, the existence of environmental income for the period, represented by the ecosystem services and the change in the environmental assets –or changed in adjusted environmental net worth-, given their residual values, are revealed to be conditioned by the institutional agreements of nations and local societies with access to the economic ownership of natural resources. We need to estimate the functions of the social total income and its

[3] We interpret "environmental profit and loss" (Lammerant, J., 2019: p. 11) and "extended profit and loss" (Obst, 2019; p. 16) resulting from production and balance accounts of corporations as conceptually synonymous with 'environmental income'.

factorial distribution for corporations and therefore determine the significance of the residual values of the environmental incomes and assets in order to judge the options for ecological-economic sustainability at individual company scale, linking the trade-offs between private and public natural productions.

The ecosystem accounting frameworks applied are farm-scale versions of the refined SNA (hereafter rSNA) and the SEEA-EEA (hereafter rSEEA-EEA) and the simplified AA (hereafter sAAS) (Campos et al., 2017; Campos et al., 2019b, 2019c, 2019d; Obst et al., 2019). In this study the valuations depend on scheduled sustainability according to biological models of future management of the consumption of the natural products valued. We focus our attention on comparing the accounting framework results for ordinary net value added (NVAo), ecosystem service (ES), change in environmental asset (CEA), change in adjusted environmental net worth adjusted (CNWead) according to WPeu and environmental income (EI).

In this study we apply the ecosystem accounting frameworks to 16 mixed holm oak *dehesas* (HOD) in Andalusia-Spain with a total area of 9,032 ha. These mixed holm oak farms are privately-owned by non-industrial farmers (Campos et al., 2019c). As the HOD is a silvopastoral ecosystem, the livestock and game species shape the open woodlands, accounting for 78% of the total area of the *dehesa* case studies, with a canopy cover fraction of 34%. The primary data source for all these HODs is Campos et al. (2019c).

The objectives of these HOD case studies are (i) to develop the conceptualizations of the ecosystem accounting systems compared and (ii) to apply the previously mentioned accounting methods according to the type of producers and consumers in the HOD case studies at individual corporation scale.

2. Accounting frameworks applied to holm oak *dehesa* case studies

2.1. Brief background to the accounting frameworks

The net operating surplus (NOS_{SNA}) is the residual (balancing) item in the standard System of National Accounts (SNA) production and generation of income and the net operating margin (NOM_{AAS}) is the balancing item in the Agroforestry Accounting System (AAS) production account. Linking the AAS net operating margin at social price ($NOM_{sp,AAS}$) and the net operating surplus at basic price ($NOS_{bp,SNA}$) is the core issue in the comparison of ecosystem accounting frameworks in this HOD case

study application at farm scale. We have previously undertaken these comparisons of residual net operating surplus and margin in studies of regional forestland in Andalusia (Campos et al., 2019a) as well as in cork oak and holm oak *dehesa* case studies at farm scale (Campos et al., 2017, 2019b, 2019c; Ovando et al., 2016; Oviedo et al., 2017). Below we present a brief description of the general accounting identities linking $NOM_{sp,AAS}$ and $NOS_{bp,SNA}$.

$NOM_{sp,AAS}$ as opposed to $NOS_{bp,SNA}$ differs in that the latter incorporates the non-commercial intermediate product of private amenity service (ISSnca), the ordinary final product of carbon fixation (FPoca), natural growth (NG), own non-commercial intermediate consumption of amenity service (SSncoa), manufactured work in progress used (WPmu), environmental work in progress used (WPeu), carbon consumption of environmental fixed asset (CFCeca), and the increase in the prices of the ordinary final product of private amenity service (ΔFPoa) along with the government ordinary final products (ΔFPo_G) of water, recreation, landscape and biodiversity (for details see Campos et al., 2019c, supplementary text S3):

$$NOM_{sp,AAS} = NOS_{bp,SNA} + ISSnca + FPoca + NG - SSncoa - WPmu - WPeu - CFCeca + \Delta FPoa + \Delta FPo_G \quad \text{(eq. 1)}$$

$$NOS_{bp,SNA} = NOM_{bp,SNA} + WPeu \quad \text{(eq. 2)},$$

where subscript bp is basic prices and subscript sp is social prices.
Taking into account eq. 2, the $NOM_{sp,AAS}$ is estimated while considering the $NOS_{bp,SNA}$:

$$NOM_{sp,AAS} = NOM_{bp,SNA} + ISSnca + FPoca + NG - SSncoa - WPmu - CFCeca + \Delta FPoa + \Delta FPo_G \quad \text{(eq. 3)}$$

In the integration of rSEEA-EEA ordinary net value added at social prices ($NVAo_{sp,rSEEA\text{-}EEA}$) in the sAAS ordinary net value added at social prices ($NVAo_{sp,sAAS}$) we assume that the rSEEA omits the fire service activity (IPfs) and the ecosystem institutional sector activity ordinary manufactured total cost (TCmo), the ordinary labor cost being implicitly included in $NVAo_{sp,rSEEA}$:

$$NVAo_{sp,sAAS} = NVAo_{sp,rSEEA} + IPfs - ICmo_{G,sAAS} - CFCmo_{G,sAAS} \quad \text{(eq. 4)}$$

The accounting identity of the environmental income (EI) in the ecosystem accounting frameworks is derived from the identity of the social total income (TI) of the Agroforestry Accounting System (AAS) (Campos et al., 2017, 2019a, 2019b, 2019c; Krutilla, 1967; McElroy, 1976; Stone, 1984). The incorporation of the EI allows the integration of the simplified sequence of ecosystem accounts within the general framework of the principles of exchange value and effective consumption by people for the period, which provide the basis for the ecosystem accounting of silvopastoral landscapes such as those of the HOD case studies.

The criteria which the structure of the ecosystem accounting of an individual product are based on are its direct and/or indirect consumption in the period and that which are expected to be consumed in the future, indefinitely by people. The ecosystem service (ES) value is embedded in an ordinary product and its perpetual flow of discounted future consumption give the environmental asset value (EA), by convention, at the closing of the period. It should be noted that the valuation of the environmental assets is subsidiary to the consumption by people of their flows of services, while the physical assets are ultimate basis for the ecological sustainability of the ecosystems. For this reason, the economic valuation of the ecosystem services based on consumer preferences should also be subsidiary to operating above the physical thresholds which avoid or at least mitigate the uncertainty as regards possible irreversible consequences of the economic activities.

The ultimate economic objective of ecosystem accounting is to measure, at social price, the individual economic activities ordinary net value added (NVAo), the ecosystem service (ES), the consumption of manufactured fixed capital (CFCm), the changes in environmental asset (CEA), the changes in adjusted environmental net worth (CNWead) according to WPeu and the environmental income (EI).

The available publications concerning the abovementioned accounting frameworks applied at regional scale to forests and farms allow us to briefly present the concepts which are of most interest from the perspective of development and application of the ecosystem accounting frameworks at farm scale[4].

Based on the results for the production, income generation and capital balance accounts of the SNA and AAS accounting methods we constructed the sequence of

[4] "At this moment there is no globally accepted uniform / standardized approach for business accounting of natural capital. In contrast, 'total freedom' exists and therefore company performance as regards NC is difficult to assess by stakeholders, including the investors" (Lammerant, 2019: p. 1).

ecosystem accounts for the rSNA, rSEEA-EEA and sSNA, which measure the ecosystem services and environmental incomes of the individual activities, farmers, government and aggregate activities in the HOD case studies (Campos et al., 2008, 2017, 2019b; Ovando et al., 2016; Oviedo et al., 2017). The rSNA includes the government institutional sector and broadens the variables included in the sequence of accounts reported in Obst et al. (2019: Table 6, p. 33). The most important of these variables are ordinary net value added (NVAo), ordinary net operating surplus (NOSo), ecosystem services (ES), change in environmental assets (CEA), change in adjusted environmental net worth (CNWead) according to the environmental work in progress used (WPeu) and the environmental income (EI). The rSNA and rSEEA-EEA are compared in the same sequence of accounts with those obtained using the sAAS.

The sAAS results are of particular interest as they highlight the insufficiency of the rSNA and rSEEA-EEA valuations in the preliminary development phase of the latter. We do not incorporate adjustments to the NVAo and NOSo according to environmental fixed capital consumption (ecosystem degradation) because it is not embedded in the ordinary total products. However, the ecosystem degradation is implicitly recorded as it is integrated in the change in environmental asset estimate (CEA) for the period.

The structures of the production and balance accounts in the rSNA, rSEEA-EEA and sAAS allow us in turn to structure the accounting records of the respective ecosystem accounting frameworks as subsystems of the SNA and AAS. Once the social total income has been estimated using the SNA and AAS methods we organize the structure of the sequence of ecosystem accounts starting with the production and income generation accounts of the total products consumption (TPc).

The general accounting identify of the environmental income (EI) is expressed as the sum of the environmental net operating margin (NOMe) and the environmental asset gain (EAg) (Campos et al., 2019a, 2019b, 2019c). These components of the EI are equivalent to the sum of the ES and the change in adjusted environmental net worth (CNWead) according to the WPeu. In all the HOD products, with the exception of carbon, the CNWead coincide with the change in the environmental asset (CEA).

We classify the net operating surplus of the rSNA (NOS_{rSNA}) into manufactured ($NOSm_{rSNA}$) and environmental ($NOSe_{rSNA}$) and also into ordinary ($NOSo_{rSNA}$) and investment ($NOSi_{rSNA}$), which in turn is separated into manufactured ($NOSmi_{rSNA}$) and environmental ($NOSei_{rSNA}$). The latter is estimated by the natural growth (NG_{rSNA}) less

the consumption of environmental fixed capital ($CFCe_{rSNA}$), represented in this study by carbon emissions (Campos et al., 2019a, 2019b):

$$NOS_{rSNA} = NOSm_{rSNA} + NOSe_{rSNA} \quad \text{(eq. 5)}$$

$$NOS_{rSNA} = NOSo_{rSNA} + NOSi_{rSNA} \quad \text{(eq. 6)}$$

$$NOSi_{rSNA} = NOSmi_{rSNA} + NOSei_{rSNA} \quad \text{(eq. 7)}$$

$$NOSei_{rSNA} = NG_{rSNA} - CFCe_{rSNA} \quad \text{(eq. 8)}$$

The net operating surplus in the rSNA (NOS_{rSNA}) differs from that of the rSEEA-EEA net operating margin ($NOM_{rSEEA\text{-}EEA}$) and the sAAS net operating margin (NOM_{sAAS}). In the rSNA the NOS_{rSNA} is environmental work in progress used ($WPeu_{rSNA}$) and the net operating margin (NOM_{rSNA}). This difference is due to the exclusion from the $NOM_{rSEEA\text{-}EEA}$ and NOM_{sAAS} of the environmental work in progress used (WPeu).

In several previous publications we have presented individual farm scale applications of the Agroforestry Accounting System (AAS) (Campos et al., 2008, 2017, Campos et al., 2019b, 2019c; Ovando et al., 2016; Oviedo et al., 2017) as well as at regional scale for forests (Campos et al., 2019a) and cork oak woodlands (Campos et al., 2019d) in Andalusia. In the next section we describe the concepts and sequences of accounts applied in the sAAS, rSNA and rSEEA-EA ecosystem accounting frameworks for the HOD case studies in Andalusia.

2.2. Simplified Agroforestry Accounting System

The simplified production and income generation accounts allow the total productconsumption (TPc)[5] to be estimated at basic price in the rSNA and at social price in the sAAS and rSEEA-EEA[6]. The social price in the sAAS and rSEEA-EEA arises from imputing the extension of non-commercial intermediate production of non-SNA services originating from the non-industrial private owner voluntary opportunity costs of the amenity (ISSnca) in the HOD case studies.

[5] Own-account gross capital formation (GCF) is not embedded in the value of the total product consumption. However, the GCF is key to estimating the environmental income embedded in the changes in manufactured fixed capital (CFCm) and the environmental asset (CEA).

[6] For simplicity we omit from the acronyms the subscripts referring to the type of ecosystem accounting, unless specified otherwise.

The rSNA intermediate product (IP_{rSNA}) components are the intermediate commercial products (IPc) and the government compensated[7] non-commercial products (ISSncc). are generated in the HOD by grazing, conservation forestry, hunting, residential, livestock, agriculture and fire service activities. Amenity and landscape activities are the main beneficiaries of these IPr_{SNA} by using up them as own commercial intermediate consumption (ICco).

The consistency of the aggregate results for the individual economic activities of the farmers and the government in the HOD is achieved in the sAA and rSEA-EEA through the subjective assumption that the land and livestock owners incur potential voluntary opportunity costs for manufactured investment in all their activities, with the exception of the amenity activity.

The accounting criteria of assigning the manufactured cost of a task to the activity triggering the investment means that, other beneficiary activities do not contribute to the cost of the task. However, it is assumed that the government compensations and the voluntary opportunity cost to the owner are justified by the improvement/mitigation of the decline in the offer of final products consumption and/or own gros capital formation in the current. In these cases it is the beneficiary activities which pay the ordinary cost of the investments in activities which have incurred opportunity costs. In the ecosystem accounting frameworks applied in these HOD case studies the compensations are considered an ordinary non-commercial intermediate product of services (ISSncc), and additionally, in the sAAS and rSEEA-EEA, the opportunity costs of the non-industrial private owners are considered an ordinary non-commercial intermediate product of amenity services (ISSnca)[8].

The apparent paradox that the ordinary net value added (NVAo) of the HOD at market/producer prices ($NVAo_{pp,HOD}$)[9] and at social price ($NVAo_{sp,HOD}$) coincide, but not their respective distributions between farmers and government institutional sectors, creates uncertainty as regards the valuations of the environmental variables of the individual activities, both at market price and at social price (Campos et al., 2019b, 2019c), as well as of the distribution of the remuneration for operating services rendered

[7] We refined the standard SNA operating subsidies net of taxes on production from transfer concept to a new product termed non-commercial intermediate product of service.
[8] In the case of public and private industrial institutional owners, given that only non-industrial private owners can consume amenities, the assignment and denomination of the voluntary opportunity cost is changed to the beneficiary public activities in the form of donation (ISSncd).
[9] Observed or simulated.

by the ordinary labour production factors (LCo), manufactured investment (NOMmo) and environmental assets (NOMeo) of the farmers and government sectors.

In addition to the ISSc and ISSncc links between the different farmer and government activities as well as among the respective activities of each, the ISSnca also create links between the amenity activity and the rest of the farmer activities.

For each of the individual activities of the non-industrial private farmers in the HOD case studies, with the exception of amenity, the measurement of the opportunity cost is based on obtaining an ordinary manufactured net operating margin (NOMmon) considered to be normal (in this study we apply a real profitability rate of 3%) for the manufactured capital used in the period on the supply of the total product consumption (TPc). The positive difference between the NOMmon and the manufactured net operating margin at basic price ($NOMmo_{bp}$) gives the ISSnca value:

$$ISSnca = NOMmon - NOMmo_{bp} \quad \text{(eq. 9)}$$

The non-SNA final production consumption ($FPc_{non\text{-}SNA}$) corresponds to the part of the total value of products without market price valued according to the willingness to pay declared by the consumers which exceeds the SNA valuation at basic price production cost, and also includes the carbon fixation omitted in the SNA. Hence, the $FPc_{non\text{-}SNA}$ comprises the values of the ISSnca and the ecosystem services (ES) of the ordinary final products without market price along with carbon.

The aggregate TPc of farmers (TPc_F), government (TPc_G) and total (TPc_{HOD}) contain double counting of intermediate products (IP) embedded in the aggregate final product consumption (FPc_F, FPc_G and FPc_{HOD}). The individual and aggregate FPc do not contain double counting. Furthermore, the aggregate ordinary total cost (TCo_F, TCo_G and TCo_{HOD}) contains double counting of own ordinary intermediate consumption (ICoo). In the sAAS we separate the ordinary total cost (TCo) into manufactured (TCmo) and environmental work in progress used (WPeu).

The IP and the ICoo are recorded at social price as product and cost respectively of the activities that produce them and those which used them and it is necessary to record them in order to measure the ordinary net value added (NVAo) of the individual activities in a consistent manner.

The sAAS excludes the WPeu from the ordinary net operating margin (NOMo). We separate the latter into ordinary manufactured net operating margin (NOMmo) and

ordinary environmental net operating margin (NOMeo). We have explicitly measured the two environmental components of WPeu and NOMeo which contribute to the total value of the TPc, and therefore it is these values which correspond to the definition of the SEEA-EEA ecosystem service, WPeu being a cost and the NOMeo an environmental fixed asset operating income:

$$TPc = ICmo + LCo + CFCmo + NOMo + WPeu \quad \text{(eq.10)}$$

$$TCmo = ICmo + LCo + CFCmo \quad \text{(eq.11)}$$

$$NOMo = NOMmo + NOMeo \quad \text{(eq.12)}$$

$$TPc = TCmo + NOMmo + NOMeo + WPwu \quad \text{(eq.13)}$$

$$TPc = TCmo + NOMmo + ES \quad \text{(eq.14)}$$

$$ES = NOMeo + WPwu \quad \text{(eq.15)}$$

The ecosystem service (ES) is the residual part (balancing item) of the observed or simulated exchange value of a total product consumption after having prioritized the payment of the ordinary manufactured total cost (TCmo) and the operating services of ordinary manufactured immobilized capital (NOMmon) at a normal rate of return in the period and specific site, if the residual NOMeo is zero or positive. The appropriate moment to estimate the ES environmental price (unitary resource rent) of a natural base product is at the first posible real or imputed transaction in the market and/or the observation of the local gatherer/consumer behaviours.[10].

In the sAAS we omit the presentation of the net value added of manufactured investment estimate (NVAmi) as it is not necessary to measure the environmental income (EI). However, to estimate the EI we do need to know the natural growth (NG) and the consumption of environmental fixed asset (CFCe), which are the components of the environmental net operating margin investment (NOMei):

$$NOMei = NG - CFCe \quad \text{(eq.16)}$$

In the balance account, investments in manufactured work in progress (WPm) and fixed capital (FCm) are presented separately at market prices. We do not present the

[10] Thus, the environmental price of grazing is derived from the contracts for leasing the livestock grazing rights to third parties (Campos et al., 2016). In the absence of a market for grazing, the environmental price is estimated according to the residual value on the basis of the livestock product transactions. (Campos et al., 2008).

change in ordinary manufactured fixed capital for the period since the change in the work in progress is integrated in the manufactured intermediate consumption (ICm) and gross formation of work in progress (GWPFm) of the production account for the period. We need to measure the change in the total environmental assets (CEA) according to the difference between its individual values at the closing (EAc) and opening (EAo) of the period:

$$CEA = EAc - EAo \quad \text{(eq.17)}$$

Estimating the CEA is of interest because its value often coincides with that of the change in adjusted environmental net worth (CNWead) according to WPeu. The lack of coincidence which sometimes occurs between both flows derived from the balance account of the environmental assets is due to the fact that the environmental income (EI) is conventionally divided into its two residual components of environmental net operating margin (NOMe) and environmental asset gain (EAg). This second EI flow has an environmental asset adjustment (EAad) of the environmental asset revaluation (EAr) which avoids double counting of the natural growth and the ordinary final product of carbon, as well as other adjustments due to deviations in the number of game species captures with respect to those expected:

$$EI = NOMe + EAg \quad \text{(eq.18)}$$
$$NOMe = NOMeo + NOMei \quad \text{(eq.19)}$$
$$EAg = EAr - EAad \quad \text{(eq.20)}$$
$$EAr = EAc - EAo + EAw - EAe \quad \text{(eq.21)}$$
$$EAad = EAwrc + EAoad \quad \text{(eq.22)}$$

where EAw is environmental asset withdrawal, EAe is environmental asset entry, EAwrc is environmental asset reclassification and EAoad is ‘other adjustments’.

Through equation 18, adding and subtracting the WPeu on the right hand side, we reach eq. 25 which gives the desired direct link between the ES of the production account and the CNWead of the balance account and which added together also give the EI of the ecosystem accounting. Although, in this HOD case studies the CNWead is also estimated by the change in environmental assets (CEA), except for carbon activity:

$$EI = WPeu + NOMeo + NOMei + EAg - WPeu \quad \text{(eq.23)}$$

$$CNWead = NOMei + EAg - WPeu \quad \text{(eq.24)}$$

$$EI = ES + CNWead \quad \text{(eq.25)}$$

$$EI = ES + CEA \quad \text{(eq.26)}$$

2.3. Refined System of National Accounts

The standard System of National Accounts (SNA) constitutes the conceptual framework for potentially estimating the total income from the individual products[11]. In the SNA, public spending in the HOD is misplaced in the government general institutional sector. In practice the SNA does not estimate the capital balances of the commercial activities. The final products consumptions are valued at basic price in the SNA. This price is the sum of the producer (market) price and the price derived from the unit value of the government compensations[12].

The SNA does not present results at individual company scale. However, economic information on flows and stocks of the activities and products of the individual companies are needed to associate the microeconomic management results with the aggregate classifications of the different types of vegetation and land uses in the sAAS, rSNA and rSEEA-EEA applied at regional/national scale at social price. In other words, the SNA limits the valuation of the individual commercial activities to the valuation of products at their basic prices. El rSNA and the sAAS coincide in the valuation of commercial flows and stocks at market prices but differ in their valuation of final products without market prices; the sAAS estimating these according to the simulated exchange value while the rSNA estimates them according to the manufactured production cost.

In the HOD case studies we incorporate the government institutional sector in the rSNA in order to embrace the misplaced public spending (Campos et al., 2019a; Ovando and Campos, 2016). Although the rSNA extends the HOW economic activities to include public activities provided by the government, it does not modify the net value added of the farmers and nation estimated in the SNA, except that it incorporates the

[11] In practice, the SNA measures the total income from livestock farming by incorporating the change in the net inventory of livestock purchases in the own-account gross capital formation. It implicitly incorporates the revaluation of the manufactured capital in the net value added through the estimation of manufactured consumption of fixed capital at replacement cost (McElroy, 1976; European Commission et al., 2009).

[12] The sum of the operating subsidies for the period and the annualized historic subsidies as consumption of manufactured fixed capital of the production cost of the ordinary product.

final product of retained economic water from the forest consumed outside the HOD in the government institutional sector[13]. The practical novelty of the rSNA is that it estimates the balances of manufactured capital and environmental assets of the SNA farmer activities as well as the government public activities with market prices (mushrooms and water).

The total product consumption in the rSNA omits natural growth (NG) and the work in progress used (WPeu) in the intermediate consumption cost (IC) of the corresponding economic activities in which they are employed. The total product consumption (TPc) in the rSNA extends the SNA final product consumption to explicitly include the intermediate product (IP)[14]. We classify the TPc[15] into intermediate (IP) and final product (FPc) of the SNA. The TPc incurs double counting due to the inclusion of the IP embedded in the final product consumption (FPc). We avoid double counting in the ordinary net value added NVAo by registering ordinary own commercial intermediate consumption (ICcoo) in the total intermediate consumption (IC):

$$TPc = IP + FPc \quad \text{(eq.27)}$$

$$IP = ICcoo \quad \text{(eq.28)}$$

The ordinary commercial intermediate consumption (ICco) in the rSNA extends the SNA ordinary intermediate consumption bought (ICcob) to include own ordinary commercial intermediate consumption (ICcoo):

$$ICco = ICcob + SScoo \quad \text{(eq.29)}$$

The rSNA ordinary gross value added (GVAo) does not represent the operating income as it incorporates the ordinary manufactured fixed capital consumption cost (CFCmo). The estimation of the latter requires subjective criteria to be applied on the

[13] In the rSNA, the valuation of forest water in the HOD does modify the net value added measured by the standard SNA in the case of irrigated land because the forest water ecosystem services are embedded in the agricultural products obtained.

[14] We assume that IP to be a SNA product as it can be considered a final product intra-consumed by farmers. In practice, the SNA does not estimate intra-consumption.

[15] We do not need to measure own account manufactured gross capital formation (GCFm) in order to estimate the ecosystem services for the period. However, it is necessary to consider it in the estimation of future resource rents, which when discounted give the values of the individual assets at the closing of the period.

obsolescence and degradation of physical stocks of constructions, equipment and other intangible manufactured capitals (such as plans for forestry, wildlife and the gathering of public biological products). There are other sources of subjectivity associated with the valuation of manufactured fixed capital consumed such as, on the one hand, homogeneity in the productivity of the new capital goods which replace the old ones, and on the other, the implicit inclusion of manufactured capital gain in the measurement of the ordinary net value added (NVAo) (McElroy, 1976). In the rSNA the NVAo still does not correspond with the operating income due to the fact that it includes the intermediate consumption of woody work in progress used (WPeu), existent in the inventories at the opening of the period. As a consequence of omitting the intermediate consumption of WPeu, the NVAo is overvalued. This means the ordinary net operating surplus (NOSo) is not pure operating capital income, being overvalued due to the amount of WPeu. The ordinary labour cost component (LCo) in the rSNA corresponds to the paid labour of employees in the HOD activities considered as there is no self-employed labour in this case:

$$GVAo = TP_c - ICco \quad \text{(eq.30)}$$

$$NVAo = GVAo - CFCmo \quad \text{(eq.31)}$$

$$NVA = LCo + NOSo \quad \text{(eq.32)}$$

Only by estimating and assigning the IP and own ordinary commercial intermediate consumption (ICcoo), respectively, to the individual activities which produce and utilize them can we estimate the ordinary net operating surpluses (NOSo) and the ecosystem services (ES) of the individual activities valued. We separate the NOSo into its three components of WPeu, ordinary manufactured net operating margin (NOMmo) and ordinary environmental net operating margin (NOMeo):

$$NOSo = WPeu + NOMmo + NOMeo \quad \text{(eq.33)}$$

Thus, it is evident that when the ES are valued according to the “resource rent” of the total product consumption they are not consistent with the definition of the ecosystem environmental operating income when the WPeu are incorporated.

It is necessary to estimate the changes in the rSNA environmental assets (CEA), which, when added to the ES give the environmental income (EI)[16]. The environmental income represents the value of the environmental asset contributions to the total income of the rSNA commercial activities valued in the HOD case studies, taken into account both for the current period and future periods total products consumptions.

2.4. Refined SEEA-Experimental Ecosystem Accounting

The System of Environmental Economic Ecosystem Accounting-Central Framework (SEEA-CF) is the standard guide for valuing market environmental assets (United Nations et al., 2014a). This asset market boundary of the SEEA-CF environmental assets is extended by the guidelines of the satellite SEEA-Experimental Ecosystem Accounting (SEEA-EEA) (United Nations et al., 2014b; United Nations, 2017).

The objective of the SEEA-EEA is to measure the ecosystem services and changes in the individual environmental assets that they accrue from the products currently consumed by people and/or forecast to be consumed in the future. The SEEA-EEA defines the ecosystem service (ES) as the gift contribution of the ecosystem to the exchange value of the natural base total product consumption (TPc) (United Nations et al., 2014b; United Nations, 2017).

The main initial difficulty in achieving consistent rSNA and sAAS comparisons with rSEEA-EEA guidelines is the absence of complete and consistent criteria for the structure of their production and capital balance accounts integrated in the extended SNA. The guidelines of the SEEA-EEA have not developed the integration of the stilezed sequences of SNA accounts which allow a common procedure to be followed, which would provide a reference for authors in order to integrate them into the ecosystem accounts. In this study we apply our own developments of the sAAS in comparison with the applications of the rSNA and the rSEEA-EEA (Campos et al., 2019b; Obst et al., 2019; United Nations et al., 2014b; United Nations, 2017).

Our aim in this description of the rSEEA-EA is to present the modifications to the simplified model of the sequence of SEEA-EEA accounts described by Obst et al. (2019: Table 6, p. 33). The SEEA-EEA includes ecosystems as a new institutional sector (with respect to the institutional sectors in the SNA), registering public product

[16] With the exception of instrumental adjustments to avoid double counting.

consumptions without manufactured costs (Obst et al., 2019)[17]. The rSEEA-EEA incorporates to the SEEA-EEA the public products consumption in the period, which have been produced with contributions from manufactured production factors paid for by the government and public landowners. The cost of public products on the part of public owners originate from the implicit payments in the voluntary opportunity costs incurred to promote the offer of public product consumptions (Campos et al., 2019b, 2019c; Masiero et al., 2019). The problem than arises in the rSEEA-EEA is that the omission of costs of public total products leads to the overvaluation of ecosystem services.

We assume that in Obst et al. (2019: Table 6, p 33) the ecosystem accounting measures a total output consumption [18] which excludes the final production of own account gross capital formation (GCF.

The rSEEA-EEA and sAAS coincide in their estimates of the values of farmer activities but differ in their estimates of public goods and services registered by the ecosystem and government institutional sectors. Below we focus on describing the similarities and differences between the valuations of public goods and services estimated by the rSEEA-EA and sAAS.

Consistency with the concept of social total income (TI) from the public product of the ecosystem institutional sector in the rSEEA-EEA requires that only those with production functions that do not involve manufactured costs are registered (Obst et al. (2019: Table 6, p. 33). As regards the HOD activities considered, this is the case of water and carbon. This criterion leads to the omission of a wide variety of ecosystem public products (FAO, 2017; OECD, 2016). Our definition of public goods and services is broader than the conventional definition (Maler et al., 2018)[19]. We follw the holistic definition of public product by Koop and Smith (1993).The public goods and services should be defined according to their economic ownership not embraced by the market in the case of activities attributed to farmers (Anderson and McChesney, 2002). We

[17] If the SEEA-EEA is to maintain consistency in its definition of ecosystem sector it cannot include public services with manufactured costs. In this case, the SEEA-EEA would incur the omission of the ecosystem services of recreation, mushrooms, landscape and biodiversity in the HOD studied here. Our version of the rSEEA-EEA *does* include these public products with manufactured costs, but not their manufactured costs.

[18] Product and output are equivalent terms in this study.

[19] "Public services are characterized by non-rivalry and non-excludability. Non-rivalry implies that the use/consumption of a service by one individual does not reduce the availability of it for another individual, for example, climate regulation. […]. Non-excludability implies that it is impossible to exclude anyone from the use/consumption of the service. Climate is also an example of non-excludability" (Mãler et al., 2018: 9502).

assume government economic ownership of all the final goods and services consumptions which public consumers benefit from freely, either directly or indirectly.

The HOD incur costs paid by the public owners (voluntary opportunity costs of the private activities) and government in the public activities of fires services, mushrooms, free access recreation, landscape conservation and threatened wild biodiversity preservation. The exclusion of the manufactured costs of these five ordinary public final products underlies the discrepancies between the rSEEA-EEA and the sAAS frameworks in the valuation of HOD ecosystem services. In other words, the rSEEA-EEA broaden the conventional definition of public activities which we assume are omitted in Obst et al. (2019: 33), although the fact that we assign them to the ecosystem institutional sector means that, by convention, they cannot contain manufactured costs.

The non-SNA intermediate consumption of farmers in the rSEEA-EEA incorporates ecosystem services contributed by the environmental work in progress used (WPeu) and the intermediate consumption of amenity originating from the opportunity costs incurred by the owners in the HOD economic activities valued in this study (Campos et al., 2019a, 2019b, 2019c; Masiero et al, 2019; Raunikar and Buongiorno, 2006), with the exception of the amenity activity which, as this only includes ordinary own manufactured intermediate consumption (ICmoo) it cannon incur voluntary opportunity costs[20].

In the rSEEA-EEA, the incorporation of degradation/enhancement of environmental assets embedded in the total product consumption lacks consistence as the only consumption of environmental fixed capital (degradation) measured in the HOD is that of carbon. As there is no functional link between the fixation and emission of carbon, it follows that there is no reason to assume that the CCFe (emission) is embedded in the final product consumption of carbon (fixation). In other words, we only explicitly register environmental fixed capital consumption (CFCe) in the estimate of investment environmental net operating margin (NOMei) of production account of carbon activity.

We incorporate in the rSEEA-EEA substantial modifications of the SEEA-EEA by Obst et al. (2019: Table 6, p. 33), which avoid the adjustments of net value added

[20] This characteristic of the final product function of the amenity activity explains the fact that a negative ecosystem service value cannot be estimated in a period, but rather, negative ordinary manufactured net operating margin.

and net operating margin. However, to measure the environmental asset gfain (EAg) it is necessary to adjust the revaluation of the environmental assets (EAr) according to natural growth and carbon fixation at opening period resource rent prices (environmental prices) (EAad) (Campos et al., 2019a). Thus, the adjustments for depletion and degradation/enhancement are integrated into the estimate of environmental asset change (CEA) and/or the change in adjusted environmental net worth (CNWead) according to WPeu.

The aggregates of the ES and CNWead measured by the rSEEA-EEA allow us to determine the individual values of the HOD ecosystem environmental incomes. However, as mentioned above, the values of ES public activities with manufactured costs in our rSEEA-EEA are not consistent with the theory of social total income nor, therefore, with the theory of environmental income.

3. Results and discussion

3.1Results

3.1.1. Opening capital

The large *dehesas* studied in this research evidence the predominant weight of the environmental assets in the total capital. Although it is feasible that some breeds of threatened autochthonous livestock could offer passive use services of legacy and existence values to consumers, we have not valued such services, hence the livestock census in this study is valued only for its fixed biological manufactured capital and work in progress. In the opening capital of the balance account we count the manufactured capital of livestock work in progress from the preceding period, and we also simultaneously register it in the withdrawal of the balance account as manufactured work in progress used (WPmu) included in the intermediate consumption of the production account, since we do not follow the rSNA criterion of registering it under inventory change in gross capital formation. These differences in accounting approach do not affect the estimation of the net values added in the three accounting methodologies applied.

The game species are an environmental asset which is valued according to the landowner market lease price less the manufactured cost of the transfer to third parties of rights to average expected game species captures for the period (transaction of the

lease price prior to captures) which we estimate as stable in the indefinite future. We apply a constant real private discount rate of 3%.

The results for the valuations of the environmental assets reveal that grazing is not the main one, but rather, the private amenity services self-consumed by the non-industrial land owners. However, the private amenity service requires the presence of livestock herding, whereby the owners of the livestock incur voluntary opportunity costs which we assign as an non-commercial intermediate product of service output of the livestock to ensure greater enjoyment of the amenities which their *dehesa* provides (see detailed analysis of the capital balance in Campos et al., 2019c). As expected, the three accounting methodologies coincide in their valuations of the capital of the commercial and non-commercial activities of mushrooms which, subsequent to their harvesting by recreational gatherers, present market prices. The rSNA, rSEEA-EEA and sAAS methodologies differ in the non-commercial activities, with the exception of carbon and water, in the rSEEA-EEA and sAAS –carbon is the only public product which is omitted in the rSNA valuation-(Tables 1-S1).

The results for the ecosystem accounting frameworks compare the modified structure of the sequence of simplified accounts of the ecosystem accounting frameworks proposed by Obst et al. (2019: Table 6, p. 33) and which we apply at farm scale in this study.

Table 1. Opening environmental assets and manufactured fixed capital indicators by aggregate commercial and non-commercial activities for refined SNA, refined SEEA, and simplified AAS in holm oak open woodlands in Andalusia, Spain (2010: €/ha).

Class	Commercial activities			Non-commercial activities				Holm oak
	Woody products	Non-woody products	Total	Amenity	Landscape	Others	Total	*dehesas*
1. Opening environmental asset (EAo)								
rSNA	1,081.9	1,353.8	2,435.7	3,051.7		1,886.1	4,937.8	7,373.5
rSEEA	1,081.9	1,353.8	2,435.7	3,051.7	438.1	3,049.6	6,539.4	8,975.1
sAAS	1,081.9	1,353.8	2,435.7	3,051.7	438.1	3,049.6	6,539.4	8,975.1
1.1 Work in progress (WP)								
rSNA	181.6	35.7	217.2					217.2
rSEEA	181.6	35.7	217.2					217.2
sAAS	181.6	35.7	217.2					217.2
1.2 Environmental fixed asset of land (EFAl)								
rSNA	60.5	1,257.0	1,317.5	3,051.7		1,886.1	4,937.8	6,255.3
rSEEA	60.5	1,257.0	1,317.5	3,051.7	438.1	3,049.6	6,539.4	7,856.9
sAAS	60.5	1,257.0	1,317.5	3,051.7	438.1	3,049.6	6,539.4	7,856.9
1.3 Environmental fixed asset of biological resources (EFAbr)								
rSNA	839.8	61.1	900.9					900.9
rSEEA	839.8	61.1	900.9					900.9
sAAS	839.8	61.1	900.9					900.9
2. Manufactured fixed capital (FCm)								
rSNA	4.5	1,601.7	1,606.2		2.3	74.2	76.5	1,682.7
rSEEA	4.5	1,553.2	1,557.7					1,557.7
sAAS	4.5	1,601.7	1,606.2		2.3	74.2	76.5	1,682.7
3. Opening capital (Co)								
rSNA	1,086.4	2,955.5	4,041.9	3,051.7	2.3	1,960.3	5,014.3	9,056.2
rSEEA	1,086.4	2,907.0	3,993.4	3,051.7	438.1	3,049.6	6,539.4	10,532.8
sAAS	1,086.4	2,955.5	4,041.9	3,051.7	440.4	3,123.8	6,615.9	10,657.8

Number of private holm oak *dehesas*: 16. Surface: 9,032 hectares. Average surface: 565 hectares

3.1.2. Simplified Agroforestry Accounting System at social prices

We have incorporated the government institutional sector in the rSNA, specifying the values of the ecosystem services and environmental incomes. In the rSEEA-EA we have kept the ecosystem institutional sector[21] adding to it the public products with manufactured costs but omitting the recording of the costs.

We do not present the results for the allocation/use of ordinary income accounts and capital account, because they are not needed for our purpose, which is to focus on the production accounts which estimate the ecosystem services (ES) and the capital balance account which estimates the change in environmental assets (CEA) as well as the change in adjusted environmental net worth (CNWead), which in turn allow us to estimate the environmental income (EI).

Tables 2 and S2-S3 show the sAAS, rSNA and rSEEA-EEA simplified sequence of ecosystem accounts in the modified from Obst et al. 2019 (Table 6, p. 33), which we have applied to the HOD case studies in Andalusia in order to estimate the environmental income. The results in the previously mentioned tables were estimated from the production and capital balance accounts data obtained in the AAS application to the HOD in Andalusia by Campos et al. (2019c).

First we describe the individual and aggregate results for each institutional sector under the sAAS (Table 2 and Fig. 1) and then we compare the sAAS results obtained with those of the rSNA and rSEEA-EEA. We focus on the values for ordinary net value added (NVAo), ordinary net operating surplus/margin (NOSo/NOMo), ecosystem service (ES), change in environmental asset (CEA), change in adjusted environmental net worth according (CNWead) to WPeu and environmental income (EI) (Tables 2-3, S2-S3 and Figs. 1-2-3, S1-S2).

In these applications of the sAAS and rSEEA-EEA at social price [22] to the HOD of Andalusia, the valuation at social price is done on the intermediate production side recording the ISSnca as well as on the cost side, registering own non-commercial intermediate consumption of ordinary services (SSncoo).

The latter arise from the use (intra-consumption) of the ISSnca imputed to the individual activities of the farmers.

[21] In the case of public activities where no manufactured costs are incurred the ecosystem service estimates of the rSEEA-EEA and sAAS coincide. In the HOD, this is the case for the water and carbon activities.

[22] The rSNA does not incorporate own non-commercial intermediate consumption of services arising from the opportunity costs of the HOD activities considered. This is why the results for both farmers and government are presented at basic prices in the SNA.

In this application of the sAAS to the HOD case studies, the ecosystem services contribute 35.0%, 65.9% and 45.2% respectively to the adjusted final products consumption (FPcad)[23] of the farmers, government and total (Table 2). Table 2 shows that the final products consumptions of mushrooms, recreational services, landscape conservation services and preservation of threatened wild biodiversity services exceed those of their respective ecosystem services. Only in the cases of the public products of carbon and economic water from forests retained in reservoirs do the values of their final products consumptions coincide with the respective values of their ecosystem services. This is due to the absence of manufactured costs in these cases (Table 2). As regards the institutional sectors in the HOD case studies, it can be seen that farmers contribute 43.3% to ordinary total net value added, 51.9% to total ecosystem services and 34.9% to total environmental income (Table 2).

Given that the holm oak is a fruiting species, the silvicultural practices employed promote an open canopy cover through early thinning and periodical pruning to encourage acorn production, grass and browse grazed by livestock, game species and other wild fauna. Thus, the ecosystem service of grazing accounts for 38.7% of the total ecosystem services provision of farmers (Table 2).

The main individual ecosystem service of the HOD is auto-consumption of the private amenity. Private non-industrial farmers implicitly pay for own intermediate consumption of the amenity (SSoa), which represents 57.3% of the final product auto-consumption of the amenity (FPcaa). The SSoa rises in accordance with the use of landowner residential dwelling services and voluntary manufactured opportunity costs incurred (SSncoo). The cultural ecosystem service of the amenity makes up 42.7% of the FPcaa and 66.0% of farmer total ecosystem services respectively (Table 2).

Table 2 shows that, although the mixture of holm oak woodland with conifer species and cork oak make up 0.8% of the total area of the HOD, the harvested products of timber and cork contribute marginally to the total final products consumption (FPc_{HOD}) and ecosystem services (ES_{HOD}) of the farmers, accounting for 2.5% and 4.2% respectively.

[23] Excludes final products consumption of conservation forestry, residential , commercial services, livestock and fire services activities.

Table 2. Stylized sequence of accounts of simplified AAS for private holm oak *dehesa* case studies in Andalusia, Spain (2010: €/ha).

Class	Farmer													Government								Holm oak *dehesas*
	Timber	Cork	Fire-wood	Nuts	Grazing	Cons. forestry	Hunting	Comm. recreation	Residential	Live-stock	Agri-culture	Amenity	Total	Fire services	Recreation	Mush-rooms	Carbon	Land-scape	Bio-diversity	Water	Total	
Production and generation of income accounts																						
.Total product consumption (TPc_{sAAS})	0.4	17.9	11.5		40.9	2.1	105.3	10.1	18.1	291.5	4.0	295.2	796.9	31.5	23.7	13.3	49.5	90.2	9.9	81.9	300.0	1,097.0
1.1 Intermediate products (IP_{sAAS})	0.4	4.4	1.6		40.3	2.1	75.6		14.0	111.7	0.8		251.1	31.5							31.5	282.6
1.1.1 Intermediate product SNA (IP_{rSNA})					27.6	1.6	18.0		14.0	33.9	0.8		96.1	31.5							31.5	127.5
1.1.2 Intermediate product non-SNA ($IP_{non\text{-}rSNA}$)	0.4	4.4	1.6		12.7	0.5	57.5			77.8			155.0									155.0
1.2 Final product consumption (FPc_{sAAS})		13.5	9.8		0.6		29.7	10.1	4.0	179.8	3.2	295.2	545.8		23.7	13.3	49.5	90.2	9.9	81.9	268.6	814.4
1.2.1 Final product consumption SNA (FPc_{rSNA})		13.5	9.8		0.6		29.7	10.1	4.0	179.8	3.2	14.0	264.7		7.1	13.3		77.1	4.8	69.6	171.8	436.5
1.2.2 Final produc consumption non SNA ($Fpc_{non\text{-}rSNA}$)												281.1	281.1		16.7		49.5	13.1	5.1	12.3	96.8	377.9
2. Ordinary total intermediate consumption (ICo_{sAAS})	0.1	8.8	3.1		5.9	0.4	55.6	7.1	1.6	334.5	2.7	169.1	588.9	10.2	2.3	0.1		69.9	1.5		84.0	672.9
2.1 Manuf. intermediate consump. bought SNA ($ICmob_{rSNA}$)	0.1	0.7	1.0		5.9	0.4	21.1	7.1	1.6	146.6	2.7		187.2	10.2	1.4	0.1		1.8	1.5		14.9	202.1
2.2 Own intermediate consumption ($ICmoo_{sAAS}$)							22.9			21.5		169.1	213.5		1.0			68.1			69.1	282.6
2.2.1 Own intermediate consumption SNA ($ICmoo_{rSNA}$)							22.9			21.5		14.0	58.4		1.0			68.1			69.1	127.5
2.2.2 Own intermediate consumption non SNA ($ICmoo_{non\text{-}rSNA}$)												155.0	155.0									155.0
2.3 Manufactured work in progress used (WPmu)										166.4			166.4									166.4
2.4 Environmental work in progress used (WPeu)		8.1	2.1				11.6						21.8									21.8
3. Ordinary gross value added ($GVAo_{sAAS}$)	0.3	9.1	8.3		35.0	1.7	49.7	3.0	16.5	-43.0	1.3	126.1	208.0	21.2	21.4	13.2	49.5	20.3	8.5	81.9	216.1	424.1
4. Ordinary consumption of fixed capital ($CFCo_{sAAS}$)	0.1	0.5	0.2		2.6	0.1	7.7	4.2	13.8	14.8	2.6		46.6	1.0	1.2	0.0		2.1	0.4		4.8	51.4
4.1 Manufactured consumption of fixed capital SNA ($CFCmo_{rSNA}$)	0.1	0.5	0.2		2.6	0.1	7.7	4.2	13.8	14.8	2.6		46.6	1.0	1.2	0.0		2.1	0.4		4.8	51.4
4.2 Ecosystem degradation non-SNA ($CFCeo_{non\text{-}rSNA}$)																						
5. Ordinary net value added ($NVAo_{sAAS}$)	0.2	8.6	8.1		32.4	1.6	41.9	-1.2	2.7	-57.8	-1.3	126.1	161.4	20.2	20.2	13.2	49.5	18.2	8.0	81.9	211.3	372.7
5.1 Labor cost (LCo_{sAAS})	0.2	8.1	3.2		5.1	1.2	19.8	5.6	8.2	44.0	3.9		99.3	20.2	3.6	0.1		5.1	2.9		31.8	131.1
5.1.1 Compensation of employees SNA ($LCoe_{rSNA}$)	0.2	8.1	2.0		5.1	1.2	19.4	5.6	8.0	42.6	3.9		96.2	20.2	3.6	0.1		5.1	2.9		31.8	128.0
5.1.2 Imputed compensation of self-employed non-SNA ($LCose_{sAAS}$)			1.2				0.3		0.1	1.4			3.1									3.1
5.2 Net operating margin ($NOMo_{sAAS}$)	0.0	0.5	4.9		27.3	0.4	22.2	-6.8	-5.5	-101.8	-5.2	126.1	62.1	0.0	16.7	13.1	49.5	13.1	5.1	81.9	179.5	241.5
5.2.1 Manufactured net operating margin ($NOMmo_{sAAS}$)	0.0	0.5	4.9		2.1	0.4	4.1	-6.8	-5.5	-101.8	-5.2		-107.2	0.0	1.0	0.5		0.2	0.8		2.5	-104.7
5.2.2 Environmental net operating margin ($NOMeo_{sAAS}$)					25.2		18.0					126.1	169.3		15.6	12.6	49.5	13.0	4.3	81.9	176.9	346.2
6. Ecosystem services (ES_{sAAS})		8.1	2.1		25.2		29.7					126.1	191.1		15.6	12.6	49.5	13.0	4.3	81.9	176.9	368.1
Changes in balance accounts																						
7. Changes in environmental asset (CEA_{sAAS})	1.6	57.7	6.9	0.0	-2.9							-187.7	-124.2				-3.2				-3.2	-127.4
8. Changes in adjusted environmental net worth ($CNWead_{sAAS}$)	1.6	57.7	6.9	0.0	-3.0		-0.3					-187.7	-124.6				-52.7				-52.7	-177.3
9. Environmental income (EI_{sAAS})	1.6	65.8	9.1	0.0	22.2		29.4					-61.6	66.5		15.6	12.6	-3.2	13.0	4.3	81.9	124.2	190.8

Number of private holm oak *dehesas*: 16. Surface: 9,032 hectares. Average surface: 565 hectares

The government final products consumption of landscape (FPcla) and water supply (FPcwa) are the largest individual public products accounting for 64.1% of the government total final products consumption and 53.6% of government ecosystem services (Table 2). While water activity does not incur manufactured cost, the landscape activity manufactured total cost represents 85.4% of the FPcla and the landscape ecosystem service accounts for 14.4% of the FPcla (Table 2).

Recreation, mushrooms, carbon and threatened wild biodiversity ecosystem services comprise 30.6% of the government final product consumption. Farmer and government activity ecosystem services contribute 35.0% and 65.9% to their respective final products consumptions.

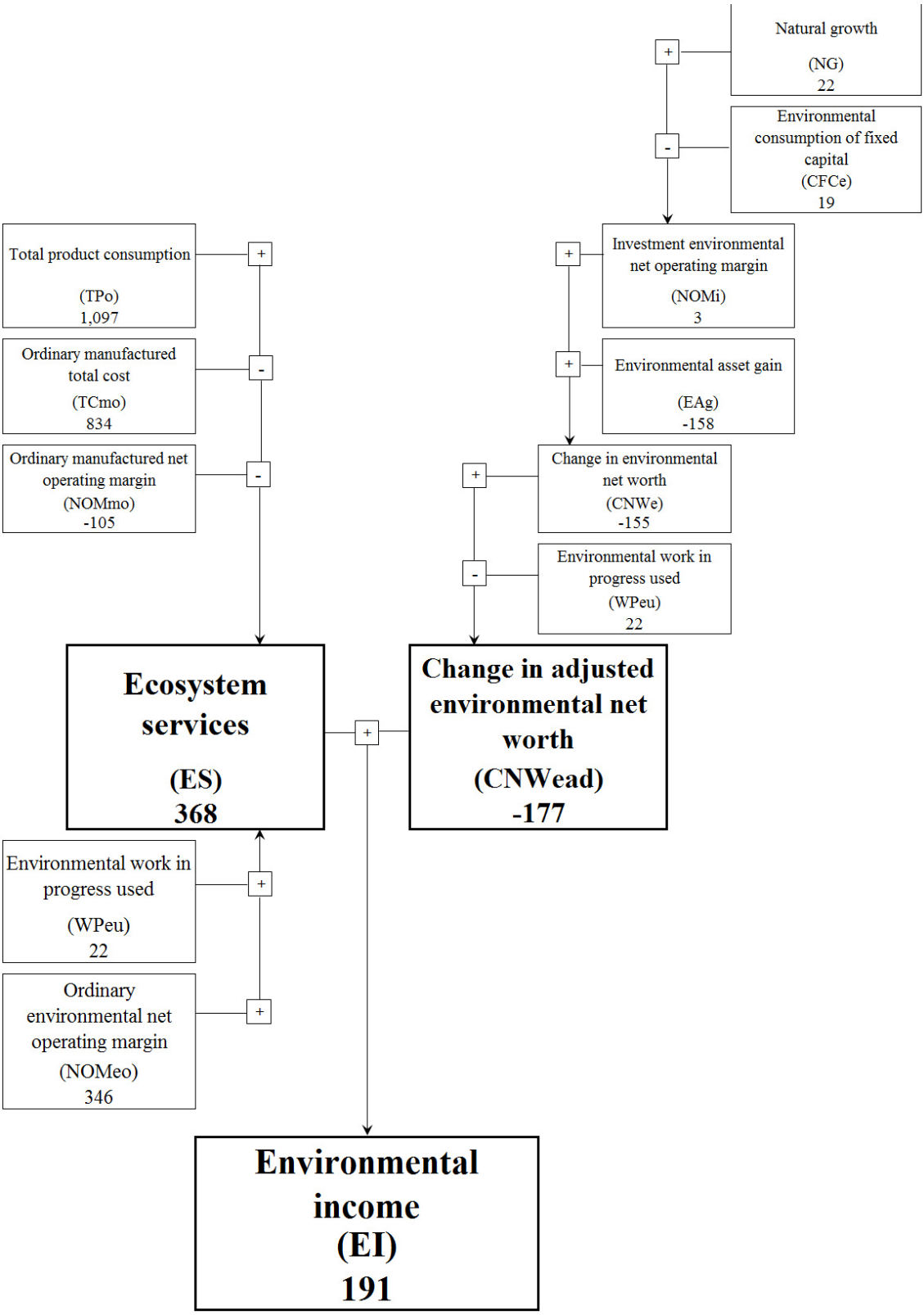
Environmental income is the key threshold indicator of the maximum value of economic sustainable ecosystem service for the period. A negative change in adjusted environmental net worth (CNWead) of an individual product in the period, as is the case in HOD for grazing, hunting, amenity and carbon, indicates overconsumption and often the decline in the environmental asset[24]. Fig. 1 reveals a total ecosystem service in the HOD case studies of 1.9 times the total environmental income. This ecosystem service overconsumption for the period is due to negative changes in adjusted environmental net worth of grazing, hunting, amenity and carbon (Table 2 and Fig. 1).

3.1.3. Ecosystem accounting framework comparisons

In the HOD case studies we focus the comparisons of the rSNA, rSEEA-EEA and sAAS results on the aggregate values for ordinary net value added (NVAo) at basic (rSNA) and social prices (rSEEA-EEA y sAAS), ecosystem service (ES), change in environmental asset (CEA), change in adjusted environmental net worth according to WPeu (CNWead) and environmental income (EI) for both farmers and government (Table 3 and Figs. 2-3)[25].

[24] Although the change in the value of the environmental asset (CEA) is a real measurement, this may not be the case for the CNWead. The latter incorporates the instrumental adjustment of the environmental asset (EAad) in the environmental asset gain estimate (EAg). By correcting the overvaluation of the ordinary environmental net operating margin (NOMeo) and unexpected game captures, the EAad explains the potential simultaneous existence of positive CEA and negative CNWead values, as is the case of carbon in this study (Table 2 and Fig.1).

[25] The results presented in Table 3 come from Tables 2, S2-S3, the latter having been drawn up from the results of Campos et al. (2019c).



Number of private holm oak *dehesas*: 16. Surface: 9,032 hectares. Average surface: 565 hectares

Figure 1. Total environmental income of simplified AAS for private holm oak *dehesa* case studies in Andalusia, Spain (2010: €/ha).

If we assume that the sAAS gives consistent total environmental income estimates in ecosystem accounting, then the rSNA undervalues the positive estimates of NVAo, ES and EI (Table 3 and Figs. 2-3). The rSNA also undervalues the negative result of the CNWead (Tables 3, S2). As the rSEEA-EEA ignores the government costs of public activities it is to be expected that it will overvalue the government NVAo, ES and EI (Tables 3, S3). However, the rSEEA-EEA and sAAS give the same estimate of CNWead. It should be emphasized that the activities most affected by our SNA and SEEA-EA refinements are those of amenity and landscape.

Table 3 and Figs. 2-3 show the aggregate results for the institutional sectors in the HOD case studies. Although the comparisons of the aggregate results lack conceptual consistency, they are of interest because they highlight the limitations of the rSNA and sSEEA-EEA in terms of measuring the differences in the values estimated by the accounting frameworks compared as regards the NVAo, ES, CEA, CNWead and EI of the 19 economic activities of the HOD case studies valued in this work.

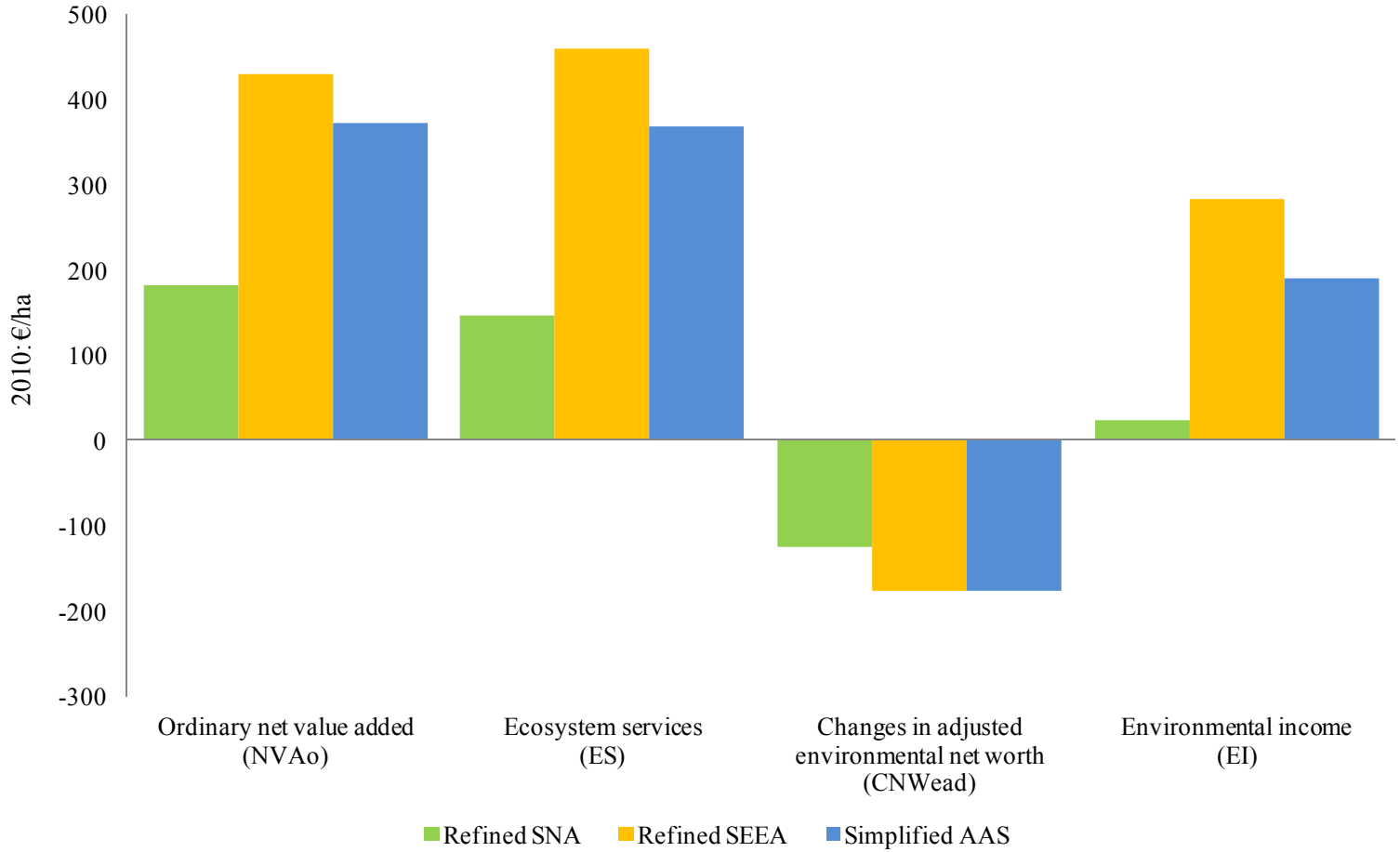
The results of the indexes compared for the ecosystem service and income indicators in the rSNA and rSEEA methodologies in comparison to the base sAAS methodology reveal similar commercial values, except for the ordinary net value added (NVAo) in the rSEEA, due to the omission of the fire service activity (Tables 4-S4).

The non-commercial indexes in Tables 4-S4 show notable undervaluation in the rSNA and overvaluations in the rSEEA, in the former due to the omission of the carbon activity and the valuation of final public products without market prices at production cost. The bias towards overvaluation in the rSEEA is due to the omission of ecosystem institutional sector activity costs.

Table 3. Ecosystem accounting: stylized refined SNA and SEEA-EEA versus simplified AAS sequence of accounts for private holm oak *dehesa* case studies in Andalusia, Spain (2010: €/ha).

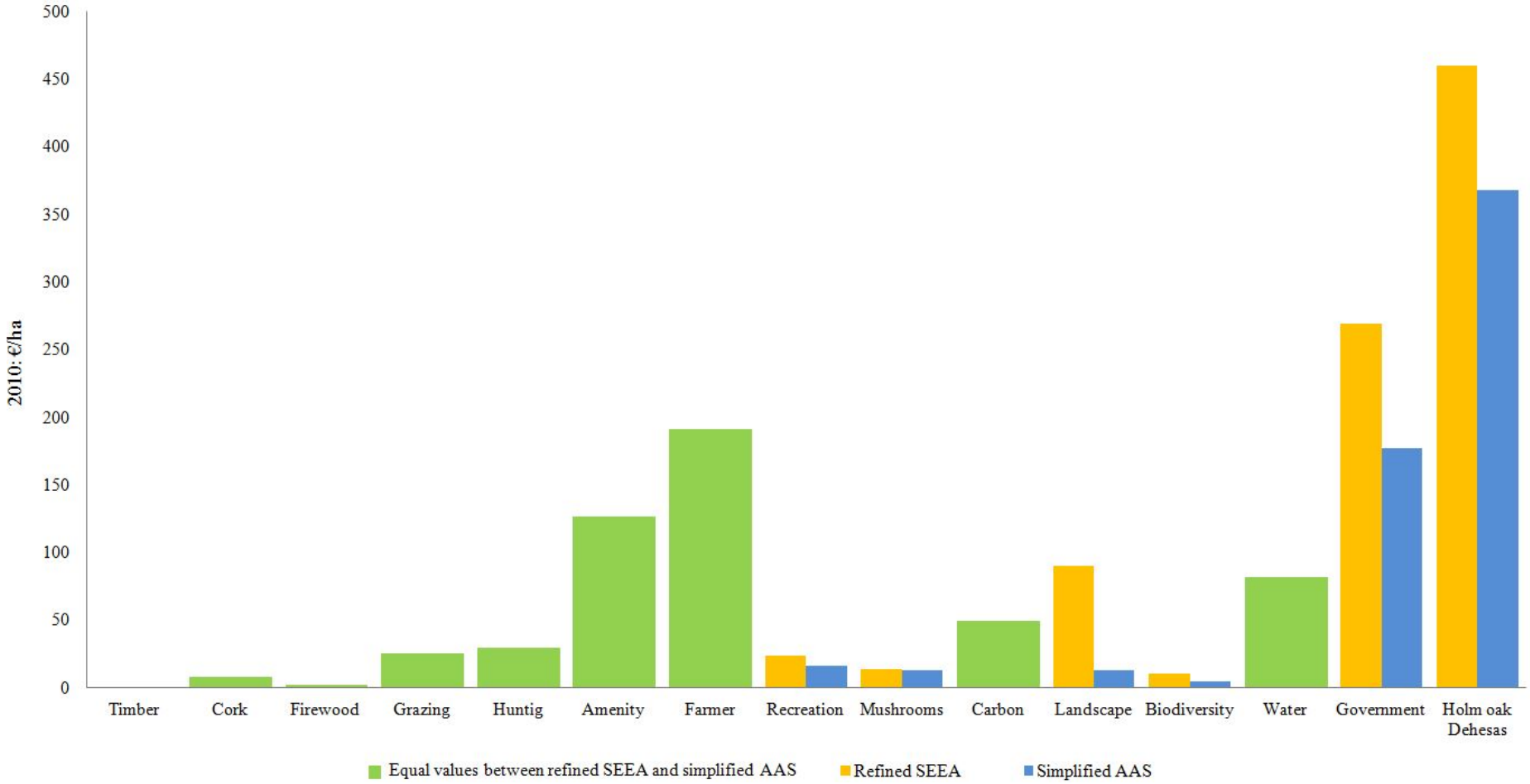
Class	Refined SNA			Refined SEEA			Simplified AAS		
	Farmer	Government	Holm oak *dehesas*	Farmer	Ecosystems	Holm oak *dehesas*	Farmer	Government	Holm oak *dehesas*
Production and generation of income accounts									
1. Total product consumption (TPc)	360.8	203.3	564.1	796.9	268.6	1,065.5	796.9	300.0	1,097.0
1.1 Intermediate products (IP)	96.1	31.5	127.5	251.1		251.1	251.1	31.5	282.6
1.1.1 Intermediate product SNA (IP_{rSNA})	96.1	31.5	127.5	96.1		96.1	96.1	31.5	127.5
1.1.2 Intermediate product non-SNA ($IP_{non\text{-}rSNA}$)				155.0		155.0	155.0		155.0
1.2 Final product consumption (FPc)	264.7	171.8	436.5	545.8	268.6	814.4	545.8	268.6	814.4
1.2.1 Final product consumption SNA (FPc_{rSNA})	264.7	171.8	436.5	264.7	82.9	347.6	264.7	171.8	436.5
1.2.2 Final produc consumption non SNA ($Fpc_{non\text{-}rSNA}$)				281.1	185.7	466.8	281.1	96.8	377.9
2. Ordinary total intermediate consumption (ICo)	245.9	84.0	329.9	588.9		588.9	588.9	84.0	672.9
2.1 Ordinary intermediate consumption SNA (ICo_{rSNA})	245.9	84.0	329.9	245.6		245.6	245.6	84.0	329.6
2.2 Ordinary intermediate consumption non-SNA ($ICo_{non\text{-}rSNA}$)				343.3		343.3	343.3		343.3
3. Ordinary gross value added (GVAo)	114.8	119.3	234.2	208.0	268.6	476.6	208.0	216.1	424.1
4. Ordinary consumption of fixed capital (CFCo)	46.6	4.8	51.4	46.6		46.6	46.6	4.8	51.4
4.1 Manufactured consumption of fixed capital SNA ($CFCmo_{rSNA}$)	46.6	4.8	51.4	46.6		46.6	46.6	4.8	51.4
4.2 Ecosystem degradation non-SNA ($CFCeo_{non\text{-}rSNA}$)									
5. Ordinary net value added (NVAo)	68.2	114.5	182.7	161.4	268.6	429.9	161.4	211.3	372.7
5.1 Labor cost (LCo)	99.3	31.8	131.1	99.3		99.3	99.3	31.8	131.1
5.1.1 Compensation of employees SNA ($LCoe_{rSNA}$)	99.3	31.8	131.1	96.2		96.2	96.2	31.8	128.0
5.1.2 Imputed compensation of self-employed non-SNA ($LCose_{non\text{-}rSNA}$)				3.1		3.1	3.1		3.1
5.2 Net operating surplus/ margin (NOS/NOMo)	-31.1	82.7	51.6	62.1	268.6	330.7	62.1	179.5	241.5
6. Ecosystem services (ES)	65.0	82.2	147.2	191.1	268.6	459.7	191.1	176.9	368.1
Changes in balance accounts									
7. Changes in environmental asset (CEA)	-124.2		-124.2	-124.2	-3.2	-127.4	-124.2	-3.2	-127.4
8. Changes in adjusted environmental net worth (CNWead)	-124.6		-124.6	-124.6	-52.7	-177.3	-124.6	-52.7	-177.3
9. Environmental income (EI)	-59.6	82.2	22.6	66.5	215.9	282.4	66.5	124.2	190.8

Number of private holm oak *dehesas*: 16. Surface: 9,032 hectares. Average surface: 565 hectares



Number of private holm oak *dehesas*: 16. Surface: 9,032 hectares. Average surface: 565 hectares

Figure 2. Selected environmental-economic ecosystem indicators measured using refined SNA and SEEA-EEA versus simplified AAS for private holm oak *dehesa* case studies in Andalusia, Spain (2010: €/ha).



Number of private holm oak *dehesas*: 16. Surface: 9,032 hectares. Average surface: 565 hectares

Figure 3. Ecosystem accounting**:** individual ecosystem services measured by refined SEEA-EEA and simplified AAS for private holm oak *dehesa* case studies in Andalusia, Spain (2010: €/ha).

Table 4. Income and ecosystem service index indicator comparisons by aggregate commercial and non-commercial activities for refined SNA, refined SEEA and simplified AAS for private holm oak *dehesa* case studies in Andalusia, Spain (Indexes rSNA/sAAS and rSEEA/sAAS: 2010).

Class	Commercial activities			Non-commercial activities				Holm oak *dehesas*
	Woody products	Non-woody products	Total	Amenity	Land-scape	Others	Total	
1. Ordinary net valued added (NVAo)								
rSNA/sAAS	1.22	1.76	1.59	0.00	0.28	0.52	0.30	0.49
rSEEA/sAAS	1.00	0.48	0.64	1.00	4.96	1.03	1.24	1.15
2. Ordinary net operating surplus (NOSo)/margin (NOMo)								
rSNA/sAAS	1.69	0.58	0.49	0.00	0.00	0.50	0.27	0.21
rSEEA/sAAS	1.00	1.00	1.00	1.00	6.86	1.07	1.29	1.37
3. Ecosystem services (ES)								
rSNA/sAAS	1.00	1.00	1.00	0.00	0.00	0.50	0.27	0.40
rSEEA/sAAS	1.00	1.00	1.00	1.00	6.95	1.09	1.30	1.25
4. Changes in environmental asset (CEA)								
rSNA/sAAS	1.00	1.00	1.00	1.00		0.00	0.98	0.98
rSEEA/sAAS	1.00	1.00	1.00	1.00		1.00	1.00	1.00
5. Changes in environmental net worth adjusted (CNWead)								
rSNA/sAAS	1.00	1.00	1.00	1.00		0.00	0.78	0.70
rSEEA/sAAS	1.00	1.00	1.00	1.00		1.00	1.00	1.00
6. Environmental income (EI)								
rSNA/sAAS	1.00	1.00	1.00	3.05	0.00	0.74	-1.68	0.12
rSEEA/sAAS	1.00	1.00	1.00	1.00	6.95	1.13	2.46	1.48

Number of private holm oak *dehesas*: 16. Surface: 9,032 hectares. Average surface: 565 hectares

The indexes of individual activity of sustainability in Table 5 show values of more than one, except for the amenity and carbon activities. The interpretation of the meaning of unsustainability of the amenity in the period lacks biophysical significance and is due exclusively to the inter-annual volatility of the variation in land prices, which do not change the long term tendency to real positive variations of around 3% (Ovando et al., 2016). In the case of carbon activity the overconsumption is due to the convention of attributing emission to negative environmental capital formation (fixed environmental capital consumption), since the environmental income is slightly positive (Tables 2-5)

The comparison of the results of the ecosystem accounting framework applications reveals that it is conceptually and functionally possible (and in consistency with the exchange value) to make visible the sAAS valuations and extensions to the SNA and SEEA-EEA embraced in the rSNA and rSEEA-EEA, maintaining the valuations of products with market price at observed market prices, at production cost in the case of final products consumption without market price in the rSNA and at simulated prices in this case for the rSEEA-EEA and sAAS. With respect to the

simplified system of accounts of Obst et al., 2019 (Table 6, p. 33), the extensions to the ecosystem accounting frameworks compared involve reclassifications and incorporations of new variables along with the government institutional sector in the rSNA (Tables 2-3, S1-S2 and Figs. S2-S3).

Table 5. Environmental income and ecosystem service indexes by individual activities, institutional sectors and accounting frameworks for private holm oak *dehesa* case studies in Andalusia, Spain (Index EI/ES: 2010).

Class	Refined SNA	Refined SEEA	Simplified AAS
1. Farmer	-0.92	0.35	0.35
1.1 Timber			
1.2 Cork	8.15	8.15	8.15
1.3 Firewood	4.24	4.24	4.24
1.4 Nuts			
1.5 Grazing	0.88	0.88	0.88
1.6 Conservation forestry[a]			
1.7 Hunting	0.99	0.99	0.99
1.8 Commercial recreation[a]			
1.9 Residential[a]			
1.10 Livestock[a]			
1.11 Agriculture[a]			
1.12 Amenity		-0.49	-0.49
2. Government[b]/Ecosystems[c]	1.00	0.80	0.70
2.1 Fire services[a]			
2.2 Recreation		1.00	1.00
2.3 Mushrooms	1.00	1.00	1.00
2.4 Carbon		-0.06	-0.06
2.5 Landscape		1.00	1.00
2.6 Biodiversity	0.00	1.00	1.00
2.7 Water	1.00	1.00	1.00
Holm oak *dehesas*	0.15	0.61	0.52

[a] is non-applicable.
[b] for refined SNA and simplified AAS.
[c] for refined SEEA.
SEEIj = EIj/ESj ≥ 1, then j total product consumption (TPcj) is sustainable.

3.2. Discussion

We focus the discussion on the conceptual structures of the three ecosystem accounting frameworks applied in the HOD case studies to the measurement of farmer, government and total environmental incomes. The most significant conceptual changes incorporated in the sequence of accounts of Obst et al. (2019: Table 6, p. 33) at farm scale are discussed below (see Tables 2-3, S2-S3).

The rSNA final product consumption of ecosystem services ($FPc_{non\text{-}SNA}$) is not accounted for as it is embedded in the SNA intermediate and final products. Given its

condition as ongoing environmental work in progress used (WPeu) at the opening of the period, it would be inconsistent to consider the WPeu as an intermediate product. We include government SNA final product consumption (FPc_{SNA}) public products without market price at production costs (recreation, landscape and biodiversity) and public products with market prices (mushrooms and water) in the rSNA.

The non-SNA final product consumption ($FPc_{non\text{-}SNA}$) in the rSEEA-EEA and sAAS components are non-SNA ordinary intermediate consumption ($IC_{non\text{-}SNA}$) and ecosystem services ($ES_{non\text{-}SNA}$) not accounted for in the SNA, and the market value of the public products of mushrooms and water.

Our sAAS incorporates the government institutional sector as collective owner of the public economic activities. We consider the total product consumption (TPc_{rAAS}) of (i) fire services measured at production cost, (ii) mushrooms, water and carbon at market prices, and (iii) recreation, landscape and biodiversity at the marginal price of consumer willingness to pay. We then separate the TPc_{rAAS} into SNA final product consumption (FPc_{SNA}) and non-SNA final product consumption ($FPc_{non\text{-}SNA}$) (see Tables 2-3, S2-S3).

The ES in the rSEEA-EEA is larger than that of the sAAS because the former omits the total ordinary costs to the public farmer and government incurred in the management and regulation of ordinary total public products. The rSEEA-EEA public ecosystem services ($ES_{rSEEA\text{-}EA}$) estimates are considered an overvaluation, except for water and carbon because these products do not have ordinary manufactured costs.

There has been no degradation in the future physical productivities of HOD economic activities where long term horizon scheduled sustainable biological modeling is considered (Campos et al., 2019a, 2019c), and when estimating the changes in environmental assets at environmental price (unit resource rent) discounted at the closing of the period, a greater environmental asset value is obtained for each individual activity than that at the opening of the period, except for grazing, private amenity and carbon environmental assets. The negative environmental asset change in the case of the private amenity is due to the market land price decrease in 2010.

An overvaluation of the ordinary net operating surplus (NOSo) is incurred in the rSNA compared with the ordinary net operating margin in the rSEEA-EEA and sAAS frameworks. This is due to the inclusion in the rSNA of the environmental work in progress used (WPeu) in the NOSo, the latter being an input from the cork inventory at the opening of the period (work in progress produced years previously), and it is not considered by the SNA as intermediate consumption of the economic activities in the

period. In contrast to the rSNA criterion, the criterion of the rSEEA-EEA and sAAS as regards the NOMois to exclude WPeu.

The consumption of manufactured fixed capital of plantations are not included in timber, cork, firewood and grazing (acorns) activities. Since they are produced by government compensation as part of the public landscape conservation service, we register them under an activity that we designate 'conservation forestry' (see details in Campos et al, 2019a). The use of manufactured fixed capital equipment is imputed in the intermediate consumption of services paid for by the farmer to contracted corporate services.

In these HOD case studies the CNWead and CEA differ with regard to grazing, hunting and carbon activity. This is due to our assumption that carbon emission involves consumption of environmental asset (CFCe). That is, carbon emission is not embedded in the ordinary final product (carbon fixation).

These HOD case studies reveal that the environmental income from individual products for the period can coincide with the sustainable economic ecosystem services. We establish this hypothesis with the following future steady state assumptions: (i) the changes in environmental assets are zero in future indefinite periods for recreation, mushrooms, water, landscape and wild biodiversity; (ii) the biological cycles of the current tree plantations for timber (conifer trees), cork (cork oak) and firewood (holm oak) and their assumed future natural regeneration give a positive change in adjusted environmental net worth adjusted according to WPeu (CNWead > 0). In simpler terms, given that the environmental income from timber, cork and firewood exceed their respective ecosystem services, it is consistent to conceptualize the EI as a sustainable ecosystem service value of these woody products, which we can consume in the period without reducing the value of their environmental asset at closing, and (ii) it is reasonable to assume that the ecosystem services and the environmental income from commercial woody products will have the same values regardless of the ecosystem accounting framework applied. This is not the case with the ecosystem services of private amenity and public non-market final product consumptions, due to the fact that their ES and EIs have been omitted completely in the rSNA and the ecosystem institutional sector in the rSEEA-EEA does not include manufactured cost of the public ordinary final goods and services.

In summary, as regards the updating of the mainstream concept of ecosystem services (ES) and environmental assets of forest and woodland landscapes, and holm

oak dehesas we acknowledge a general agreement that standard SNA economic activities should be refined to incorporate non-market total products and incomes at regional/national and individual corporate scales (Atkinson and Obst, 2017; Edens et al., 2013; Krutilla, 1967; Stone, 1984; La Notte et al., 2019a, 2019b), economic rent (resource rent) as the true value of the ES for the period and, all else being equal, their future discounted flows should give the environmental asset values for the period. No main stream scientific discrepancies exist as regards the concept of environmental income, but the lack of standard, complete sequences of ecosystem accounts means that, in practice, multiple terms continue to be used such as environmental income, ecosystem income or sustainable potential flow without distinguishing whether they are referring to nature ecosystem service or income. These two concepts in steady state management give similar economic figures, but they usually differ when over/under use of natural resources exists.

4. Policy implications

At the current stage of discussion of the SEEA-EEA guidelines, a policy challenge is "to explore the current state of play and opportunities for alignment between the public and private sectors when it comes to the SEEA" (Lammerant, 2019: p. 1). Thus, the sustainable management aspect of renewable environmental assets should encourage concerted action on management plans between corporations and the government. In the HCD these farmers and governments contracts, given amounts of individual physical environmental assets above the conservation threat threshold, could be agreed on the basis of previous knowledge on the preferences of the owners as regards payment of self-consumption of private amenities (ISSnca), donations of non-commercial intermediate products (ISSncd) and the effective economic demands by public consumers (represented by the government) for total products consumption dependent on the private management of silvopastoral landscapes.

The available information on the private economies of the *dehesa* case studies in Andalusia and Extremadura reveals the predominance of non-competitive rates of operating profit for the commercial activities[26] at basic prices (Campos et al., 2017; Ovando et al., 2016; Oviedo et al., 2017). In the long term, the sequence of recurrent

[26] The commercial activities exclude the private amenity activity.

periods of negative commercial net operating margin at basic prices arises from the the existence of a final amenity service product without market price (FPcpa) which is auto-consumed by the private non-industrial owner of the land and livestock. (Campos et al., 2019a, 2019b, 2019c; Ovando et al., 2016; Oviedo et al., 2017).

The challenge to be addressed is that of estimating the exact value of the public payment for the expected non-voluntary opportunity cost of the manufactured investment of the owner for the production of compensated non-commercial intermediate services (ISSncc). We estimate the value of the ISSncc once we have determined the private owners' willingness to pay for the contribution of the individual activity to their use of the private amenities. In this case the expected voluntary opportunity cost incurred by the non-industrial owner is represented by the amenity service non-commercial intermediate production (ISSnca) of the activity receiving the possible compensation for undertaking the new investment and/or avoiding the management abandonment.

The positive residual value of the ISSncc[27] is estimated by the difference between the normal ordinary net operating margin ($NOMon_{rAAS}$) less the ordinary net operating margin at basic price ($NOMo_{pb,rAS}$) and the ISSnca:

$$ISSncc = NOMon_{rAAS} - NOMo_{pb,rAS} - ISSnca \quad \text{(eq. 34)}$$

We estimate the $NOMon_{rAAS}$ based on the subjective assumption of what is considered a normal real rate of private operating profit from the ordinary manufactured capital invested during the period.

In the HOD case studies, the public consumers can reveal/declare a willingness to pay (WTP if they are unsure which owner may cease or reduce the future offer of public services which they use in the period. Having verified the existence of an ISSncc value > 0, the owner can legitimately claim compensation additional to that currently estimated by the ISSncc from the beneficiaries of the public service consumption in the HOD case studies, if the WTP ≥ ISSncc.

One issue associated with the abovementioned ISSncc estimation is that it is necessary to determine the ISSnca value according to the type of management of the individual activity. A second issue is that the beneficiaries must reveal/declare their

[27] A negative ISSncc residual value indicates the existence of excess operating marging (profits) at basic price for the individual activity.

DAP in order to determine whether it equals or exceeds the ISSncc, which would maintain and/or improve the sustainability of the management in the HOD case studies.

One critical aspect when attempting to reach agreement on compensation for maintaining/improving sustainability is the legitimacy of the payment according to the initial economic property rights of the owners and public consumers prior to the agreement. Public compensation is legitimate if it is based on reciprocation for the loss of economic value of a previous legal use which will be lost in the future and/or loss of profit from a private investment due to a new action aimed at improving/mitigating potential abandonment, which favours the future offer of ordinary public products.

5. Concluding remarks

In these HOD case studies we have focused attention on the economic rationale of private owner amenity consumers and the rationale of the government interested in the sustainability of biological environmental asset management. We have not included other non-profit institutional organizations in these HOD case studies, such as public owners and NGOs, which can contribute to the non-commercial intermediate production of donation services (ISSncd) in order to ensure the continuity/improvement of nature based public products.

We have shown that since the accounting systems compared are based on the exchange value declared/revealed by the consumers through their consumption of the final products consumption, they are applicable regardless of the territorial unit size considered.

One of the most consistent arguments in favour of implanting ecosystem accounting at individual corporation scale refers to the fact that the voluntary opportunity cost of the individual activities of the owners can only be estimated at individual corporation scale. It follows therefore that the SEEA-EEA applied to an ecosystem type at regional/national scale must be based on prior application at corporation scale in order to provide consistent values for the ecosystem services and environmental assets of the economic activities when the owners and the government incur voluntary opportunity costs. In other words, the ecosystem accounting methodology must value the net operating margin of the individual activities at social prices, since their estimation at social prices can lead to biased valuations of the ecosystem services.

Finally, concerted action by both the owners and the government as regards public compensation for additional production of public goods and services based on scientific knowledge could increase the likelihood of acceptance by active public consumers (e.g. recreation services) and passive consumers (e.g. landscape services). However, for the moment, the sustainable governance expressed in government agendas is still pending, awaiting future approval of the ecosystem accounting frameworks and associated new budgets for the departments of statistics in order to produce harmonized farm type ecosystem accounts at individual activity scale, suitable for providing the scientific information which could legitimize, in the eyes of society, agreements between governments and corporations which manage threatened renewable environmental assets and, where possible, improve the provision of environmental goods and services under conditions of ecological sustainability.

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Appendix: Supplementary material

Agroforestry Accounting System environmental incomes compared with SNA and SEEA-EEA at corporation scale: applications to holm oak *dehesas* in Andalusia-Spain

This appendix includes:

Supplementary tables for

Agroforestry Accounting System environmental incomes compared with SNA and SEEA-EEA at corporation scale: applications to holm oak *dehesas* in Andalusia-Spain

Table S1. Indixes indicators of opening environmental assets and manufactured fixed capital by aggregate commercial and non-commerical activities for refined SNA, refined SEEA and simplified AAS for private holm oak *dehesas* case studies in Andalusia (2010).

Class	Commercial activities			Non-commercial activities				Holm oak *dehesas*
	Woody products	Non-woody products	Total	Amenity	Land-scape	Others	Total	
1. Opening environmental asset (EAo)								
rSNA/sAAS	1.00	1.00	1.00	1.00	0.00	0.62	0.76	0.82
rSEEA/sAAS	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.1 Work in progress (WP)								
rSNA/sAAS	1.00	1.00	1.00					1.00
rSEEA/sAAS	1.00	1.00	1.00					1.00
1.2 Environmental fixed asset land (EFAl)								
rSNA/sAAS	1.00	1.00	1.00	1.00	0.00	0.62	0.76	0.80
rSEEA/sAAS	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.3 Environmental fixed asset biological resources (EFAbr)								
rSNA/sAAS	1.00	1.00	1.00					1.00
rSEEA/sAAS	1.00	1.00	1.00					1.00
2. Manufactured capital (FCm)								
rSNA/sAAS	1.00	1.00	1.00		1.00	1.00	1.00	1.00
rSEEA/sAAS	1.00	0.97	0.97		0.00	0.00	0.00	0.93
3. Opening capital (Co)								
rSNA/sAAS	1.00	1.00	1.00	1.00	0.01	0.63	0.76	0.85
rSEEA/sAAS	1.00	0.98	0.99	1.00	0.99	0.98	0.99	0.99

Number of private holm oak *dehesas*: 16. Surface: 9,032 hectares. Average surface: 565 hectares

Table S2. Stylized sequence of accounts of refined SNA for private holm oak *dehesas* case studies in Andalusia, Spain (2010: €/ha).

Class	Farmer													Government								Holm oak *dehesas*
	Timber	Cork	Fire-wood	Nuts	Gra-zing	Cons. forestry	Hun-ting	Comm. recreation	Resi-dential	Live-stock	Agri-culture	Amenity	Total	Fire services	Recrea-tion	Mush-rooms	Carbon	Land-scape	Bio-diversity	Water	Total	
Production and generation of income accounts																						
1. Total product consumption (TPc_{rSNA})		13.5	9.8		28.2	1.6	47.8	10.1	18.1	213.7	4.0	14.0	360.8	31.5	7.1	13.3		77.1	4.8	69.6	203.3	564.1
1.1 Intermediate products (IP_{rSNA})					27.6	1.6	18.0		14.0	33.9	0.8		96.1	31.5							31.5	127.5
1.1.1 Intermediate product SNA (IP_{rSNA})					27.6	1.6	18.0		14.0	33.9	0.8		96.1	31.5							31.5	127.5
1.1.2 Intermediate product non-SNA ($IP_{non\text{-}rSNA}$)																						
1.2 Final product consumption (FPc_{rSNA})		13.5	9.8		0.6		29.7	10.1	4.0	179.8	3.2	14.0	264.7		7.1	13.3		77.1	4.8	69.6	171.8	436.5
1.2.1 Final product consumption SNA (FPc_{rSNA})		13.5	9.8		0.6		29.7	10.1	4.0	179.8	3.2	14.0	264.7		7.1	13.3		77.1	4.8	69.6	171.8	436.5
1.2.2 Final product consumption non SNA ($Fpc_{non\text{-}rSNA}$)																						
2. Ordinary total intermediate consumption (ICo_{rSNA})	0.1	0.7	1.0		5.9	0.4	44.0	7.1	1.6	168.3	2.7	14.0	245.9	10.2	2.3	0.1		69.9	1.5		84.0	329.9
2.1Manufactured intermediate consumption bought SNA ($ICmob_{rSNA}$)	0.1	0.7	1.0		5.9	0.4	21.1	7.1	1.6	146.9	2.7		187.5	10.2	1.4	0.1		1.8	1.5		14.9	202.4
2.2 Own intermediate consumption ($ICmoo_{rSNA}$)							22.9			21.5		14.0	58.4		1.0			68.1			69.1	127.5
2.2.1 Own intermediate consumption SNA ($ICmoo_{rSNA}$)							22.9			21.5		14.0	58.4		1.0			68.1			69.1	127.5
2.2.2 Own intermediate consumption non SNA ($ICmoo_{non\text{-}rSNA}$)																						
3. Ordinary gross value added ($GVAo_{rSNA}$)	-0.1	12.7	8.8		22.3	1.2	3.8	3.0	16.5	45.4	1.3		114.8	21.2	4.7	13.2		7.2	3.3	69.6	119.3	234.2
4. Ordinary consumption of fixed capital ($CFCo_{rSNA}$)	0.1	0.5	0.2		2.6	0.1	7.7	4.2	13.8	14.8	2.6		46.6	1.0	1.2	0.0		2.1	0.4		4.8	51.4
4.1 Manufactured consumption of fixed capital SNA ($CFCmo_{rSNA}$)	0.1	0.5	0.2		2.6	0.1	7.7	4.2	13.8	14.8	2.6		46.6	1.0	1.2	0.0		2.1	0.4		4.8	51.4
4.2 Ecosystem degradation non-SNA ($CFCeo_{non\text{-}rSNA}$)																						
5. Ordinary net value added ($NVAo_{rSNA}$)	-0.2	12.3	8.6		19.7	1.1	-4.0	-1.2	2.7	30.6	-1.3		68.2	20.2	3.6	13.2		5.1	2.9	69.6	114.5	182.7
5.1 Labor cost (LCo_{rSNA})	0.2	8.1	3.2		5.1	1.2	19.8	5.6	8.2	44.0	3.9		99.3	20.2	3.6	0.1		5.1	2.9		31.8	131.1
5.1.1 Compensation of employees SNA ($LCoe_{rSNA}$)	0.2	8.1	2.0		5.1	1.2	19.4	5.6	8.0	42.6	3.9		96.2	20.2	3.6	0.1		5.1	2.9		31.8	128.0
5.1.2 Imputed compensation of self-employed non-SNA ($LCose_{non\text{-}rSNA}$)			1.2				0.3		0.1	1.4			3.1									3.1
5.2 Net operating surplus ($NOSo_{rSNA}$)	-0.4	4.2	5.4		14.6	-0.1	-23.7	-6.8	-5.5	-13.4	-5.2		-31.1	0.0		13.1		0.0	0.0	69.6	82.7	51.6
5.2.1 Manufactured net operating margin ($NOMmo_{rSNA}$)	-0.4	-3.9	3.2		-10.6	-0.1	-53.4	-6.8	-5.5	-13.4	-5.2		-96.1	0.0		0.5		0.0	0.0		0.5	-95.6
5.2.2 Environmental net operating margin ($NOMeo_{rSNA}$)					25.2		18.0						43.2			12.6				69.6	82.2	125.4
5.2.3 Environmental work in progress used (WPeu)		8.1	2.1				11.6						21.8									21.8
6. Ecosystem services (ES_{rSNA})		8.1	2.1		25.2		29.7						65.0			12.6				69.6	82.2	147.2
Changes in balance accounts																						
7. Changes in environmental asset (CEA_{rSNA})	1.6	57.7	6.9	0.0	-2.9							-187.7	-124.2									-124.2
8. Changes in adjusted environmental net worth ($CNWead_{rSNA}$)	1.6	57.7	6.9	0.0	-3.0		-0.3					-187.7	-124.6									-124.6
9. Environmental income (EI_{rSNA})	1.6	65.8	9.1	0.0	22.2		29.4					-187.7	-59.6			12.6				69.6	82.2	22.6

Number of private holm oak *dehesas*: 16. Surface: 9,032 hectares. Average surface: 565 hectares

Table S3. Stylized sequence of accounts of refined SEEA for private holm oak *dehesas* case studies in Andalusia, Spain (2010: €/ha).

Class	Farmer													Government								Holm oak *dehesas*
	Timber	Cork	Fire-wood	Nuts	Gra-zing	Cons. forestry	Hun-ting	Comm. recreation	Resi-dential	Live-stock	Agri-culture	Amenity	Total	Fire services	Recrea-tion	Mush-rooms	Carbon	Land-scape	Bio-diversity	Water	Total	
Production and generation of income accounts																						
1. Total product consumption (TPc_{rSEEA})	0.4	17.9	11.5		40.9	2.1	105.3	10.1	18.1	291.5	4.0	295.2	796.9		23.7	13.3	49.5	90.2	9.9	81.9	268.6	1,065.5
1.1 Intermediate products (IP_{rSEEA})	0.4	4.4	1.6		40.3	2.1	75.6		14.0	111.7	0.8		251.1									251.1
1.1.1 Intermediate product SNA (IP_{rSNA})					27.6	1.6	18.0		14.0	33.9	0.8		96.1									96.1
1.1.2 Intermediate product non-SNA ($IP_{non\text{-}rSNA}$)	0.4	4.4	1.6		12.7	0.5	57.5			77.8			155.0									155.0
1.2 Final product consumption (FPc_{rSEEA})		13.5	9.8		0.6		29.7	10.1	4.0	179.8	3.2	295.2	545.8		23.7	13.3	49.5	90.2	9.9	81.9	268.6	814.4
1.2.1 Final product consumption SNA (FPc_{rSNA})		13.5	9.8		0.6		29.7	10.1	4.0	179.8	3.2	14.0	264.7			13.3				69.6	82.9	347.6
1.2.2 Final produc consumption non SNA ($Fpc_{non\text{-}rSNA}$)												281.1	281.1		23.7		49.5	90.2	9.9	12.3	185.7	466.8
2. Ordinary total intermediate consumption (ICo_{rSEEA})	0.1	8.8	3.1		5.9	0.4	55.6	7.1	1.6	334.5	2.7	169.1	588.9									588.9
2.1Manufactured intermediate consumption bought SNA ($ICmob_{rSNA}$)	0.1	0.7	1.0		5.9	0.4	21.1	7.1	1.6	146.6	2.7		187.2									187.2
2.2 Own intermediate consumption ($ICmoo_{rSEEA}$)							22.9			21.5		169.1	213.5									213.5
2.2.1 Own intermediate consumption SNA ($ICmoo_{rSNA}$)							22.9			21.5		14.0	58.4									58.4
2.2.2 Own intermediate consumption non SNA ($ICmoo_{non\text{-}rSNA}$)												155.0	155.0									155.0
2.3 Manufactured work in progress used (WPmu)										166.4			166.4									166.4
2.4 Environmental work in progress used (WPeu)		8.1	2.1				11.6						21.8									21.8
3. Ordinary gross value added ($GVAo_{rSEEA}$)	0.3	9.1	8.3		35.0	1.7	49.7	3.0	16.5	-43.0	1.3	126.1	208.0		23.7	13.3	49.5	90.2	9.9	81.9	268.6	476.6
4. Ordinary consumption of fixed capital ($CFCo_{rSEEA}$)	0.1	0.5	0.2		2.6	0.1	7.7	4.2	13.8	14.8	2.6		46.6									46.6
4.1 Manufactured consumption of fixed capital SNA ($CFCmo_{rSNA}$)	0.1	0.5	0.2		2.6	0.1	7.7	4.2	13.8	14.8	2.6		46.6									46.6
4.2 Ecosystem degradation non-SNA ($CFCeo_{non\text{-}rSNA}$)																						
5. Ordinary net value added ($NVAo_{rSEEA}$)	0.2	8.6	8.1		32.4	1.6	41.9	-1.2	2.7	-57.8	-1.3	126.1	161.4		23.7	13.3	49.5	90.2	9.9	81.9	268.6	429.9
5.1 Labor cost (LCo_{rSEEA})	0.2	8.1	3.2		5.1	1.2	19.8	5.6	8.2	44.0	3.9		99.3									99.3
5.1.1 Compensation of employees SNA ($LCoe_{rSNA}$)	0.2	8.1	2.0		5.1	1.2	19.4	5.6	8.0	42.6	3.9		96.2									96.2
5.1.2 Imputed compensation of self-employed non-SNA ($LCose_{rSEEA}$)			1.2				0.3		0.1	1.4			3.1									3.1
5.2 Net operating margin ($NOMo_{rSEEA}$)	0.0	0.5	4.9		27.3	0.4	22.2	-6.8	-5.5	-101.8	-5.2	126.1	62.1		23.7	13.3	49.5	90.2	9.9	81.9	268.6	330.7
5.2.1 Manufactured net operating margin ($NOMmo_{rSEEA}$)	0.0	0.5	4.9		2.1	0.4	4.1	-6.8	-5.5	-101.8	-5.2		-107.2									-107.2
5.2.2 Environmental net operating margin ($NOMeo_{rSEEA}$)					25.2		18.0					126.1	169.3		23.7	13.3	49.5	90.2	9.9	81.9	268.6	437.9
6. Ecosystem services (ES_{rSEEA})		8.1	2.1		25.2		29.7					126.1	191.1		23.7	13.3	49.5	90.2	9.9	81.9	268.6	459.7
Changes in balance accounts																						
7. Changes in environmental asset (CEA_{rSEEA})	1.6	57.7	6.9	0.0	-2.9							-187.7	-124.2				-3.2				-3.2	-127.4
8. Changes in adjusted environmental net worth ($CNWead_{rSEEA}$)	1.6	57.7	6.9	0.0	-3.0		-0.3					-187.7	-124.6				-52.7				-52.7	-177.3
9. Environmental income (EI_{rSEEA})	1.6	65.8	9.1	0.0	22.2		29.4					-61.6	66.5		23.7	13.3	-3.2	90.2	9.9	81.9	215.9	282.4

Number of private holm oak *dehesas*: 16. Surface: 9,032 hectares. Average surface: 565 hectares

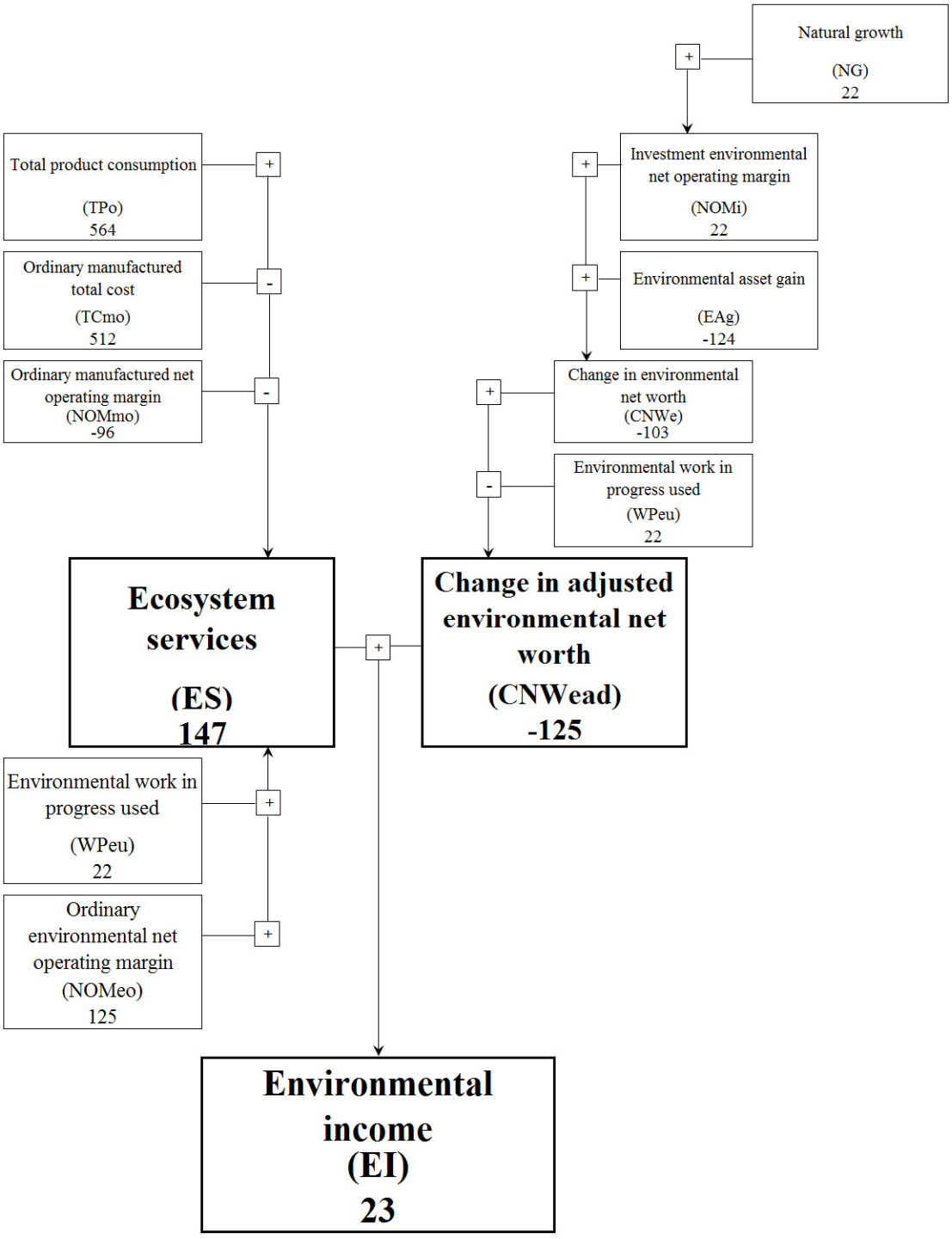
Table S4. Incomes and ecosystem services indicators by aggregate commercial and non-commercial activities for refined SNA, refined SEEA and simplified AAS for private holm oak *dehesas* case studies in Andalusia (2010: €/ha).

Class	Commercial activities			Non-commercial activities				Holm oak *dehesas*
	Woody products	Non-woody products	Total	Amenity	Landscape	Others	Total	
1. Ordinary net valued added (NVAo)								
rSNA	20.7	67.8	88.4		5.1	89.3	94.3	182.7
rSEEA	16.9	18.3	35.3	126.1	90.2	178.4	394.7	429.9
sAAS	16.9	38.6	55.5	126.1	18.2	172.9	317.2	372.7
2. Ordinary net operating surplus (NOSo)/margin (NOMo)								
rSNA	9.2	-40.2	-31.1		0.0	82.7	82.7	51.6
rSEEA	5.4	-69.5	-64.0	126.1	90.2	178.4	394.7	330.7
sAAS	5.4	-69.5	-64.0	126.1	13.1	166.3	305.6	241.5
3. Ecosystem services (ES)								
rSNA	10.2	54.8	65.0			82.2	82.2	147.2
rSEEA	10.2	54.8	65.0	126.1	90.2	178.4	394.7	459.7
sAAS	10.2	54.8	65.0	126.1	13.0	164.0	303.0	368.1
4. Changes in environmental asset (CEA)								
rSNA	66.3	-2.8	63.5	-187.7			-187.7	-124.2
rSEEA	66.3	-2.8	63.5	-187.7		-3.2	-190.9	-127.4
sAAS	66.3	-2.8	63.5	-187.7		-3.2	-190.9	-127.4
5. Changes in environmental net worth adjusted (CNWead)								
rSNA	66.3	-3.2	63.1	-187.7			-187.7	-124.6
rSEEA	66.3	-3.2	63.1	-187.7		-52.7	-240.4	-177.3
sAAS	66.3	-3.2	63.1	-187.7		-52.7	-240.4	-177.3
6. Environmental income (EI)								
rSNA	76.5	51.6	128.1	-187.7		82.2	-105.5	22.6
rSEEA	76.5	51.6	128.1	-61.6	90.2	125.7	154.3	282.4
sAAS	76.5	51.6	128.1	-61.6	13.0	111.3	62.6	190.8

Number of private holm oak *dehesas*: 16. Surface: 9,032 hectares. Average surface: 565 hectares

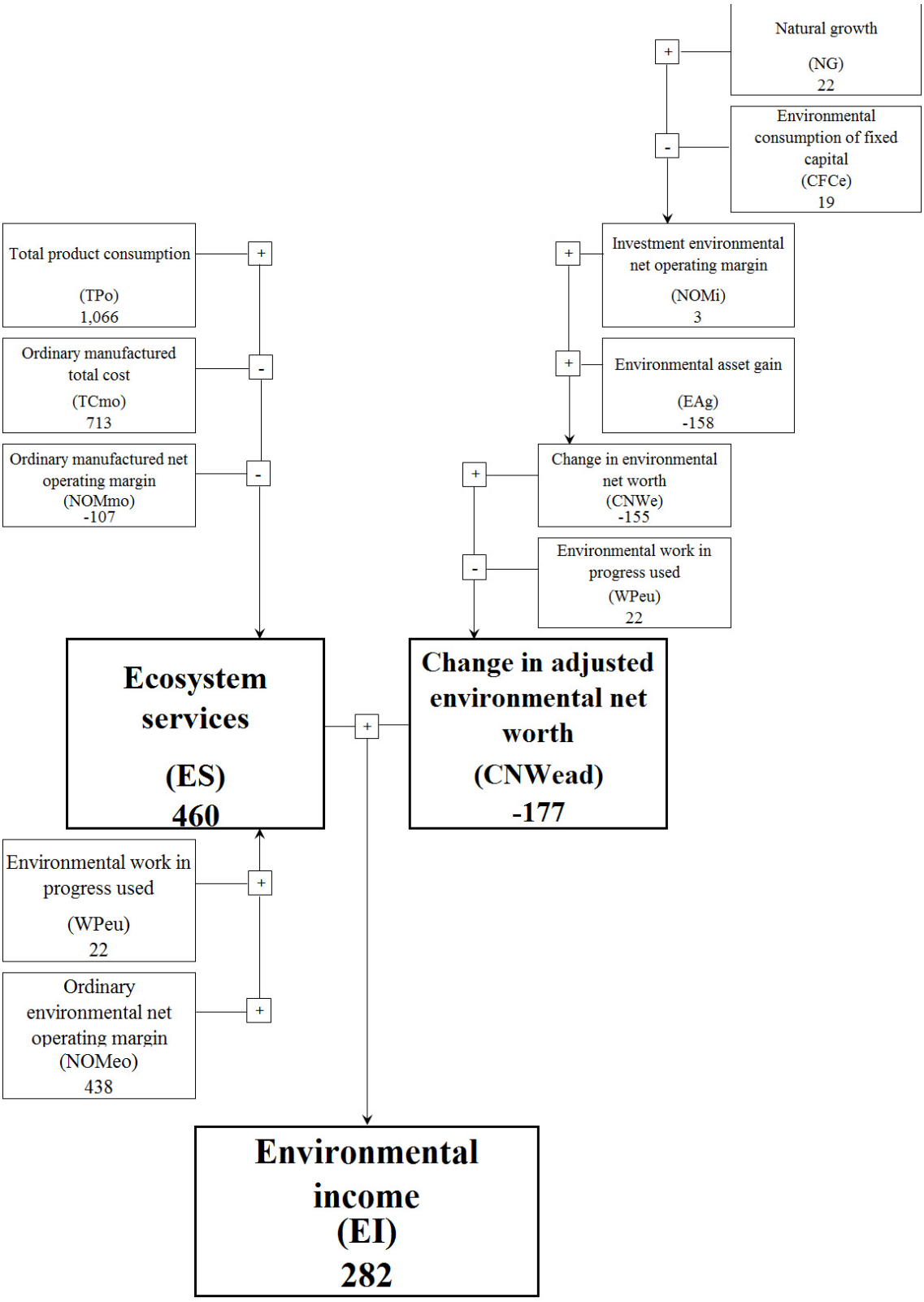
Supplementary figures for

Agroforestry Accounting System environmental incomes compared with SNA and SEEA-EEA at corporation scale: applications to holm oak *dehesas* in Andalusia-Spain



Number of private holm oak *dehesas*: 16. Surface: 9,032 hectares. Average surface: 565 hectares

Figure S1. Total environmental income in refined SNA for private holm oak *dehesas* case studies in Andalusia (2010: €/ha).



Number of private holm oak *dehesas*: 16. Surface: 9,032 hectares. Average surface: 565 hectares

Figure S2. Total environmental income in refined SEEA for private holm oak *dehesas* case studies in Andalusia (2010: €/ha).