Aggregation of the ecosystem service values in urban ecosystem account, application of the principles of gross ecosystem product (GEP)

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Discussion topic/paper on London Group 2021

Introduction and the scope of the paper

Paper discusses the aggregation of individual ecosystem service values into one single aggregated value and the aggregation of exchange and welfare values. Exchange values are the values at which goods, services, labour or assets are in fact exchanged or else could be exchanged for cash (2008 SNA, 3.118). Welfare values/willingness to pay values include consumer surplus and have been extensively used in other policy contexts such as for cost-benefit analysis or within environmental policy. The UN SEEA EA focusses on the application of exchange values, as these are directly comparable to values reported in the SNA (chapter 9.3 UN SEEA EA chapters 8-11 and 12-14). However, in chapter 12 (Annex 12.1 page 267) also complementary approaches to valuation are considered and it is discussed how willingness to pay techniques may be applied to estimate changes in welfare values and used in an accounting approach. The SEEA EA also outlines the logic that exchange and welfare values could be both used in accounting context (A12.17), and how in the context of ecosystem services a bridge table could be compiled (par. 12.2.2). In our study monetary values based on exchange values and those representing consumer surplus are covered.

We have used the urban ecosystem account for Estonia as an example for the aggregation of ecosystem values. The pilot aggregation was based on the data produced in a frame of Eurostat grant 881542— 2019-EE-ECOSYSTEMS, details are described in the methodological report "Development of the ecosystem accounts". Work is based on our current understanding and best knowledge.

In case of urban ecosystem accounts there are three major dimensions at play while compiling ecosystem services supply tables: the different ecosystem services that are provided, the ecosystem assets that provide these ecosystem services (urban green, urban grey and natural ecosystems within urban area) and the valuation methods. The latter is important to consider because we applied two different approaches on the services at the same time; the first approach consists of the "exchange value based methods " i.e. market price, cost-based and revealed preferences methods that provide exchange values and the second one is stated preferences method that provides welfare values. The GEP which is the final total value of all of these would depend on the change in any of the previous aspects.

Aggregated value estimates could have several restrictions. Despite the concerns that exist around aggregation, CBD (Convention on Biological Diversity) has selected gross ecosystem product (GEP) as

[1] This work has been a joint effort of environmental accountants of Statistics Estonia, Statistics Netherlands and scientist of Tallinn Technical University.

a candidate for one of the lead indicators and it has been listed in "Proposed headline indicators of the monitoring framework for the post-2020 global biodiversity framework"(goal B, page 5).

UNCEEA has asked on a meeting on June 2021 for higher involvement of the LG on Environmental Economic Accounting for developing further research on valuation and aggregation of ecosystem services. Improvements and more specifications are needed for the valuation and aggregation aspects of ecosystem services than which are currently described in recommendations and guidelines (UN SEEA EA chapters 8-11 and 12-14).

UN SEEA EA on the aggregation of valuation results

This paper will discuss the feasibility, problems and possible meaning behind the aggregation of the ecosystem service values as proposed by UN SEEA EA (chapter 9.17 on page 190).

Paragraph 9.17 of the manual UN SEEA EA outlines the following: „ Aggregate measures of ecosystem services can be derived by summing across columns (i.e., to estimate the total supply or use of a single service) and by summing across rows (i.e. to estimate the total supply by an ecosystem type or the total use by type of economic unit). The aggregate measure gross ecosystem product (GEP) is equal to the sum of all final ecosystem services (i.e., used by economic units) at their exchange value supplied by all ecosystem types located within an ecosystem accounting area over an accounting period less the net imports of intermediate services. In cases where the net imports of intermediate services, i.e., imports less exports of intermediate services are small GEP may be assumed to be the sum of final ecosystem services supplied by the EAA.[2]

Although not stated explicitly in the SEEA EA, GEP could be based on exchange values (which is the focus of SEEA EA), but also on welfare values.

Urban ecosystem thematic account as an example for the aggregation of valuation results

In the current paper we use the urban ecosystem account as the example for the aggregation of ecosystem values. In case of urban ecosystems:

1. Ecosystem services are more in demand due to the close proximity of the provisioning areas and beneficiaries of the ecosystem service
2. The alternative uses of land in urban areas i.e. ecosystems is apparent and relevant due to high demand. Hence the question on alternative use of land and how to entangle the aggregation of service values per ecosystem types is important.
3. As urban ecosystems comprise different asset types and a lot of non-market ecosystem services, the aggregations to a scale may convey added value.

In case of the urban thematic account, ecosystem services provided by distinctive urban areas could in principle be compared based on the calculated GEP indicator if theoretical and conceptual difficulties are solved. The GEP approach (developed by BaolongHan-RCEES-China) of summing up different service values was discussed and analysed. In the case of China, GEP was also initially tested

[2] - wording according to last draft version as is being prepared by the editor and the SEEA EA TC

on urbanized areas, and government now requires consideration of ecological benefits, as measured by GEP, in the evaluation criteria of the performance of local governments, which could create real accountability among officials for how they affect ecosystem services (Ouyang et al. 2020).

First dimension of gross ecosystem product: spatially explicit urban ecosystem account

In urban areas accounting for market and nonmarket values was performed both on build-up areas and natural ecosystems.

The need to treat the city and the urban natural ecosystems in one framework was suggested by stakeholders so that the focus should not be on the natural ecosystems but the urban area (green and grey) which also comprises natural ecosystems. Due to that a complex criterion for classifying the urban ecosystem which considers both the population density and the distance of artificial areas from the ecosystems was developed.

The concept chosen and described in methodological report "Development of the ecosystem accounts" improves the incompatibilities of administrative urban areas-boundaries. For the compilation of the urban ecosystem extent, proposals outlined in UN SEEA EA chapter 13.6 "Accounting for urban areas" were analyzed and considering the services chosen for the valuation and available data, the presentation of extent account that uses individual asset approach (table 13.7, p 292) which split urban area into urban ecosystem assets and natural ecosystem types was chosen.

The chosen framework allows to allocate both the services provided by natural ecosystems present in city space and also allocate the values of artificially modified typical green artificial areas.

Basic mapping units were linked to ecosystem extent framework. Basic mapping units were adjusted in one occasion: private yards were split into green (urban assets: private yards) and artificial area (buildings) based on the data in building register.

Derived ecosystem extent was used as ecosystem dimension of the urban ecosystem services supply table.

Second dimension of gross ecosystem product: ecosystem services supply

Stakeholders were consulted in order to identify relevant and feasible ecosystem services flows to measure. We have the ecosystem services which are mainly provided by natural ecosystems that happen to be located in urban areas and in another hand we have services unique for urban environments. We have applied several exchange based methods: market based, expenditure based, time use based approach, travel cost approach etc., depending on the service. In addition we used CVM study results (study carried out by Tallinn Technical University). The overview of the ecosystem services chosen for the monetary valuation with exchange value based methods and included in CVM studies in both natural/semi-natural ecosystems and urban ecosystems is given in table 1. Chapter 5 of the methodological report "Development of the ecosystem accounts", gives additional insight into the process of the selection of the services for monetary valuation in urban areas.

Table 1. Ecosystem services chosen for the monetary valuation with exchange value based methods and inclusion in CVM studies in both natural/semi-natural ecosystems and urban ecosystems. The selection of the services was done based on consultations with stakeholders, feasible methods and available data.

Valuation methods of ecosystem services					
SERVICE	**Exchange value based valuation method(s)**	**CVM forest**	**CVM wetland**	**CVM grassland**	**CVM urban**
Fodder	Rent price			x	
Medicinal herbs		x	X	x	
Herbaceous biomass used for producing energy (bioenergy)	Market price				
Agricultural production (crops)	Rent price				
Wild berries, mushrooms	Market price	x	X		
Wild game	Market price				
Timber	Stumpage prices				
Peat	Market price				
Forest seed	Market price	x	X	X	
Organic waste which is used for producing compost	Market price				
Flood protection				X	
Global climate regulation: C sequestration (storage)	Payment for Ecosystem Services (PES) schemes	x	X	X	x
Air quality (PM_x)	Benefit transfer (avoided damage costs)	x	X		x
Photosynthesis (oxygen production)		x	X	X	x
Pollination	Avoided damage costs	x		X	
Maintenance of soil fertility		x		X	
Habitat conservation for biological species		x	X	X	x
Water infiltration	Replacement cost				
Regulating microclimate (cooling, wind, light mitigation)					x
Noise mitigation					x
Recreation	Valuation by time-use	x	X	X	x
Recreational hunting	Expenditure-based valuation approach				
Nature education	Expenditure-based valuation approach	X	X	X	x
Ensuring landscape diversity		X	X	X	x
Aesthetic experience					x

The compiled matrix i.e. supply table by urban ecosystem types was chosen to accommodate all relevant flows of ecosystem services.

Third dimension, - detailed flows on the level of ecosystem types and services which are the subject of aggregation are displayed in blocks A, B and C of table 2. The table display the values of ecosystem services according to the allocation matrix of the valuation results obtained by different approaches in urban ecosystem accounts:

- Table A displays the ecosystem service values results received by exchange based valuation method to be allocated both to urban assets and natural ecosystems in urban areas.
- Table B displays the willingness to pay ecosystem service values results derived by contingent valuation method of urban study
- Table C displays contingent valuation method based valuation method results to be allocated to natural ecosystems in urban areas.

Table 2. Urban ecosystem services supply table. A. Results of the exchange value based valuation methods in urban areas, 2019, thousand €

Ecosystem/ Map unit	Fodder	Agricultural production	Wild berries and mushroom	Timber	Peat	Organic waste	Global climate regulation:	Air quality regulation	Pollination	Rainfall infiltration	Recreation	Nature education	TOTAL
Urban green		**70**				**107**		**345**	**457**	**7 873**	**2 755**	**1 084**	**12 692**
Green space								86	119	1 960	676	446	**3 286**
Cemetery						36		5	1	117	40	10	**209**
Line of trees						71		10	125	232	55	27	**520**
Private Yard								243	201	5 564	1 950	573	**8 530**
Horticultural land		70						2	11		34	29	**146**
Urban grey								**0**	**62**		**1 418**	**848**	**2 329**
Buildings and other facilities									1		1 041	610	**1 652**
Building											546	321	**867**
Airport									0		5		**5**
Railroads									0				**0**
Port											1		**1**
Area used for sport activities									1		43	3	**46**
Roads													
Production yard											447	286	**732**
Other artificial areas, excluding private yard								0	62		377	239	**677**
Inland habitats with no vegetation									60		374	239	**673**
Wasteland								0	1		2	0	**3**
Power lines								0					**0**
Excavation sites									0		0		**0**
Landfill													
Forest ride								0	1		0	0	**1**
Natural and semi-natural ecosystems	**96**	**64**	**279**	**2 427**	**2**	**803**	**1 128**	**142**	**404**	**2 609**	**2 276**	**605**	**10 834**
Forest			278	2 427		803	1 128	114	88	2 609	1 299	422	**9 168**
Grassland	74		0					19	311	0	543	92	**1 040**
Cropland, excluding horticultural land	21	64						9	5	0	281	14	**394**
Wetland	0		1		2			0	0	0	17	3	**23**
Coast									0		2	4	**7**
Inland waterbodies											133	69	**202**
Other								**0**	**0**		**3**	**0**	**4**
Grand Total	**96**	**134**	**279**	**2 427**	**2**	**910**	**1 128**	**488**	**923**	**10 481**	**6 453**	**2 537**	**25 858**

B. Results of urban CVM including urban green spaces and forests in urban areas, 2019, thousand €

Ecosystem/Map unit	Air quality	Climate regulation	Shade provision	Noise mitigation	Habitat conservation	Recreation	Nature education	Aesthetic experience	TOTAL
Urban green	**2 169**	**3 027**	**1 145**	**1 492**	**1 485**	**1 585**	**1 051**	**2 586**	**14 540**
Green space	1 488	2 076	785	1 023	1 019	1 087	721	1 774	9 972
Cemetery	86	120	45	59	59	63	42	103	577
Line of trees	325	453	171	223	222	237	157	387	2 177
Private Yard	261	365	138	180	179	191	127	312	1 752
Horticultural land	10	13	5	7	7	7	5	11	63
Urban grey									
Buildings and other facilities									
Building									
Airport									
Railroads									
Port									
Area used for sport activities									
Roads									
Production yard									
Other artificial areas, excluding private yard									
Inland habitats with no vegetation									
Wasteland									
Power lines									
Excavation sites									
Landfill									
Forest ride									
Natural and semi-natural ecosystems	**410**	**572**	**216**	**282**	**281**	**300**	**199**	**489**	**2 748**
Forest	410	572	216	282	281	300	199	489	2 748
Grassland									
Cropland, excluding horticultural land									
Wetland									
Coast									
Inland waterbodies									
Other									
Grand Total	**2 579**	**3 599**	**1 361**	**1 773**	**1 766**	**1 885**	**1 249**	**3 075**	**17 288**

C. Results from CVM study of forest, wetland, grassland in urban areas, 2019, thousand €

Ecosystem/Map unit	**Medicinal herbs**	**Wild berries and mushroom**	**Global climate regulation: carbon sequestration and storage**	**Air quality regulation**	**Pollination**	**Maintenance of soil fertility**	**Habitat conservation**	**Recreation**	**Nature education**	**TOTAL**
Urban green										
Green space										
Cemetery										
Line of trees										
Private Yard										
Horticultural land										
Urban grey										
Buildings and other facilities										
Building										
Airport										
Railroads										
Port										
Area used for sport activities										
Roads										
Production yard										
Other artificial areas, excluding private yard										
Inland habitats with no vegetation										
Wasteland										
Power lines										
Excavation sites										
Landfill										
Forest ride										
Natural and semi-natural ecosystems	**83**	**23**	**54**	**1**	**57**	**33**	**163**	**17**	**108**	**539**
Forest	19	22			12	8				**61**
Grassland	61		53		45	25	157	17	105	**462**
Cropland, excluding horticultural land										
Wetland	4	1	1	1			7	0	3	**16**
Coast										
Inland waterbodies										
Other										
Grand Total	**83**	**23**	**54**	**1**	**57**	**33**	**163**	**17**	**108**	**539**

For more details on selection and valuation of different urban ecosystem services please have a look at the dedicated chapters of the methodological report: "Development of the ecosystem accounts". Methods for ecosystem services on urban natural areas are described in chapter 7. The services covered are all relevant in various urban natural ecosystems types. The service specific only for urban ecosystems are discussed in subchapters 10.6.1.1 (Organic waste which is used for producing compost) and 10.6.1.2 (water infiltration). CVM results for urban ecosystems are described in chapter 10.6.2. Allocation of urban ecosystem services values to urban ecosystem types e.g. producing a supply table is described and displayed in chapter 10.7.

Aggregation of urban ecosystem services exchange and welfare values

In the previous paragraphs it was explained that ecosystem services supply table of urban ecosystems have three major dimensions at play: the different set of ecosystem services, the ecosystem assets that provide the ecosystem services (urban green, urban grey and natural ecosystems within urban area) and the different valuation approaches. The first approach of valuation methods provide exchange values, which is the focus of the SEEA EA, and these include market price, cost-based and revealed preferences methods, the second approach provides welfare values: contingent valuation method (CVM, stated preferences). In our study, GEP as indicator for urban areas is the final total value of all of these and would be dependent on the change in these aspects.

Regarding the consideration of various valuation methods we tried to take into account the service values both of market and non-market valuation methods. We argue that CVM study results are relevant to consider (as the values ecosystem services). When evaluating the services of urban ecosystems, it must be taken into account that urban ecosystems can influence well-being differently from natural ecosystems, such as forests. This should also be taken into account when choosing ecosystem evaluation methods. For example, to visit a hiking trail in the forest, visitors usually have to drive to get there, the visitor's transport costs and the time spent on the visit can be well monitored. Consequently, it is very appropriate to measure the monetary equivalent of the recreational value of a forest ecosystem using either the travel cost method or the time cost method. In urban areas people come into contact with ecosystems usually not as a result of a special trip to a large city park, but with many brief exposures to urban green ecosystems, such as tree alleys, lawns and small parks. Contact with urban ecosystems takes place in many ways- on the way to and from work, on walks with family, from the window of the vehicle and the window of the office and the home apartment. In general, it can be said that the typical contact with the urban ecosystem in an urban area is rather short in time, but the number of contacts per person can be relatively high. The time taken for such contacts is difficult to measure using travel cost and time cost methods, because unlike visiting natural ecosystems outside the city, there are typically no travel costs, as ecosystems are not specifically visited but are contacted when moving for other purposes. However, based on a survey of people, it can be said that contacts with the ecosystems of urban areas have a positive effect on well-being, even if the visit to the ecosystem is not an end in itself, but takes place by passing. Therefore, when assessing the monetary value to ecosystem services in urban areas, it is reasonable to measure the change in human welfare due to ecosystem services directly by using the contingent valuation method. Thus, it can be argued that given the specific nature of the expression of urban ecosystem services, the use of stated preferences based methods for measuring their value is particularly justified compared to natural ecosystems.

So, there is a necessity that subjective valuation methods need to be included for the sake of completeness and coverage of benefits. The key question that arises is how to aggregate ecosystem services while applying these different methods.

Table 3 displays the results of the aggregation of the values of the ecosystem services indicated in the separate blocks of the table 2, which were subject for the monetary valuation with exchange value based methods and CVM study in urban ecosystems alongside with natural/semi-natural ecosystems. Be noted that the aggregation is done by ecosystem types. Total GEP amounts to 42.5 million.

Table 3. Urban ecosystem service values by valuation methods and urban ecosystem asset types, million euros

	GEP	Exchange based values	Urban CVM	CVM natural eco-systems
GEP	**42.5**	25.8	17.2	0.5
Urban ecosystem assets "urban green"	27.2	12.7	14.5	-
Natural ecosystems "natural and semi natural ecosystems"	13.0	10.8	2.7	0.5
Artificial areas (grey)	2.3	2.3	-	

Ecosystems/map units in urban areas were grouped into categories of urban green, natural green and urban grey areas. The total value of services is 42.5 million €. Green assets contribute 28.2 million and natural ecosystems 13.5 million euros. Exchange based methods count for 23.5 million and contingent valuation methods 17.3 million service value. Table 2 outlines the calculated values by asset types. When looking into the values in more detail then we see that the values of water infiltration (10.4 million) service and recreation (6.4 million) dominate, followed by timber provision (2.4 million). The biggest green assets, private yards and green areas, together with forest in a city contribute the biggest amount of services. This of course depends on a number of aspects like selection of the methods for valuation and the way ecosystem contribution is identified.

Figure 1 shows schematically the proportions of the services provided by urban ecosystem (vertical dimension displays ecosystem types). On a left side in pink colours, the values measured by exchange based methods and on a right side in blue colours the services measured by contingent valuation methods are displayed.

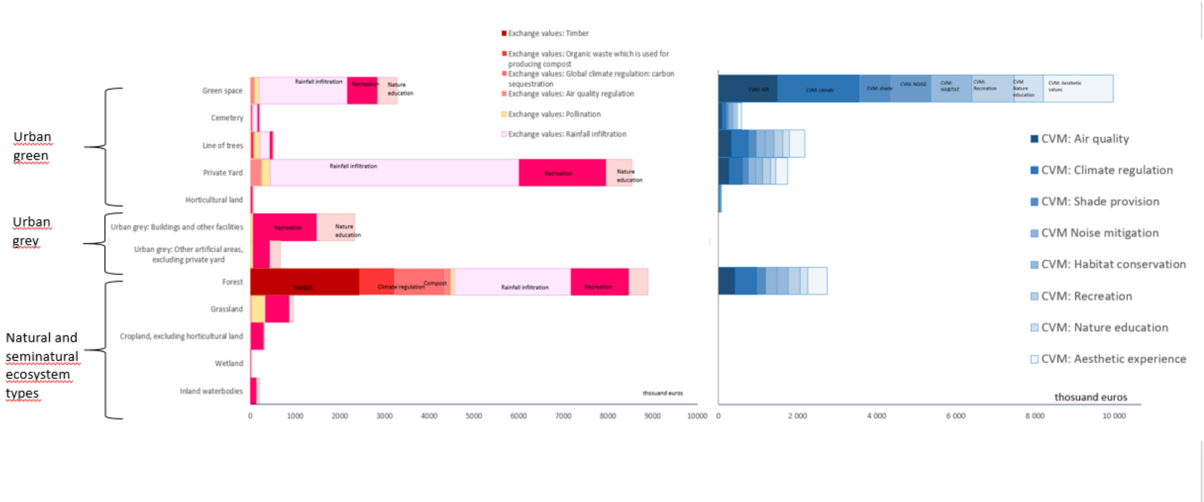

Figure 1. Illustrative chart of the services values provided by urban ecosystem types, thousand euros. Enlarge for viewing details.

Observations:

1. Valuation results suggest that urban green assets and private yards (in addition also urban forests) are contributing the largest share of the services values when considering both methods.
2. CVM results highlight urban green space and tree rows while exchange based methods capture services provided mostly by urban private yards and urban forest.
3. If total values derived by both methods (exchange based and CVM) give the results to a certain degree on the comparable scale, then the distribution of valuation results of urban ecosystem assets and types show that services and assets are not the same, therefor methods are not parallel and they capture distinctive phenomena .
4. Gathering all valuation results in one framework highlighted the questions of coverage and comparability. For example three services: rainfall infiltration, timber provisioning and compost producing services, dominate exchange based values. Each of those values taken separately seem justified in first glance. Are these dominating services most important as well or is this dominance just the artefact caused by the properties of the valuation methods used?
5. The under-coverage of certain natural ecosystem assets and services becomes apparent. If service values are aggregated, you do not see that certain ecosystem assets and services, which should also have values, might have remained out of the scope.
6. The under-coverage of certain natural ecosystem types by CVM studies is also noticeable. Presence of only one natural ecosystem type (forest) was predetermined by the CVM questionnaires. This is well reflected in the CVM results as well.

Discussion

Based on the work done in China and suggestions of CBD and UNSD, we analysed the GEP as an integrated approach on urban area ecosystem services. Urban areas were chosen as there is often a high interest for different uses of land (land parcels) related to policy goals and there the simple aggregated value could be valuable for development decisions. The gross ecosystem product indicator could have the economic and social importance and if certain implementation issues are solved, it could reflect the value of ecosystem assets. However without links to basic data, semantics and analysis, the true meaning behind the single number of the gross product could be of no meaning and use.

The urban ecosystem account gives a GEP value of 42.5 million euros (table 3). The GEP, which is the total value of all of these dimensions (assuming it includes both exchange and welfare values), would be dependent on the change in any of the three major dimensions at play while compiling ecosystem services supply tables: ecosystem services that make up the basket, service provisioning assets (urban green, urban grey and natural ecosystems within urban area) and the valuation approaches. These details are well represented in ecosystem services supply tables, which include service supply by ecosystem types. So, we think that if gross ecosystem product would be calculated the link to the basic supply matrixes needs to be maintained.

The Dasgupta review published this year, has been considered to be an important guiding document for ecosystem accounting both on national and international level. The Dasgupta review outlines the suggestions and also the theoretical obstacles while applying aggregate measures. It has been considered a threat that while aggregating, several important components of the ecosystem capital (services) may be missed entirely if the figures would be used in practical decisions. Dasgupta review suggest the use of the aggregate measures but also warns that, given it focuses on ecosystem service flows, not stocks, GEP alone should not be used as a sustainability index. Dasgupta review turns attention to the theoretical obstacles and specifically to the fact that values of several non-monetary regulative services and cultural services would remain out of the sight and could be overlooked (A12.1.2 Valuation of Ecosystem Services – the case of Qinghai, page 315 - 318). We agree with the Dasgupta review that highlights the concern that several ecosystem services may be overlooked or underestimated if the figures would be used for policy.

After the launch of the Dasgupta review UK Office of National Statistics gave the suggestions[3] on how the statistical system should adjust and suggests filling of the conceptual and empirical gaps and creating a broader measure which must be done through a consistent expansion of the production and asset boundaries based on principles that one cannot "cherry pick".

We are of the opinion that CVM could provide at least certain values for several regulatory and cultural services which have currently been considered difficult to cover by exchange based values. There may be a potential overlap or double counting between the values obtained by alternative methods, but this overlap is currently difficult to capture. In case of the same assets providing the service, linear scaling between two methods could be carried out and it could be investigated if there is a correlation between the services provided by assets valued by different methods. In case of correlation, coefficients could, in principle, be used for gap filling purposes. Unfortunately not enough data points are available.

In case of recreation, the CVM value is surprisingly low compare to exchange based value. This is explained by the design of the CVM study. Exchange based values were based on time use method (number of people * cost of time).

The analysis of aggregation of the service values as described in GEP approach revealed that certain decisions while applying valuation methods may distort the picture. Currently rainfall infiltration dominates the values: in private yards and green spaces highest values are calculated for rainwater infiltration. In forests, rainwater infiltration is the second most important service in terms of monetary value in current selection of services and urban ecosystems context. This is due to the fact that during calculation of the value with replacement cost method, we assumed that supply equals use and all natural area with soil surface in urban area absorb water. This calculation of the supply did not consider the actual use (benefits) of the service (and therefore not fully following the method description given in SEEA EA p. 9.49 where the service value is defined as the price of the ecosystem service as the cost of using the substitute to provide the same benefits), which would be the highest in dense areas with a lot of covered ground and smallest in natural areas, and therefore likely overestimates the value of the service. For example, as private yards, green spaces, and forests make up a large part of the total urban area and city parks form a relatively large share of city forest, the value of the service is also distributed primarily between these areas. It is however disputable if the value calculated by exchange based methods, and mostly relevant for high density areas, could be attributed to the areas with a significant share of natural ecosystems, because the question arises if there exists a societal need for that high level of the ecosystem service provisioning in these more natural areas because there may not be an immediate beneficiary. This will depend on the fate of the non-infiltrating water: if it flows directly across the surface towards areas used by men, it is of relevance, but if the water would end up in the stream network and drains away it is of less relevance. Also as expert knowledge was used for the drainage rates, it could be useful to check input data for more precise results.

[3] (https://www.greengrowthknowledge.org/sites/default/files/%23GGKPwebinar_30%20March%202021-compressed.pdf, page 32).

Similar issue arises with the calculation of provisioning compost with market price method which gave quite high results. The calculations were based on the supply, which depend on the provisioning area, and do not consider the actual overall use. In case of actual use, some forest ecosystems in urban areas would not be providing the service as no leaf matter is collected there; that in turn would decrease the service value.

For calculating GEP all services and ecosystem should be included for the ecosystem accounting area. This means including both exchange and welfare values. However it is also important how people perceive and differentiate between urban ecosystems and their services. This is clearly shown by the fact that the CVM study revealed that urban ecosystem services were ranked quite differently from natural ecosystem services in terms of subjective importance. For example if the recreational service was not considered important in natural ecosystems than it was considered important and got measured in urban areas.

In general we have experienced that finding the value of services of ecosystems in urban areas could be more difficult than in the case of natural ecosystems due to complexity of the urban area.

The definition of GEP requires a correction for the net import of ecosystem services. This correction has not been taken into account here. In general one can say that import and export will differ between ecosystem services, and depend on the spatial distance between supply (ecosystem type) and use (economic sector). For example, pollination is supplied by natural bee habitats, and used by croplands within bee foraging distance. Similar case is for example rainfall infiltration, where water is not infiltrating in a patch of soil, for instance located in a park, but may flow to a paved residential area, or across a street, resulting in flooding and associated nuisance.

The issue of import and export of ecosystem services therefore requires additional (spatial) analysis, and is not only coupled to the computation of GEP per se. However, broadly speaking, the smaller the ecosystem accounting areas are, the larger the impact of import/export can be expected to be (because of the high border length /area ratio), so for urban areas the effect can expected to be relatively high.

Conclusion

We think that for analyses which are dealing with relative importance of a specific ecosystems or ecosystem types in the provisioning of certain services or the spectrum of the different services provided by single ecosystem types - the aggregation of the monetary values of service is important.

We can say that the concerns related to the possible loss of details of ecosystem services while aggregating are justified. The link to the supply tables of the services is important and needs to be maintained for the sake of transparency. In order not to miss the important components of the ecosystem capital (services), these need to be included and be observable when the figures would be used in policy decisions.

In general, aggregate measures are an important feature of the balance sheets of national economies, which is also why aggregated ecosystem service (and asset) values are necessary. In case of Estonia the local municipalities could in principle be compared based on the GEP profiles if certain implementation difficulties could be solved. In addition, more needs to be known how these figures should be interpreted and be put into the right context.

More understanding is needed how GEP is used in case of China with the considerations of ecological benefits and as the evaluation criteria of local governments' performance. Users' opinions on a suitability of the framework and methods, in this case for service valuation and compilation of the supply table of urban ecosystem services supply, would be needed as well.

The concept of aggregate measure of ecosystem services needs further investigation in the sense of summing across columns (i.e., to estimate the total supply of an ecosystem asset). In particular more guidance is needed how exchange values and welfare values can be compared / aggregated, as these values may (partially) overlap.

In future more attention should be given to regulative and cultural services and the way how to link those to supply tables in a form of satellites. Otherwise these values could remain out of the sight. The current effort has been the first attempt for us to compile the indicator of GEP for Estonia and it opens up a series of questions to be answered on the considering of the various valuation methods, non-use values and aggregation. It also shows the gaps both in the knowledge and data of ecosystem service supply matrix by ecosystem types.

Hence we can consider this effort as a beginning of the longer processes in compiling aggregated indicator of the flow of the ecosystem service values.