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STRUCTURAL MODEL OF FOREST ECOSYSTEM SERVICES' PAYMENT FOR WATER QUALITY IMPROVEMENT

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Abstract
The publication deals with the development of a structural model of payment schemes for ecosystem services (PES) oriented to usage of forests for water, soil and microclimate quality improvement. Proposed structural model is built on the Meta analyses base of more than 50 PES schemes worldwide. The proposed structural model has three top down levels – groups of categories, categories and attributes. There are seven groups of categories, 17 categories and more than 120 attributes. The structured information about studied PES schemes is stored in a warehouse managed by unique web platform created by the authors. An important part presented study is the developed generic use case of PES schemes with definition of seven participated actors.

Keywords*: PES scheme, structural model, forest, water quality, web platform*

Introduction

Payments for ecosystem services or PES programs are defined as formal or informal contracts where landowners receive remuneration for managing their land and offering one or more ecosystem services and which include actual payments between at least one willing buyer and one willing seller (Mercer et al. 2011).
Three basic types of PES are known in the past practice. The first type is government-funded schemes. In them, the buyer (e.g. the European Commission, a particular government or local authority) is a third party (often a hierarchy) acting on behalf of service users. Funding under these schemes is to compensate service providers by allocating revenue derived from targeted tax revenue or from the general budget (Porras et al. 2012). The second type of PES is the schemes funded by private users. In these schemes, buyers are end-users of the services. These schemes can be considered as "private transactions" and reflect genuine customer demand for services. The third type of PES is schemes funded by utilities. The purpose of the funding is to compensate suppliers by allocating revenues from user charges or tariffs, from a public service or a regulated private service. For example, charges for the use of downstream water facilities, installations and facilities for land use activities that affect the function of the catchment area. Such schemes may also include large irrigation or hydropower areas.
According to Smith et al. 2013, PES schemes can be developed on a number of spatial scales - international, national, catchment level, local and neighboring levels. According to Muradian et al. 2010, the green economy includes three schematic

components. The first concerns the importance of economic stimulus. This idea refers to the relative weight of the economic stimulus and can bring about social, moral or other non-economic incentives. The second component is the directness of the transfer related to the degree of interaction between end buyers and sellers (Tacconi 2012). The most direct payments will be made between one buyer and one seller without intermediaries. According to Fripp 2014, there are a number of options for PES, how it should be formulated and the most appropriate means for its funding. In any case, robust scientific data is needed to build appropriate PES. PES payments can only be made if the value of the service is recognized by the buyer and the seller and the appropriate transaction infrastructure (market) exists.

Materials and Methods

The presented study is based on a meta-analysis of more than 50 PES schemes for water, microclimate and soil quality improvement. The schemes studied cover much of the world and they are from Europe, Asia, Africa, North and Southern America. Table 1 provides a sample list of countries as well as data source used in conducted analysis.

Table 1. Excerpt from listed countries of analyzed PES schemes

Country	Source of information
Austria	https://www.wien.gv.at/english/environment/protection/eco/
Bolivia	http://www.watershedmarkets.org/casestudies/Bolivia_ICO.html
Brazil	http://www.watershedmarkets.org/casestudies/Brazil_CPCJ_E.html
Bulgaria	http://www.wwf.bg/what_we_do/policy_and_green_economy/nature_protection_and_sustainable_rural_development/bulgarka/drinking_water_conservation/
China	http://www.watershedmarkets.org/casestudies/China_SLCP_eng.html
Colombia	http://www.watershedmarkets.org/casestudies/Colombia_Campoalegre_E.html
Germany	http://www.urbem.net/WP2/WP2_case_studies.pdf
Uganda	http://www.watershedmarkets.org/casestudies/Uganda_beer_for_wetlands.html
United Kingdom	The Water Industry Commission for Scotland
United States	http://www.methowsalmon.org/

In order to store the structural description of investigated PES schemes, the authors created a Web platform for PES schemes warehouse. In paper, the developed structured model will be illustrated by means of that platform.

Results and Discussion

As noted in introduction, the definitions of the main PES schemes types depend on the stakeholders and their relationships. Therefore, before going to the description of proposed structural model, we will define base actors of PES scheme and their relationships.

Buyer actors are focused on prospects looking to solve a problem or meet an objective that ES help them to achieve. Buyers encompass all of the different roles or stakeholders involved in the purchase decision and are usually represented by decision maker. The buyers pay for chosen ES.
User actors solve their initial problem by choosing ES. This means that their context must build from this new status quo to what's next. The objective for user actors is to create higher loyalty and retention, as well as increase account value through renewals, cross and up sell.
Beneficiaries are actors, who derive advantage from ES, for improving their activities or other non-material needs as better environment, health etc.
Payer are actors that fund ES due to work done or goods received. Usually, payers are not the end user or beneficiary of ES.
Volunteer actors refers to activities performed willingly and without pay to provide ES for others outside the volunteers' household or family.
Intermediary actors act as a link between ES interested parties in order to try and bring about an agreement. Intermediaries can buy ES from one or more suppliers and sell it to interested buyers.

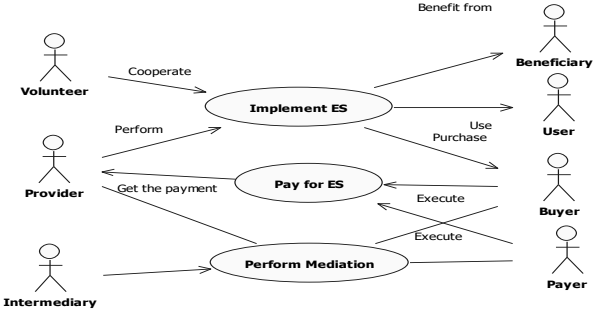

Figure 1. Generic use case of PES scheme

Provider actors are vendor that provides ES solutions and/or services to end users, buyers, and beneficiaries in exchange of payment. This broad term incorporates all ES businesses that provide products and solutions through services that are on-demand, pay per use or a hybrid delivery model.
The potential benefits and participants in PES schemes according to Bulgarian legislation are presented on Fig. 2.
The developed structural model of PES schemes is focused mainly on usage of forests for environment improvement mainly water quality, agro ecological conditions betterment and local climate mitigation. In the created model a PES scheme is considered as structure composed by groups of categories (classes) named General, Geography, Governance and financial, Environmental, Indicators, Benefits and Other information (Fig. 2).
Each group contains one or more categories or classes. In turn, each category contains one or more attributes. The group General consists of following categories – Respondent information, Scheme general information and Implemented categories of ecosystem services; Geography – Scheme scale and location and Population area

of the scheme; Environmental – Ecosystem, Water uses and issues, Wetland characteristics; Forest ecosystem characteristics and Water body characteristics; Governance and financial – Scheme governance, Scheme timeline and Scheme implementation costs; Indicators – Water quality indicators, Microclimate indicators, Soil indicators; Benefits – Benefits; Other information – Availability of further data.

The most complex groups of categories are Environmental, Governance and financial, and Indicators, which are the corollary of the model (Fig. 3).

In the developed platform, PES scheme structure is presented as a web form and the composing categories as tabs (Fig. 4).

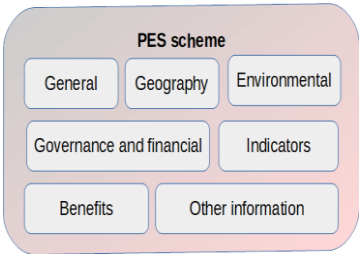

Figure 2. High level of PES and scheme structure

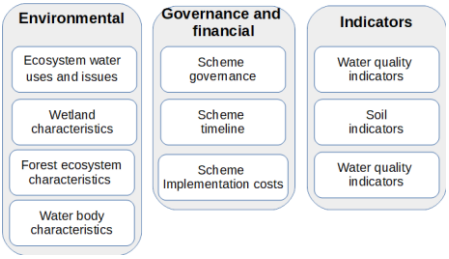

Figure 3. Structure of Environmental, Governance, and financial information. Indicators.

The description of a particular PES scheme is materialized (or instantiated) by setting of specific values for the attributes. In this case, we say that there is an instance of the PES scheme. One instance consists of instances of composing categories. The instances of categories, in turn are represented by values of their attributes. Each category may have either only one or multiple instances. A with multiple instances is illustrated on Fig. 5.

The categories having more than one instance will be identified to be of a vector type. The one-instance categories we denoted as of a scalar type. The categories of a vector type are – Water quality indicators, Microclimate indicators, Soil indicators and Benefits. The remaining categories are of a scalar type.

The attributes of categories may be text fields, text areas, selectable from a list of alternatives, dates, and images. They also may be of a scalar or vector type. On Fig. 6, the attribute named Forest area is a scalar and Tree species is a vector. Only the selectable, date and image types may be either a scalar or vectors.

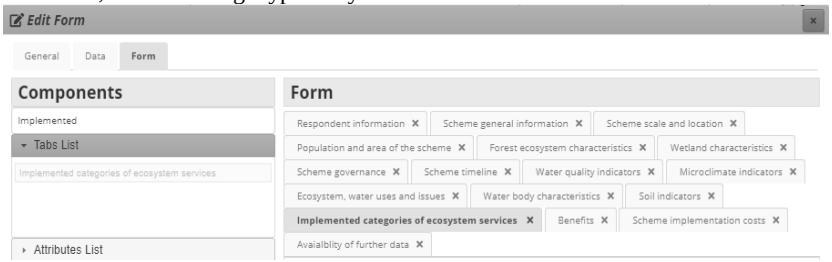

Figure 4. Structure of PES scheme implemented as a web form

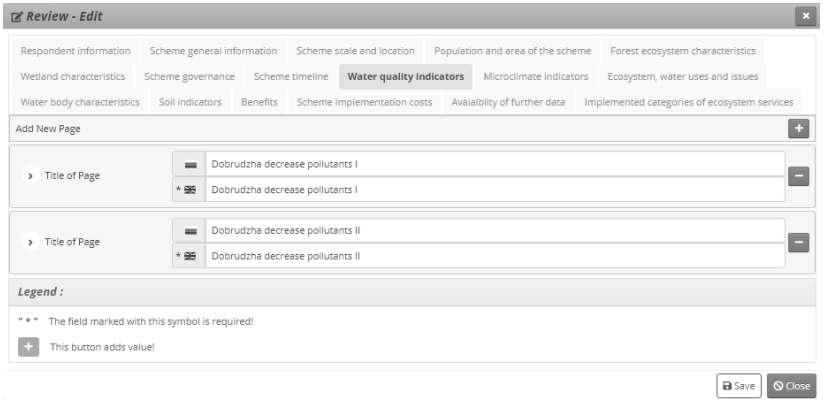

Figure 5. Multi-instance category

Below we will describe categories with their attributes consolidated by the groups to which they belong.

General. *Respondent information* contains contact information and country names and the attributes, such as Name of respondent, Contact person, Address of contact person – text fields of scalar type, and Country - selectable of vector type. The reason the attribute Country is a vector is that a PES scheme can be implemented in more than one country.

Scheme general information sets out a general description of the PES scheme. The attribute Scheme scale is a text and a scalar one. The attributes Scheme geographical location NUTS - broad region, Scheme geographical location NUTS - region and Scheme geographical location NUTS – district are of vector type. The rationale behind this approach is that a scheme may cover more than one NUTS unit. The category *Implemented categories of ecosystem services* contains descriptions of ecosystem categories relevant to described PES scheme. The attributes containing these descriptions are scalar text areas – Regulating, Provisioning, Socio-cultural and Supporting. The last attribute is image of vector type and may contain one or more images illustrated the descriptions in the other four attributes.

Geography**.** *Population area of the scheme* has following attributes: Number of beneficiaries (if relevant and available), Area of case study (if relevant and available), Local communities, Area of afforestation created by the case study, Households, Firms, Farmers, Area of existing forest participating in the case study, which are scalar.

Population area of the scheme is composed of: Number of beneficiaries (if relevant and available), Area of case study (if relevant and available), Local communities, Area of afforestation created by the case study, Households, Firms, Farmers, Area of existing forest participating in the case study. All of them are test fields and scalar.

Environmental. *Ecosystem, water uses and issues* All attributes belonging to that category are selectable of vector type namely - Type of ecosystem targeted by the case study, Use of water targeted by the case study, Water issues targeted by the case study: quality, Water issues targeted by the case study: other, Management

measures rewarded by the case study, General water benefits generated by the case study, Specific water benefits generated by the case study. *Wetland characteristics* contains two selectable vector indicators – Wetland type and Wetland subtype. The both attributes are vectors, because a scheme may contain different wetlands types and subtypes. *Forest ecosystem characteristics* has scalar and vector attributes. The attributes Forest canopy and Forest origin are of type selectable scalars. The attributes Forest area, Forest location and Forest age are scalar text fields. The attributes Tree species and Forest type are selectable and of a vector type, because a forest can consist of more than one tree species and can combine more than one type of forest. *Water body indicators* encompasses following attributes: Type of water body, Waterbody quality, Lake basin surface, Water body surface, Flow rate of water body and River basin surface - text field and scalar values.

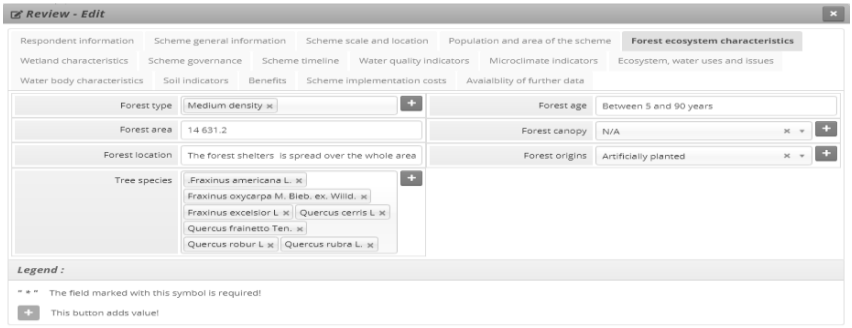

Figure 6. Vector and scalar attributes

Governance and financial**.** *Scheme governance* is mainly focused on actors of PES scheme - Providers of services, Users, Buyers, Payers, Intermediaries, and Volunteers, which are vector attributes. Two additional attributes - Case study description and Degree of scheme voluntariness are text area and scalar. *Scheme timeline* is relative simple one having three text fields of scalar attributes - Case study establishment year, Case study duration (time horizon) and Case study status. *Scheme implementation costs* consists of four pairs of attributes. Each pair of attributes consists of one vector-type attribute that contains a detailed description of a specific cost group and scalar attribute that is equal to the sum of the costs incurred in that group. The cost groups are Transaction starting, Implementation, Opportunity, and Recurring transaction costs.

Indicators**.** *Water quality indicators* is a complex category. It contains four groups of indicators – Physical, Chemical, Biochemical and Biological indicators together with their x-ant, x-target and x-post values. The meaning of their x-ant, x-target and x-post values is as follows - x-ant attribute is value of measured pollutant before applying the PES scheme; x-target is the target value to be reached, when the scheme will be implemented and x-post - the achieved measured value of that pollutant at the end of PES scheme implementation. Each indicator is a generic for the specific pollutant. Because of the wide variety of pollutants pertaining to a particular indicator, a PES scheme may target several specific pollutants of one indicator. For example, organic pollutant can be of different types. In order to list all

pollutants treated by a PES scheme, it is necessary to create more than one of these categories. That is why the category is of a vector type. The vector components are set up by creating the new pages. Each page records the specific indicators and their respective values. *Microclimatic indicators* have four attributes - Microclimatic indicator and the respective x-ant, x-post and x-target values. Since any number of microclimatic indicators is possible, this category should of a vector type. Each component of the vector consists of the specific microclimatic indicator and its x-ant, x-post and target values. *Soil indicators* are of selectable type together with their x-ant, x-post and x-target values. Since the category is of a vector type, any number of soil indicators can be added along with their x-ant, x-post and x-target values.
Benefits. The reason that Benefits are of a vector type is the same as for Soil indicators. In such a way, we may add arbitrary number of benefits. Each Name of benefit attribute is packaged together with its x-ant, x-post and x-target value.
Other information. *Availability of further data* is a map dataset - the attributes contain answers of following questions: Are the economic data related to the case study implementation available?; Are the monitoring data for the case study available?; Is the information on the monetary amount of payments available?; Are the maps or GIS data for the case study available?; Are the cost-effectiveness estimates for the case study available?; Do you think this is an interesting case for further investigation and why? The questions are considered as keys to answers related to specific PES scheme described.

Conclusions

The proposed structural model is a first attempt to create detailed structural model of PES schemes related to the use of forests to improve the quality of water, microclimate and soil. It is more oriented toward forest ecosystem services and their application to improve the quality of surface water. The developed platform is unique application dealing with PES schemes information. It is an open warehouse for gathering and browsing PES schemes information. The future development of PES reviewing platform will be in the directions of improving and facilitating the reporting tool. Additionally, the authors consider computation effectiveness and cost effectiveness of reviewed schemes. Another foreseen direction is adding Big data and Decision making support. The platform allows rapid analysis and evaluation, as well as team work online, which will significantly speed up the process of creating new PES schemes. The proposed platform can be the useful tool for ecosystem services payment and sustainable development of regions. It is free of use and can be found on http://dev.elliot.virtech-bg.com/review.

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