Food Safety as a Global Public Good in the Context of Common Agricultural Policy
Case Study: Demand Side Evaluation using Mutli-Criterial Analysis in Bulgaria

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Abstract
The food safety as providing utility available on an international scale falls within the classical definition of the global public goods. This paper presents a multi-criterial model for assessing the demand side of food safety as a public good in Bulgaria, in a context which can be easily articulated with the broader scope of European Union 's Common Agriculture Policy. Based on a large pool of experts in agriculture as well as consumers and farmers in the South-Central Region of Bulgaria, a specific survey was tailored and applied following the methodology of Analytic Network Processes and the Benefits-Opportunities-Costs and Risks (BOCR) specific framework. Weights of importance for food safety in the context of other significant public goods were derived to express demand side priorities under general strategic criteria. Contingency valuation (CV) as a method to measure the willingness to pay for the food safety was also included in the survey and was processed in accordance with the previously demand side weights of importance calculations. Sensitivity Analysis completes the paper and constitutes an example about how national agricultural policy influences the enforcement provision of public goods. The analysis performed in this paper can be easily extended to nearby countries in the attempt to improve on the European policy's coherence regarding food safety.
Keywords: Food Safety, Public Goods, Contingent Analysis, Multi-Criterial Analysis, Analytic Network Processes.

Introduction
Facing the global climate change as well as the structural shifts in the world economy, for issues like the food safety, social polarization and economic sustainability in agriculture, determining convenient monetary values associated with specific public goods on both demand and supply side is of a particular importance in the optimal design of the Europe's Common Agriculture Policies (CAP's). This paper focuses on implementation of the most relevant methods concerning demand-side valuation assessments of public goods/bads (PGBs) provided by the agricultural and

forestry systems (AFS) with a focus on food safety in the context of other relevant public goods in Bulgarian agriculture with the scope of achieving comparable monetary values for distinct degrees of improvements. Following previous studies on combining contingent valuation and the analytical hierarchy process, benefits, opportunities, costs and risks are structured in a complex Analytical Network (ANP) Model in which the control hierarchy is providing overriding criteria for comparing each type of interaction that is intended by the network representation of the demand for public goods in agriculture in the south-central planning region in Bulgaria. Sensitivity analysis concluding the paper provides an insight over the derived relative importance of food safety on particular directives in the European CAP.

Food safety as a public good in the context of European Union (EU)'s Common Agricultural Policy (CAP): Literature Review

The concept of public goods was developed by Samuelson (1954) and Musgrave (1959). These authors state that markets are not a suitable mechanism for trade of some goods. The society demands certain goods which are not measured by prices. The reasons for that are inherent qualities of public goods (PG) – non-excludability and non-rivalry in consumption. The market mechanism is insufficient in such cases, so provisions of these goods need a different approach. Economists work on a normative approach, for considering when public or state intervention in markets may overcome this problem.

Public goods are used as a term in socio-political contexts: things which are 'for the common good'. Development of the PG concept is a core in debates about future policy concerning maintenance of their availability and usage. We adopt the neo-classical economic approach in consideration of PG.

Public good is an item whose consumption is not decided by the individual consumer, but by the society as a whole. A public good (or service) may be consumed without reducing the amount available for others and cannot be withheld from those who do not pay for it. Cornes and Sandler (2003) give a clear exposition of the economic meaning of "public goods". These goods have the two key intrinsic features non-rivalry and non-excludability, as mentioned earlier. Non-rivalry means that more than one person can consume the good at the same time. Non-excludability means that the good is provided to everyone in the same place. These two characteristics set up an inappropriate supply and pricing of these goods in conventional markets, and they are often therefore described as examples of market failure. Overcoming of market failure proposes consideration of some kind of collective action or public intervention, for correcting it.

There are relatively few examples of pure public goods. Examples include flood control systems, public water supplies, street lighting for roads and motorways, lighthouse protection for ships and also national defense services.

The OECD, in its analysis of public goods in farming and forestry (OECD, 2013), suggests using various ways to ensure adequate provision of public goods according to the social norms and the level of private provision. The public financing is just one of them. Other authors have found similarity between PGs and private goods. They include both tangible goods and less tangible services demanded by society. Bureau et Mahé (2008); Bureau (2010), Poux (2012) describe social and environmental elements of public goods. Dwyer and Hodge (1995) have explored the phenomenon of non-profit provision where goals other than profit maximization drive production choices. It is so-called socially-responsible production where economic and wider

social and environmental goals are combined, in specific types of farming and forestry practice (e.g. Grouiez, 2014; SFSCC, 2015). In these situations, traders in markets would be motivated to maintain PGs, due to the broader mix of drivers to which they respond.

Market failure stimulates economists to search appropriate tools for correcting this situation. Three kinds of recommendations are usually suggested: state intervention for providing goods directly (e.g. compulsory purchase and nature reserve management); the use of market instruments to influence provision (e.g. tax or incentive payment/subsidy to decrease private generation of public bads or increase private supply of public goods in the production of private goods); or regulation in order to re-define property rights so as to place public duties upon private actors (e.g. prohibition on certain types of land use or management, for sites or assets of specific public values).

Research methodology: Benefits, Opportunities, Costs and Risks (BOCR) Models using Analytic Network processes (ANP) in the context of Multi-Criterial Analysis:

Analytic Network Processes (ANP) theory as introduced by Thomas Saaty (see Saaty, 2009) belong to the multi-criterial decision making (MCDM) topic and it is grounded on the mathematical theory of stochastic matrices, eigen values and vectors, graphs and networks as well as on the behavioral economics and decision making. The building blocks in modelling certain decision problem in this context are clusters, nodes and connections. Pairwise comparisons of the nodes are done with respect to certain control criterion and the most linguistic to numerical scale is Saaty's 1-9. In assessing the importance of several alternatives, benefits and costs are difficult to be expressed in monetary terms, especially when tangible aspects must be compared with intangible ones. One of the most complex models within the theory of Analytic Network processes (ANP) is the network with Benefits, Opportunities, Costs and Risks (BOCR). A BOCR model will have four separate hierarchies: Benefits hierarchy (B), and similar Opportunities hierarchy (O), Costs hierarchy (C) and Risk hierarchy (R). The importance of criteria in its correspondent hierarchy is pairwise estimated and this process produces relative criteria weights. Synthesis of the alternative priorities in a weighted sum produces conditional alternative priorities for each hierarchy. Using an extra control hierarchy represented by strategic criteria like economic, social and environmental the alternatives under each of the previous four networks are weighted into final ones. A detailed description of the estimation of a BOCR with both advantages and shortcomings is described in a schematic representation of the BOCR ANP model is shown in the Figure 1. below.
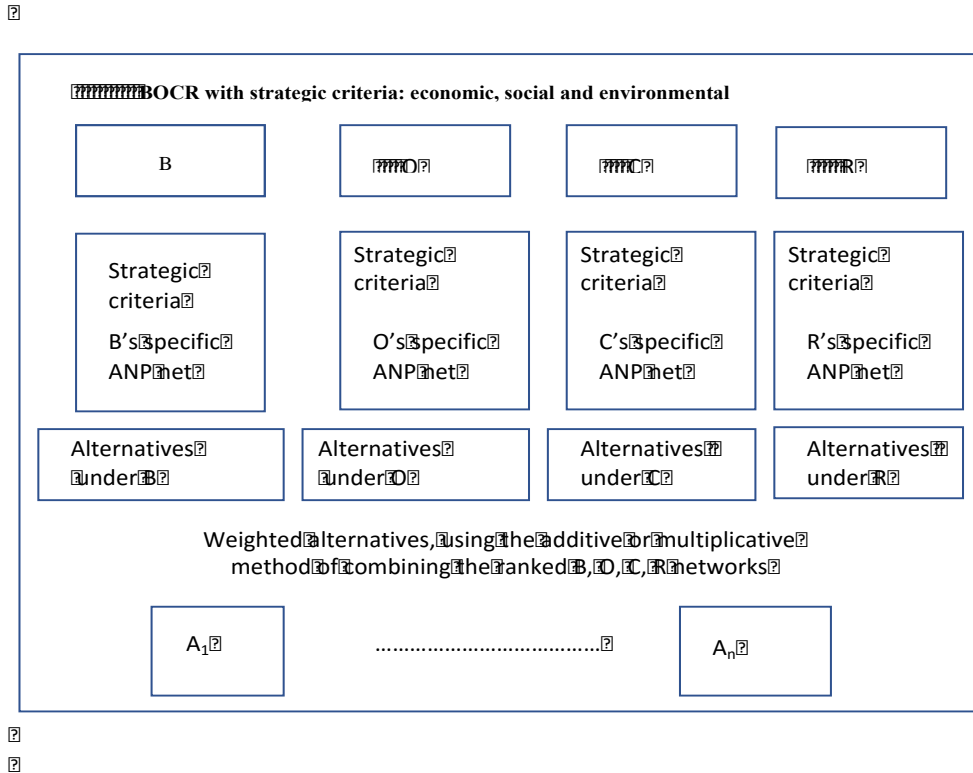
Figure 1. The structure of a BOCR-ANP model
Source: Authors

The model developed in this paper has the above particular form described in the context of the Figure 1. The strategic criteria are *Social*, *Economic* and *Environment*. Clusters considering categories of influence on the demand side of the previously mentioned three public goods were constructed after a careful literature review. Most influential papers are listed in the references. The decision to consider the three public goods in the alternatives as being the Water Quality, Food Safety and Scenery and Recreation was taken after a large survey on the prevalent public goods in Bulgarian agriculture was conducted. Also, every node considered, as well as the connections in between nodes resulted from the large-scale survey with both experts and representatives of the demand and supply side involved in the delivery and consumption of the public goods presented in (Nikolov D., Mihnea A., Boevsky I., Borisov P., Radev T. (2017)). It is shown in previously cited paper how the required data for estimation of public goods (PGs) were collected by conducting focus groups, during which were discussed in depth study subjects, thanks to the benefits of developing group dynamics and effect. During the discussions by spontaneously thorough discussion of the predetermined range of issues were formulated clear categories and definitions, which helped to better explain and understand quantitative studies of phenomena. The discussions were led by a moderator who put matters to discuss, monitor the equal participation of persons focuses on interesting new guidelines spontaneously expressed by the participants. In leading the discussion moderator uses the following projective techniques: Techniques Association techniques and complementarity. The discussions attended by 14 people - farmers, representatives of agricultural associations, local public authorities and consultants. The participants were divided into two groups of 7 persons. Each group received natural-geographic map of the area and a list of ten potential PGs. Each participant was asked to determine distribution of public goods in the region using 3 color sticky notes (red = available; white

= neutral; blue = no). As a result, it was found that the most important public goods/bads in the region are: Water Quality, Food Safety and Scenery and Recreation. Nodes in every previous cluster were distributed according to their influence split on the three strategic criteria and separately, benefits, opportunities, costs and risks for each of the three alternatives. Their distribution is shown in the Table 1 below.

Table 1: Node distribution in the BOCR model

Elements		Water quality	Food safety	Scenery and recreation
Benefits	Social	Rural Population	Cooperatives	Potential Tourist
	Economic	Rural Population in the Hotspot Area	Food Clusters	Rural Population in the Hotspot Area
	Environment	Local Authorities	Cooperatives	Potential Tourist
Opportunities	Social	Subsidies	Subsidies	Eco-Road
	Economic	Potential Tourist	Crop Rotation	Potential Tourist
	Environment	Water	Eco-Standards	High Natural Value Land
Costs	Social	Subsidies	Subsidies	Subsidies
	Economic	Water	Eco-Standards	Land
	Environment	Irrigation Costs	Eco-Standards	Soil Degradation
Risk	Social	Skilled Workforce	Diseases and Pests	Air-Quality
	Economic	Flooding	Skilled Workforce	Soil Erosion
	Environment	Bio-Diversity	Diseases and Pests	Road (Infrastructure and Maintenance)

Source: Authors

The above constructed BOCR model was implemented in the freely available Super Decisions Software where there is a special BOCR template. The appearance of the general structure as it schematic presented in Figure 1 is shown in Figure 2 below.
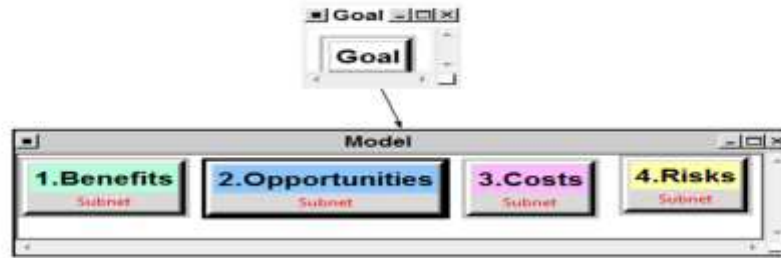
Figure 2. BOCR template in the Super Decisions software
Source: Authors

In Figure 3 below it is shown how the row containing the node distribution of Opportunities, economic with respect to the alternatives-having only two nodes: Potential Tourist and Crop Rotation is implemented within the BOCR template in the Super Decision Software.
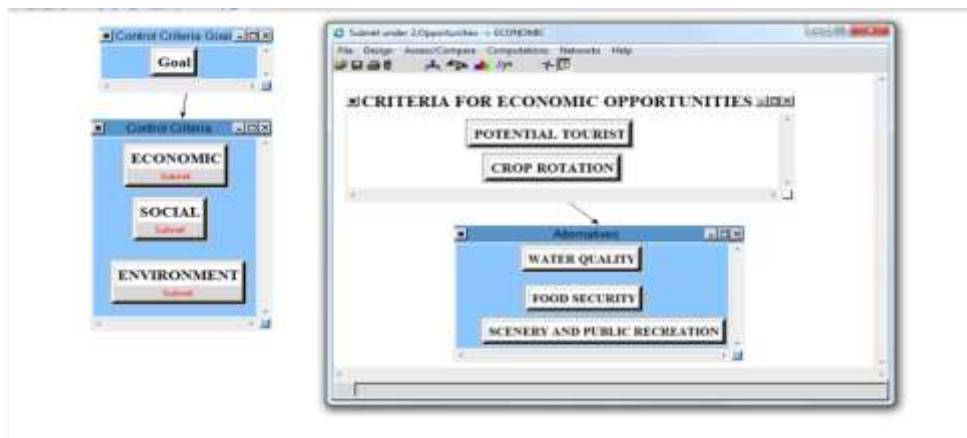

Figure 3: Criteria for economic opportunities implemented in Super Decisions software
Source: Authors

BOCR for Estimating the Food safety 's Demand Side as a Public Good in the South Region of Bulgaria: Survey Design and Model Estimation
The BOCR Survey Design
The survey designed according to the BOCR methodology was delivered to the group of 87 experts in the South region of Bulgaria, following the strict methodology of the preference and pairwise comparison and also the 1-9 fundamental scale. The order of the alternatives over which preference and pairwise comparison is expressed is altered in order to avoid the framework effect. Results built on a large scale regional survey. The survey is developed in two formats. First one is asking questions about preference and pairwise comparisons as in the original framework of the ANP theory, using the 1-9 Saaty's fundamental scale. As the responses need a throughout perspective and timely attention, this survey was delivered to a focus group constituted by highly skilled experts in the domain, to be individually completed. Answers were aggregated following the group decision technique appropriate in the ANP context, namely through the consideration

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of the geometrical mean of alternative choices regarding the same pairwise comparison, followed by the synthesis of the group decision resulted model. The second format, designed to assess the demand for the previously mentioned three public goods by a large group of stakeholders is asking questions about preference and intensity of preference on an increasing nominal scale from 1 to 9. These results were imputed using the Super Decisions software framework in the Direct Mode. This Direct Mode allows for the computation of the priority weights and the synthesis of the model comparable to the one in which pairwise comparison is performed, as well as for similar sensitivity analysis. Contingency valuation concludes every individual survey.

An example of how several questions present in the survey addressed to the stakeholders as well as the Contingency Valuation (CV) was performed is shown below, in Figure 4.

| 31 | When you think of the **ENVIRONMENT OPPORTUNITIES** of ECO-STANDARDS what is more important? | | | |
| 32 | When you think of the **ENVIRONMENT OPPORTUNITIES** of HIGH NATURAL VALUE LAND what is more important? | | | |

Mark with grades from 1 to 9, with 1 – none and 9 – very strong

№	**SOCIAL RISKS are connected with less public goods due to lack of some factors as** SKILLED WORKFORCE, DISEASES AND PESTS and AIR-QUALITY	FS	SC	WQ
33	When you think of the **SOCIAL RISKS** of (lacking) SKILLED WORKFORCE what (public good) is more vulnerable?			
34	When you think of the **SOCIAL RISKS** of confronting with DISEASES AND PESTS what (public good) is more adversely affected?			
35	When you think of the **SOCIAL RISKS** of a poor AIR-QUALITY what (public good) is more adversely affected?			

Mark with grades from 1 to 9, with 1 – none and 9 – very strong

№	**ECONOMIC RISKS** are connected with the opportunities to have a less public goods from the influence of several factors	FS	SC	WQ
36	When you think of the **ECONOMIC RISKS** of FLOODING what (public good) is more adversely affected?			
37	When you think of the **ECONOMIC RISKS** of (lacking) SKILLED WORKFORCE what (public good) is more adversely affected?			
38	When you think of the **ECONOMIC RISKS** of SOIL EROSION what (public good) is more adversely affected?			

Mark with grades from 1 to 9, with 1 – none and 9 – very strong

№	**ENVIRONMENT RISKS** are connected with the opportunities to have a less public goods from the influence of several factors	FS	SC	WQ
36	When you think of the **ENVIRONMENT RISKS** of lacking BIO-DIVERSITY what (public good) is more adversely affected?			

| 37 | When you think of the **ENVIRONMENT RISKS** of facing DISEASES AND PESTS what (public good) is more adversely affected? | | |
| 38 | When you think of the **ENVIRONMENT RISKS** of (lacking) ROAD (infrastructure and maintenance) what (public good) is more adversely affected? | | |

Mark with grades from 1 to 9, with 1 – none and 9 – very strong

38. *How* much *would you pay for* **a moderate** *improvement in the PGBs provided by the AFS in the selected HS?* Mark the preferred yearly amount, which would be paid through national taxation.

0 €/year	5 €/year	10 €/year	15 €/year	20 €/year	25 €/year	30 €/year	35 €/year	40 €/year	45 €/year	50 €/year	> 50 €/year

39. *How much would you pay for* **a significant** *improvement in the PGBs provided by the AFS in the* selected *HS?* Mark the preferred yearly amount, which would be paid through national taxation.

0 €/year	5 €/year	10 €/year	15 €/year	20 €/year	25 €/year	30 €/year	35 €/year	40 €/year	45 €/year	50 €/year	> 50 €/year

Figure 4. A sample of the BOCR survey in the direct mode addressed to the stakeholders
Source: Authors

Survey aggregation and Model estimation
Surveys addressed to the stakeholders were processed in the Direct Mode in the Super Decisions and afterwards the resulted priority weights were averaged per each component. If the control criteria: Benefits(B), Opportunities (O), Cost (C) and Risk (R) are weighted equal importance in measuring the weights of importance under the Economic, Social and Environmental strategic criteria, then the weights of importance for the three previously mentioned PG are shown in the next Table 2.

Table 2 Weights of importance for PGs under equal importance of the strategic criteria

NAME	NORMALS
FOOD SAFETY	-0.407464
SCENERY AND PUBLIC RECREATION	0.065043
WATER QUALITY	-0.527493

Source: Own Calculation

This can be interpreted that under an equal overall assessment of the aspects involved in the demand decision the importance of the water quality demand is underestimated with 52 percent, the importance of food safety demand is underestimated with 40 percent while the demand for

scenery and public recreation is slightly important. This brings to the attention that an unfocused advertising of the benefits of the food safety in which the three strategic criteria are equally emphasized lead to an undersized demand for food safety with 40 percent.

On the other hand, if the importance of the Benefits in achieving PG is emphasized and increased with only ten percent, the synthesized new weights of importance for the three PG are shown in Table 3:

Table 3 Weights of importance for PGs under equal 10 percent increase in the Benefits' importance

NAME	NORMALS
FOOD SAFETY	0.271
SCENERY AND PUBLIC RECREATION	0.429
WATER QUALITY	0.300

Source: Own Calculation

The three selected public goods to be considered for a priority weight determination in the context of the AHP/ANP methodology were analyzed under some strategic criteria, namely Economic, Social and Environmental splinted under some control criteria represented by Benefits, Opportunities, Costs and Risk (BOCR). The BOCR merits model was aimed to capture different aspects in the demand of the public goods and it can point to meaningful sensitivity analysis in order to design efficient environmental policies for supporting a certain chosen public good.

The individual responses collected among the stakeholders will be aggregated in two ways. The first and simplest one is to average over the synthetized resulting priority weights of the three public goods under consideration. The disadvantage of this approach is that it does not allow for the sensitivity analysis. For this aspect to overcome, alternatively, opinions of the stakeholders will be averaged for every question and the results will be imputed in a BOCR averaged model. Thus, through the synthesis of this last one model it will also be possible to perform synthesis analysis and comparisons with the results delivered from the expert group decision will be made. Regarding the contingency valuation, this model emphasizes the dependence on the various importance granted to the generic benefits, opportunities, costs and risk. This dependence is illustrated in Table 4 below.

Table 4. Monetary valuation of the PG's depending on the importance granted to the generic criteria B.O.C.R

	B	O	C	R
Relative weight of importance	0.526	0.1307	0.2785	0.06415
	Resulted weight of importance for the PG's	Monetary value as resulted from CV (in BGN)		
FOOD SAFETY	0.331363	21.92545		
SCENERY AND RECREATION	0.367993	22.07197		
WATER QUALITY	0.300644	21.80258		

Source: Own Calculation

Results show that the monetary value associated to the improvement with one unit of the existent Food Safety conditions is of approximately 22 BGN, sensible equal to the one associated with the other two public goods considered, only if in the policies designed to promote these public goods emphasize twice more Benefits of Food Safety then the costs associated with it (comparing 0.526, the weight of importance for Benefits with 0.2785, the weight of importance for Costs) while Risks in achieving one unit in improving the Food Safety should almost be left aside when presented to the public. Depending on the participants to the survey, the same estimations are intended to be performed with the suppliers of public goods and results to be compared.

Conclusions

A previous large survey conducted in the South Region of Bulgaria prior to this study identified the most important three public goods delivered within regional agricultural activities, on both supply and demand side. These three goods are Food Safety, Water Quality and Scenery and Public Recreation. Also, in the previously conducted study were determined the determinant factors which influence both demand and supply of these public goods and among these were crop rotation, subsidies, irrigation costs, eco-standards, diseases and pests, skilled workforce, flooding.

This paper builds a multi-criterial model in the special template of the BOCR using ANP technique having as alternatives the previously three main public goods. Nodes were considered from the previous studies, as mentioned, while their grouping in clusters, and connections according to the influence were established based on a focus group with experts in agriculture from South Region of Bulgaria. Strategic criteria in this BOCR model were Economic, Social and Environmental and every aspect regarding Benefits, Opportunities, Costs and Risk in demanding these public goods was weighted against these three strategic criteria, as well as all the alternatives and the intermediary nodes. This focus group validated the model and provided

estimates of it using the pairwise comparison and the 1-9 Saaty numerical scale according to the usual ANP methodology. The model was estimated using the Super Decisions Software and individual opinions were aggregated using of the geometrical mean, according to the specific group decision methodology specific to the ANP technique. Further on, a large-scale survey was conducted with the participation of the stakeholders in the South region and results were individually inputted in the direct mode in the model. Weights of importance for the alternatives were weighted and, in the end, what was delivered from the experts was averaged with what was delivered from the stakeholders. Contingency valuation was also included in the survey designated for the stakeholders and this allowed to determine monetary value for Food Safety in the context of the three public goods considered. The specific construction of the model allows this model to articulate it on further up specific Bulgarian policy considerations derived from the EU's CAP and to design policy recommendations so that one specific public good –if wanted-is stimulated. More precisely, the results show that under an equal importance granted to the main four aspects, Benefits, Opportunities, Costs and Risks, the weight of importance of the Food Safety is negative, meaning underestimated with 40%. This means that the Costs and Risks are underestimated with respect to Food Safety in Bulgaria and therefore the public is not willing to pay when the demand for this public good was estimated by the stakeholders. If Benefits in the improving with one unit on the Food safety are twice emphasized with respect to the correspondent Costs, then the associated importance of the three public goods become sensible equal and the monetary value associated with one unit of improvement in the Food Safety is about 22 BGN. This shows how, using sensitivity analysis within this model, a convenient policy mix could be designed so that one out of these three public goods will be favored, in accordance with the national and Eu's CAP.

The article underlines, by using the stakeholders and experts from the South Region of Bulgaria, how the Food Safety could be evaluated in monetary terms, in accordance with the three public goods considered. In order for these best practices to be properly measured, the BOCR model introduced a sustainable method for evaluating them, according to the ANP methodology and to the EU's CAP regulations framework. The validation of the previous results of the literature by the practitioners, confirmed the relevant character of such a large-scale study, while the benefits of such methods is very well linked to a more practical and sustainable way of providing added value for both researchers and specialists from the field in question.

Also, all the methodology and particular surveys administrated in Bulgaria could be easily replicated in context countries and determine specific and effective policies mix to enforce, for example, significant improvements in the Food Safety across EU's countries as well as to determine more precise monetary values associated with these improves.

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