Michail Salampasis
Thomas Bournaris (Eds.)

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Editors
Michail Salampasis
TEI of Thessaloniki
Thessaloniki, Greece

Thomas Bournaris
Aristotle University of Thessaloniki
Thessaloniki, Greece

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Contents

CAP 2020 Regionalization Design: A Decision Support System

Dimitris Kremmydas[1](✉), Michael Malliapis[1], Leyteris Nellas[1], Apostolos Polymeros[3], Stelios Rozakis[2], and Kostas Tsiboukas[1]

[1] Department of Agricultural Economics & Rural Development, Agricultural University of Athens, Iera Odos 75, 11855 Athens, Greece
{kremmydas,michael,enellas,tsiboukas}@aua.gr

[2] Department of Environmental Engineering, Technical University of Crete, Chania, Greece
srozakis@isc.tuc.gr

[3] Directorate of Agricultural Extension, Greek Ministry of Agriculture, Athens, Greece
apolymeros@minagric.gr

Abstract. The latest Common Agricultural Policy reform provides national authorities with several implementation options for fine tuning individual goals. Among other, member states can opt for regionalization, i.e. vary the basic payment unit value between national agronomic or administrative regions that have been defined at the beginning of the programming period. We present a Decision support System that support national authorities to implement regionalization in a transparent way facilitating collaboration with different shareholders.

Keywords: Common Agricultural Policy · Decision Support System · Basic Payment Scheme

1 Introduction

Common Agricultural Policy (CAP) is the agricultural policy of the European Union (EU), introduced in 1962 and fully implemented in 1968. It is considered to be the first real EU common policy replacing all relevant national agricultural policies while since then numerous reforms have been applied (Table 1). For the last 20 years, CAP is absorbing more or less about 0,5%–0,6%[1] of the EU GDP and 50%–60%[2] of the EU budget annualy. Therefore CAP evaluation is a persisting issue in the Agricultural Economics field.

[1] "CAP expenditure and CAP reform path", accessed from http://ec.europa.eu/agriculture/cap-post-2013/graphs/graph2_en.pdf.

[2] "CAP expenditure in the total EU expenditure", accessed from http://ec.europa.eu/agriculture/cap-post-2013/graphs/graph1_en.pdf.

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Table 1. EU-CAP reform milestones

Year	Short description
1979	Overproduction problems. Measures are put in place to align production with market needs. Introduction of market quotas and expenditure ceiling
1992	"McSharry reform". The CAP shifts from market support to producer support. Introduction of direct aid payments, "set-aside" payments, measures to encourage retirement
1999	"Agenda 2000". Introduction of two Pillars, production support and rural development. Agri-environment schemes became compulsory
2003	"Midterm CAP reform". The link between subsidies and production is cut. Introduction of "Decoupled payments" and "Cross-compliance". "Multifunctionality of agriculture" notion
2006	Sugar regime reform
2008	"Health Check". Enforcement of the 2003 reform
2013	"2014–2020 CAP reform". Introduction of "national envelopes" for members states, i.e. flexibility in the budgeting and implementation of first pillar measurements. Introduction of "Basic Payment Scheme", "Green Payment", "Young Farmers Scheme" and "Redistributive Payment". Gradual abolition of "Historical model"

Compiled from:
a. "The Common Agricultural Policy: A story to be continued", European Commission, accessed from http://ec.europa.eu/agriculture/50-years-of-cap/files/history/history_book_lr_en.pdf
b. Pezaros (2000)
c. "Overview of CAP Reform 2014–2020", European Commission, accessed from http://ec.europa.eu/agriculture/policy-perspectives/policy-briefs/05_en.pdf

The new CAP design, acknowledging the wide diversity of agronomic production potential and climatic, environmental as well as socio-economic conditions and needs across the EU, offers implementation flexibility to member states. Indicatively, member states may: differentiate the basic payment per hectare according to administrative or agronomic criteria; choose from different options for internal convergence for payments per hectare until 2019; opt in for the right to use a redistributive payment for the first hectares; enable the "small farm scheme", where small farms receive an annual subsidy of 500€–1250€ with minimal administrative burden; preserve a limited amount for coupled payments; grant an additional payment for areas with natural constraints (as defined under Rural Development rules)[3].

The latest Common Agricultural Policy reform (CAP2020) provides national authorities with several implementation options for fine tuning individual goals. 30% of the national CAP funding is connected to the farmers' compliance to a predefined set of pro-environmental practices. Up to 5% can be devoted to farms of areas with natural constraints, up to 13% to coupled payments, up to 10% to small farmers' scheme, up to 2% to new farmers' scheme and up to 3% to the national rights stock. The rest, called

[3] Compiled from European Commission MEMO, "CAP Reform – an explanation of the main elements", accessed from http://europa.eu/rapid/press-release_MEMO-13-621_en.htm

basic payment scheme (BPS) is the main layer of income support (over 50% of the national budget), based on payment entitlements activated on eligible land and decoupled from production.

Within this scheme, among other options, Member States (MS) can opt to apply BPS in finer scale than the national level, termed hereafter as *regionalization.*

In the Direct Payments regulation (1307/2013), Article 23(1) notes

> *Member States may decide, by 1 August 2014, to apply the basic payment scheme at regional level. In such cases, they shall define the regions in accordance with objective and non-discriminatory criteria such as their agronomic and socio-economic characteristics, their regional agricultural potential, or their institutional or administrative structure.*

Thus, MS can differentiate the unit value of the basic payment (BP) on the basis of national, agronomic or administrative regions that have been defined at the beginning of the programming period. Policy assigned regionalization regions (RR) can coincide with administrative or geographic regions but can also be not related to them, such as the case of agronomic criteria where a region is defined on the basis of specific crop areas (e.g. arable or permanent crops). Hence, regionalization regions may represent a broader category than administrative or geographic regions and shall not be confused with them.

The only regulation guideline regarding regionalization is that it should be in accordance with objective and non-discriminatory criteria. Practically MS are totally free to draw the regions and allocate the BPS budget.

This flexibility provides to policy makers numerous different alternatives on how to form regions and allocate the budget. Additionally the fact that different stakeholders are affected in a distinct way, call for a transparent design process. Towards this end we propose a Decision support System (DSS) that will support national authorities to implement regionalization in a transparent way facilitating collaboration with different shareholders. In this paper we present its design overview and give a proof-of-concept implementation.

In Sect. 2, we provide details on the mathematical representation of modeling regionalization; in Sect. 3 we give a small review of the use of decision support systems in agricultural policy evaluation; in Sects. 4 and 5 we present the design and the implementation of the employed regionalization DSS.

2 Modeling CAP2020 Regionalization

There are three regionalization types, based on how regionalization regions (RR) are defined.

- RRs are administrative-based partitions (e.g. prefecture-based) or socio-economic related partitions (e.g. mountainous vs. non-mountainous areas). The distinctive feature in this case is that each farm is related with only one RR. The farm's basic payment unit value (BPUV) equals to the RR basic payment unit value that the farm belongs to (Eq. 1).

- RRs are agronomic based partitions (e.g. Arable vs. Tree crops). In this case farms can be related to more than one RR, e.g. half of farm area is connected to arable RR and the other half to tree RR. The farm's BPUV equals the average of each agronomic region (agronomic = crop) basic payment unit value weighted by the share of each crop area to total farm area in a reference year, as in Eq. 2.
- RR definition is a hybrid case of the previous two cases. For example when the RRs are mountainous vs. non-mountainous arable crops vs. non-mountainous permanent crops. Then the farm's BPUV is like the second case but the agronomic basic payment unit value can differ from one farm to another, as in Eq. 3.

Administrative-based regionalization

$$BP_f^F = BP_{r(f)}^R \quad \forall f \quad BP_r^R = BP_r^{BUDGET} / \sum_{f(r)} TL_f^E \tag{1}$$

Agronomic-based regionalization

$$BP_f^F = \frac{\sum_g \sum_{c(g)} \left(BP_g^R \cdot X_{f,c} \right)}{TL_f^E} \quad BP_g^R = BP_g^{BUDGET} / \sum_{c(g)} \sum_f X_{f,c} \tag{2}$$

Combined regionalization

$$BP_f^F = \frac{\sum_g \sum_{c(g)} \left(BP_{g,r}^R \cdot X_{f,c} \right)}{TL_f^E} \quad BP_{g,r}^R = BP_{g,r}^{BUDGET} / \sum_{c(g)} \sum_{f(r)} X_{f,c} \tag{3}$$

where

BP_f^F: Basic payment unit value applicable to farm-f (euro/ha)
BP_r^R: Basic payment unit value applicable to administrative region-r, where $r(f)$ is the region of farm-f) (euro/ha)
BP_r^{BUDGET}: The Basic Payment budget for region-r, where $f(r)$ is the set of farms that belong to region-r (euro)
$BP_{g,r}^R$: Basic payment unit value applicable to agronomic region-g under administrative region-g, where $c(g)$ is the crop-set related to g (euro/ha)
$BP_{g,r}^{BUDGET}$: The Basic Payment budget for agronomic region-g under administrative region-g, (euro)
TL_f^E: Total eligible land for farm-f (ha)
$X_{f,c}^B$: Area of crop-c in farm-f in the reference period (ha).

For an illustrative example regarding those three regionalization types, see Kremmydas et al. (2018).

Therefore the policy-makers options regarding regionalization can be decomposed to the following sequential decisions:

(a) the regionalization type, i.e. administrative, agronomic or hybrid
(b) the allocation of farms and/or crops to the corresponding RRs (defining $f(r)$ and $c(g)$ sets)
(c) the allocation of the total budget to the defined RRs (defining BP_r^{BUDGET}, BP_g^{BUDGET}, $BP_{g,r}^{BUDGET}$).

The DSS addresses those three phases, as described in Sect. 4.

3 Decision Support Systems and Agricultural Policy Evaluation

Decision Support System (DSS) is any kind of a computer program facilitating decision making process. It is an umbrella term that covers any computerized system that supports decision making in an organization. DSS enhances the capability of decision makers to take more accurate and on-time decisions. It has been acknowledged that decisions utilizing DSS can be made more quickly and accurately than unaided decisions (Djamasbi and Loiacono 2008; Todd and Benbasat 2000; Chan et al. 2017).

A properly designed DSS is an interactive software-based system intended to help decision makers compile useful information from a combination of raw data, documents, and personal knowledge, or business models to identify and solve problems and make decisions (Sprague 1980).

According to Power and Sharda (2007), there are five categories of DSS which can be recognized by identifying the dominant architectural component that provides the functionality for supporting decision-making (Power 2002). The five categories include model-driven DSS, as well as communications-driven, data-driven, document driven and knowledge-driven DSS. The architecture is most often comprised of three fundamental components: the database or knowledge base, the model (i.e., the decision context and user criteria) and the user interface. The database or knowledge base holds the data used by the model to derive its conclusions. The user interface is the way through which the user interacts with the DSS to provide the necessary inputs and pick the results.

Agricultural policy needs strategic decisions and requires DSS to evaluate and understand the outcome of each alternative for optimal decision-making. So, the domain is a privileged area for the technology of DSS. There are a lot of DSS covering several aspects of this area and some distinguished papers are mentioned below.

Manos et al. (2010) present a DSS for sustainable development and environmental protection of agricultural regions. The system aims at the optimization of the production plan of an agricultural region taking in account the available resources, the environmental parameters, and the vulnerability map of the region. In their paper, Borges et al. (2010) demonstrate the use of a model base approach to anticipate the impacts of changes in CAP and/or in prices on land use in rural areas (including forest land). In Louhichi et al. (2010) is presented a bio-economic farm model for different bio-physical and socio-economic contexts, facilitating the linking of micro and macro analysis. Model use is illustrated with an analysis of the impacts of the CAP reform of 2003 for arable and livestock farms in a context of market liberalization. Bournaris and Papathanasiou (2012), present a DSS for the planning of agricultural production in agricultural holdings or in agricultural areas. The system simulates different scenarios and policies and proposes alternative production plans. Finally, a paper of Rovaia et al. (2016) presents a comprehensive model for the governance of rural landscape and a first simplified application to a cultural landscape.

4 The CAP2020 Regionalization Decision Support System

National authorities have a great flexibility on how to draw regionalization regions and allocate budget. Consequently they can potentially pursue a wide range of objectives. This means that the required data in order to evaluate the objectives can only approximately be determined during the development of the DSS and very probably new data will be requested during the consultation with other stakeholders.

The DSS knowledge base currently contains data from the Greek Payments Authority on previous CAP regime; the current direct payment allocation per farm size and prefecture. However the database can easily be extended to contain other socio-economic data like the income indicators per farm size and farm activity from the national FADN database; the regional GDP per sector from the national statistical authorities; etc.

The DSS models the effects of the policy makers decisions regarding the three regionalization options (type, region definition, budget allocation) to the Single Farm Payment value for each farm, as described in Sect. 2. Output is provided in the basis of farm grouping of farm economic size and type of farming. Spatial output is also present, providing a visual representation of the effects n each prefecture. In any case the model can be extended to provide output for other measures that represent individual policy goals.

Overall, given an established strategic goal, the DSS provides a clear picture of how that goal is affected for any selected scenarios. The DSS usage is expected to be in an iterative mode: policy makers and stakeholders draw regions, try some budget allocations and observe the effects and then restart the process to fine tune policy results.

We distinguish two DSS use cases that correspond to the regionalization design decisions that are described in Sect. 2 and another one that extends the DSS with collaboration features.

4.1 Select Regionalization Type and Define Regions

Policy makers form a regionalization scenario, i.e. select regionalization type and define regions, by means of exploratory analysis. The definition of regions is based on some partition variables, e.g. the NUTS nomenclature, the altitude or some crop classification like arable vs. permanent crops. Thus the user selects the partition variables which identify the different regions. The user very probably will further consolidate those regions to more homogeneous ones. In order to do so, he will examine certain regions' property variables, e.g. the prevailed crop pattern, the importance of agriculture, the current single payment unit value, etc. He can thus refine initial region creation either manually or through a clustering tool that will suggest him the regions that are as homogeneous as possible. The activity diagram of this use case is provided in Fig. 1.

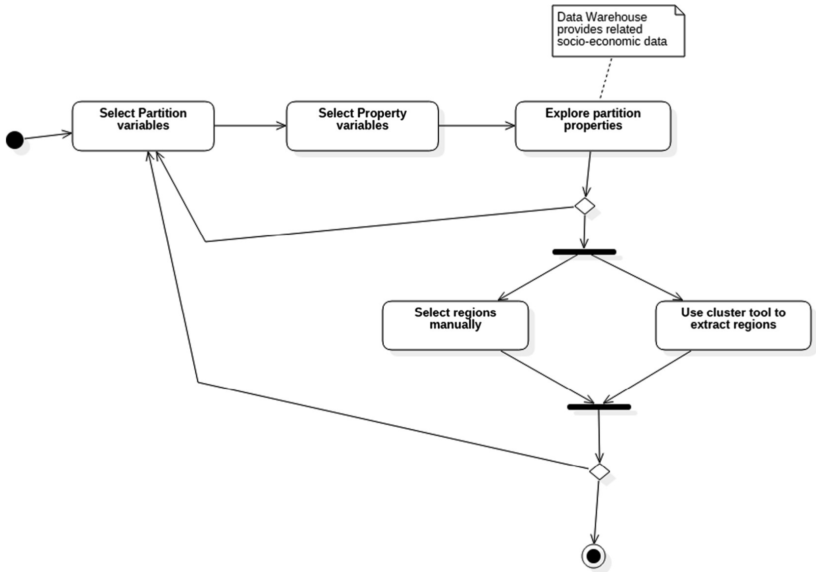


Fig. 1. Activity Diagram for exploratory extraction of regions

4.2 Budget Allocation Across Regionalization Regions

When the user has concluded to a region formation scenario he is ready to set budget allocation. This is expected to be a trial and error exercise where policy makers investigate the effects across different stakeholders for different allocations. Users can manually set the budget share or can use tools of predefined allocations, e.g. budget share proportional to the number of entitlements or to the gross value of direct payments in each region. Then the DSS engine will calculate the indicators and present them to the user. Based on the results the user can save the regionalization scenario and restart the process. The indicators of the scenario effect will span to different stakeholder classes, e.g. farms per NUTS administrative level or per type of farming or per farm income class. The activity diagram of this use case is provided in Fig. 2.

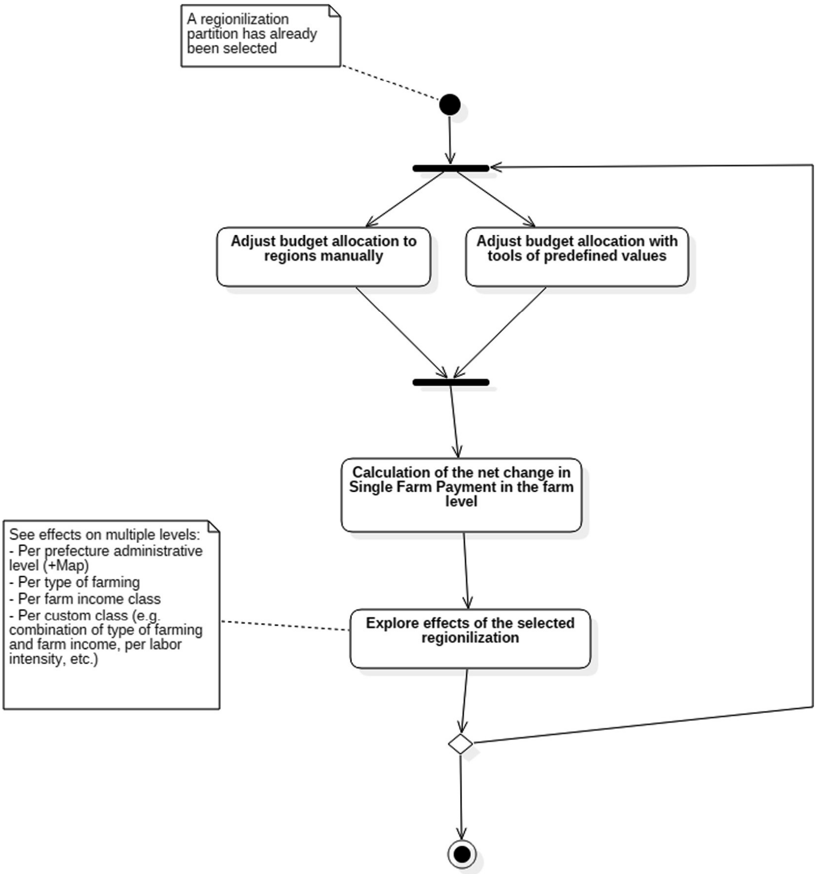


Fig. 2. Activity Diagram for exploring the effects of various budget allocations between regions

4.3 Dissemination and Collaboration

Dissemination and collaboration use case: Due to the different interests of stakeholders, collaboration is a very important aspect of the regionalization decision process and thus is incorporated into the DSS. When a user is satisfied with a scenario (regionalization region definition + budget allocation) he can save it and choose to share it, either with other users of the system or in public. A discussion channel, e.g. a forum thread, will be automatically created so that other users can comment and discuss scenarios. Users will also be able to load the scenarios of other users in order to adjust them to their point of view.

5 A Swift Exhibition of the System

We used the R-Shiny web application framework (Chang et al. 2017) for agile development.

For the region formation stage, we used the following partition variables: NUTS-3, Altitude, Less-Favored-Area, current regionalization regions, municipalities.

For deciding on the region homogeneity we provided the following property variables: number of farms, sum of utilized agricultural area, mean Single Farm Payment unit value, sum of Single Farm Payment value.

In Figs. 3a and 3b, one can see that the user has selected to partition regionalization regions (RR) by Prefectures (Fig. 3a) and to examine the homogeneity of the formulated RRs using the variables of *number of farms, sum of utilized agricultural rea, sum of SFP value* and *mean unit* value.

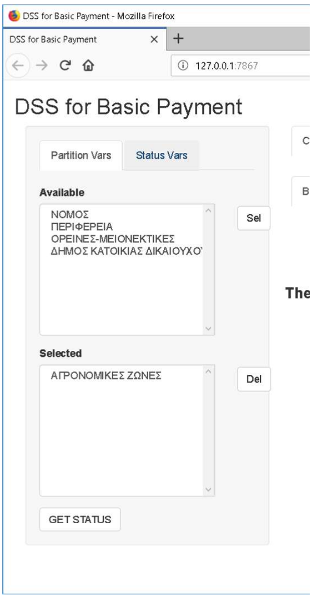


Fig. 3a. Partition variables

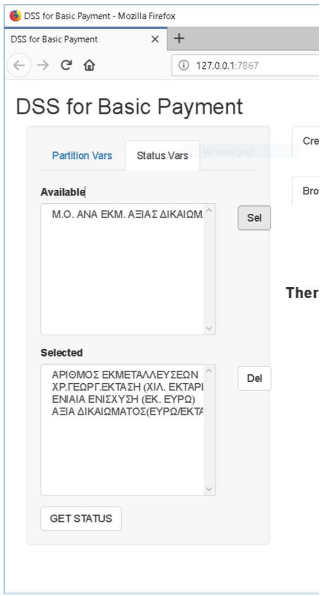


Fig. 3b. Homogeneity status variables

In Fig. 4a we show the status of the DSS when the user has clicked the STATUS button. The values of the status variables are shown grouped by the partition variables. The user can sort prefectures based on status variables and/or filter values. Furthermore on the clusters tab the user can perform a hierarchical or a k-means clustering in order effectively see the homogeneous RRs. In Fig. 4b, the user has selected to perform k-means cluster, eliciting 3 regions based on the number of farms contained in an RR and the mean SFP unit value. The DSS outputs the mean values of the clusters and also adds to CI.G column the number of the cluster that each RR belongs to (see Fig. 4c).

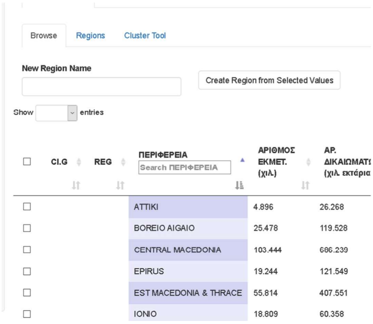


Fig. 4a. Values of status variables grouped by partition variables (STATUS button)

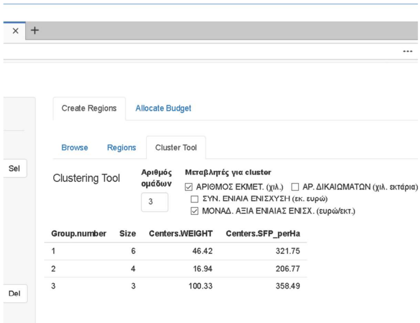


Fig. 4b. Clustering tool

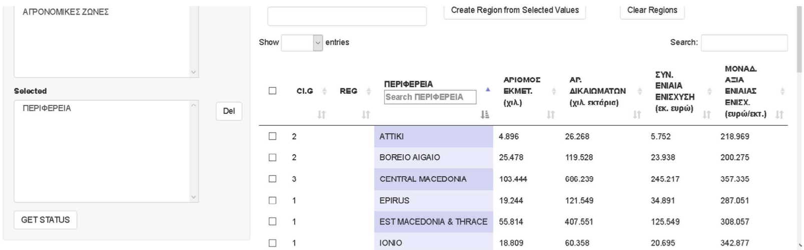


Fig. 4c. Transfer of cluster analysis results

After the user has a clear picture of the homogeneity of the potential RRs, he can further proceed on creating the real RRs. In Fig. 5a, the user has created three regions (Region 1, 2 and 3) after sorting by the CI.G column (the cluster number the region belongs to). Those RRs are a further grouping of the potential RRs. For instance Region 1 is composed of *NOTIO AGAIO, VOREIO AGAIO, ATTIKI, WESTERN MACEDONIA, EPIRUS*. The user can explore many further groupings since the DSS provides instantly their properties regarding the status variables. This is shown in Fig. 5b.

When the user has concluded to a certain RR formation he proceeds to the Budget allocation phase, as shown in Fig. 5c. There, apart from defining the total SFP budget (in this case 1159 mil. Euro), he allocates it to the different regions. It will be also be possible to define Convergence and Redistributive Payment scheme parameters; however this is still under development.

When the user click the *See Effects* button the DSS model is run and all relevant results are given back. They are given grouped by NUTS-3, by Prefecture, by economic size and by type of farming, so that the user can explore the effects on several dimensions (Fig. 6). Also there is a *Complete* option that provides a detailed grouping of all above dimensions. For instance, the user can explore the effects on KRITI prefecture for Arable type of farming for economic size of *2000–8000* economic size group.

Furthermore, for each of the above dimensions, information is also presented by means of maps. In Fig. 7a the net effect (mil. Euro) of the current Regionalization scenario for each NUTS-3 region is presented in a map. Users can also see this map for a certain type of farming or for a certain economic size.

Finally the distribution of the SFP unit value is given in a table and in a chart. In Fig. 7b, the user sees the distribution of the SFP unit value in the current situation (blue line) vs. the user created scenario (red line). Those distributions are also provided for the economic size and type of farming dimensions.

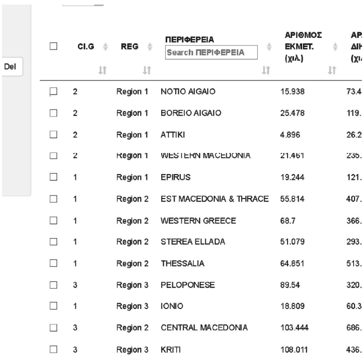


Fig. 5a. Three regions are created

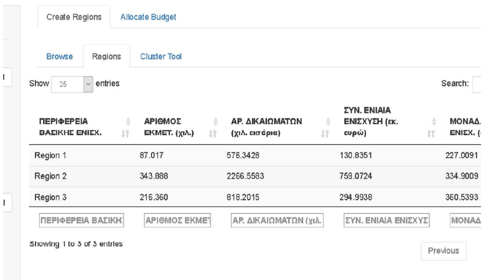


Fig. 5b. Status variables for the created RRs

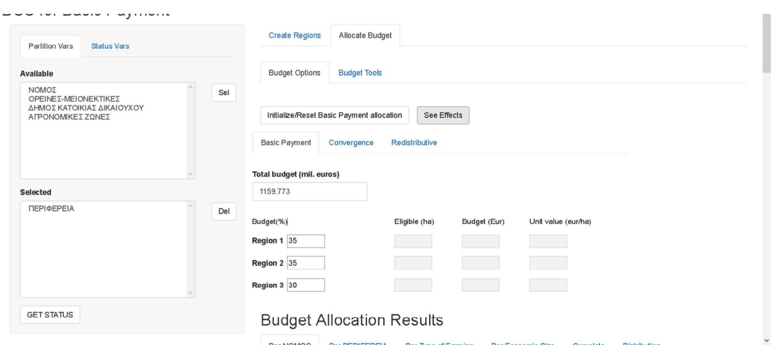
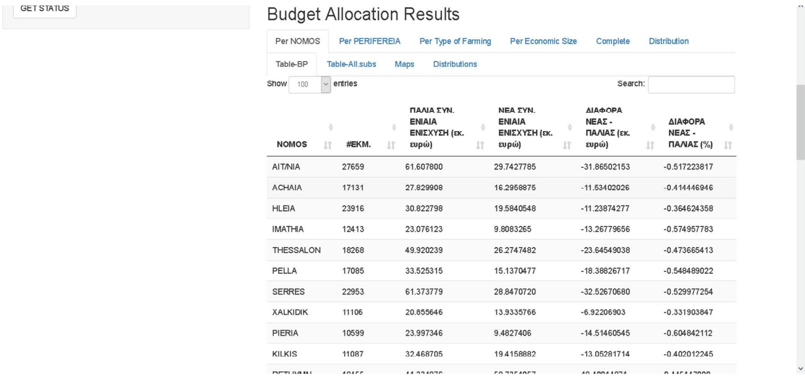


Fig. 5c. Budget allocation panel



NOMOS	#EKM.	ΠΑΛΙΑ ΣΥΝ. ΕΝΙΑΙΑ ΕΝΙΣΧΥΣΗ (εκ. ευρώ)	ΝΕΑ ΣΥΝ. ΕΝΙΑΙΑ ΕΝΙΣΧΥΣΗ (εκ. ευρώ)	ΔΙΑΦΟΡΑ ΝΕΑΣ - ΠΑΛΙΑΣ (εκ. ευρώ)	ΔΙΑΦΟΡΑ ΝΕΑΣ - ΠΑΛΙΑΣ (%)
AIT/NIA	27659	61.607800	29.7427785	-31.86502153	-0.517223817
ACHAIA	17131	27.829908	16.2958875	-11.53402026	-0.414446946
HLEIA	23916	30.822798	19.5840548	-11.23874277	-0.364624358
IMATHIA	12413	23.076123	9.8083265	-13.26779656	-0.574957783
THESSALON	18268	49.920239	26.2747482	-23.64549038	-0.473665413
PELLA	17085	33.525315	15.1370477	-18.38826717	-0.548489022
SERRES	22953	61.373779	28.8470720	-32.52670680	-0.529977254
XALKIDIK	11106	20.855646	13.9335766	-6.92206903	-0.331903847
PIERIA	10599	23.997346	9.4827406	-14.51460545	-0.604842112
KILKIS	11087	32.468705	19.4158882	-13.05281714	-0.402012245

Fig. 6. Budget allocation results

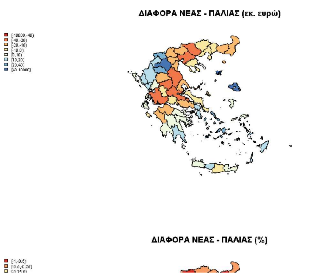


Fig. 7a. Three regions are created

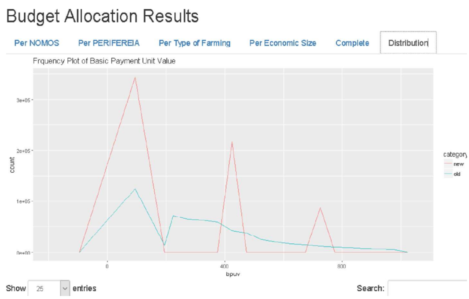


Fig. 7b. Status variables for the created RRs (Color figure online)

6 Conclusions

The latest Common Agricultural Policy reform (CAP2020) provides national authorities with several implementation options for fine tuning individual goals. This creates the need for a transparent policy design process. Towards this end we presented a DSS that support regionalization design in a transparent way facilitating collaboration with different shareholders, in three distinct steps: selection of regionalization type and definition of regions; budget allocation across regionalization regions; dissemination and collaboration between stakeholders.

In the future we plan to extend the DSS database with socio-economic data. Furthermore a mathematical programming farm model will be incorporated so that the adaptation of farms to selected policy scenarios can be evaluated. Finally a pilot implementation with selected stakeholders is also planned.

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