PLUS4-CMP
Conceptual Design

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Report for COMPLEX WP3, Deliverable 3.3, Technical report on PLUS4-CMP model design and specifications” October 07th, 2013

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Preliminary note

This document comprises deliverable 3.3,Technical report on PLUS4-CMP model design and specifications, and responds to Task 3.5, in the Document of Work (DOW), part A, page 16 of 50, not Task 3.10 as stated in the task descriptions, which corresponds to Deliverable 3.5 (PLUS4-CMP model and full system documentation) due to be presented in month 27. This document has been prepared for circulation and internal consultation to COMPLEX team members, whose views and suggestions will be incorporated into the final model (Deliverable 3.5).

1: Introduction

The impacts of policies intended to reduce carbon emissions will have characteristic space-time impacts. These impacts will influence economy, patterns of land-use, social cohesion and compliance. The integrated dynamic model proposed here, known as the Participatory Land Use Simulator for Climate Mitigation Policies (PLUS4-CMP) will simulate the complex interaction of these interlinked domains by focusing on the implementation of Renewable Energy-related Landscape Features (RELF). If there is no demand for RELF, initiated principally through national and regional level policy, no land will be allocated for windfarms, solar installations, biogas plants, biofuel crops etc, and neither will further RE uses be added to the existing ones (e.g windmills alongside road or dikes, solar installations on rooftops, biofuel from waste streams, etc). Equally, if local actors are not supportive of initiatives that implant RELF in their territories, even where demand is allocated higher up the chain, implementation will not be successful. Conversely, if demand for RELF is driven from the bottom-upwards, national or regional economic realities or direct legislation (such as outlawing individual production of renewable energies, as has recently happened in Spain) can freeze implementation completely. This report on model design concentrates on the implications of RE expansion on land use as a core dependent variable. The expansion of RE as such is also a core dependent variable in itself. The impact of related land use changes on the potential for the realization of RE is a relationship that will get more attention is subsequent elaborations.

2: PLUS4-CMP Model Design

2.1: Basic structure and components

PLUS4-CMP will be the result of the integration of several discursive and analytical models and theories. It aims to contribute to a transition to a low carbon economy by identifying potential social and ecological conflicts of RE expansion so they can be avoided/minimised.

Two key elements can be distinguished inside PLUS4-CMP (see figure 1 below):

a) Land **demand** for RE uses will be modelled by combining a policy analysis based on the Contextual Interaction Theory (CIT) with economic data. The CIT that is used here is based on the work of De Boer and Bressers (see Bressers 2004, De Boer and Bressers 2011 and De Boer 2012) and analyses the likelihood of policy implementation and the influence of contextual factors on the related interaction processes. The CIT model is mostly a qualitative framework that guides interpretative policy process analysis. Through the progress made as part of this work it is to be developed into a model with additional explanatory potential.

b) RE land use **allocation** will be modelled by a companion sub-model[1] where local stakeholder information will be included by means of PAR (Participatory Action Research) methodologies integrated with a Cellular Automata-based (CA) land use allocation module. In addition, this part of the model also includes a specific sub-model to define land suitability for RE production. Both PLUS4-CMP key elements are connected by a feedback loop. The demand submodel determines the amount of land to be changed or combined with RE uses and the companion submodel feeds the demand model by determining which scenarios are going to be modelled. The model is dynamic and fully integrated. To produce the land use simulations for each scenario, new land use is allocated according to the demand in each scenario at yearly timesteps from time t1 (the current date) to time t2 (2050). At each yearly increment (tn+1), all modules are updated to reflect the land use configuration achieved in the previous time step (tn). This means that if land is unexpectedly occupied or becomes vacant, the demand targets are updated in the Demand sub-model. Determinism is avoided by stochastic elements in both the demand sub-model and the land use allocator, which may give the system "shocks". This allows the effects of unpredictable climate episodes (e.g. such as the sudden release of massive amounts of greenhouse gas due to arctic melting) to be modelled as knock on effects e.g. increased economic stimuli for RE leading to increased demand, increased actor motivation at all levels leading to increased competition for certain types of land, etc.

RE realizations can change land use, either by replacement of use or by adding functions, and can have positive or negative impacts on the attractiveness of the land for new uses. This can create both positive and negative feedback loops. Another link between both elements of the model is that the change in land use in a certain area will have an influence on the likelihood of further RE realization in the following years. These relations between the two parts of the model will be later further specified.

1*Companion modelling (ComMod) is a scientific posture relevant to the use of simulation tools when dealing with complex systems and human-environment interaction. In ComMod, all stakeholders with relevant knowledge about a particular problem are involved in model development, which proceeds as a cycle of iterative back and forth steps between field and model* (Barreteau et al 2003). *ComMod works collectively towards solutions of complex human-environment interaction problems through a process of open knowledge sharing between stakeholders.*

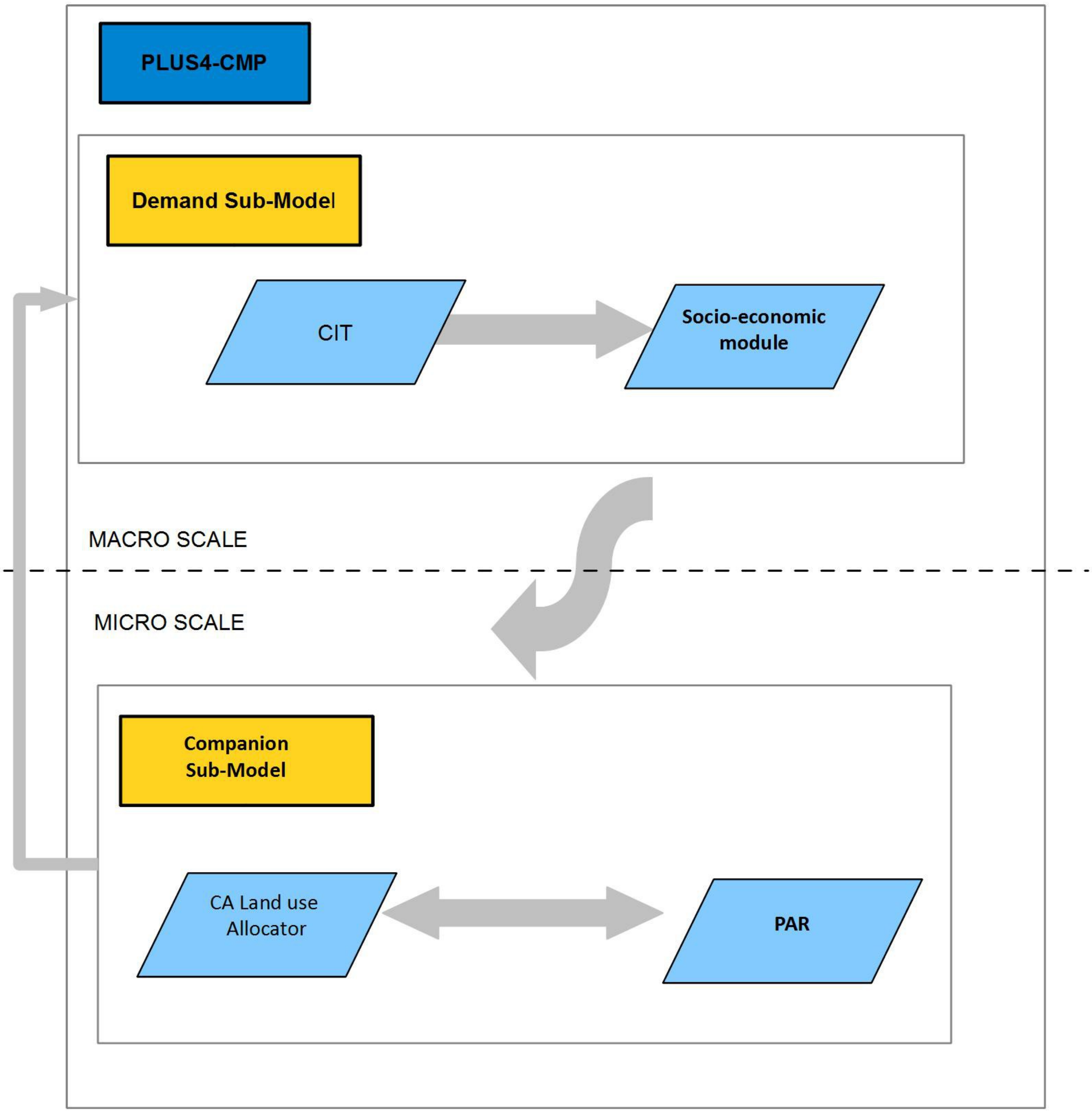

Figure 1: Conceptual overview of the PLUS4-CMP model

3: PLUS4-CMP Deliverables

Each element of the integrated model plays an important role in the final (PLUS4-CMP) system, which will act as a policy support tool. Some of the WP3 deliverables that will emerge from the modelling activities undertaken are specified in the figure below, e.g. policy briefings based on the work developed by/with the stakeholders in different scales of policy implementation process and stakeholders´ empowerment in relation with the RE deployment and policies.

The aim is therefore not only to develop tools and approaches that explore issues surrounding RELF implementation, but also policy recommendations on the basis of our analysis. Social empowerment improvement is also an eventual goal; as during workshops stakeholders will be provided with information on RE and the related policies, and discussions will point out the different points of view about RE development in the case study area. As a result, at the end of the project, every stakeholder involved in the process will become accustomed to managing information on the issue and discussing it with the others.

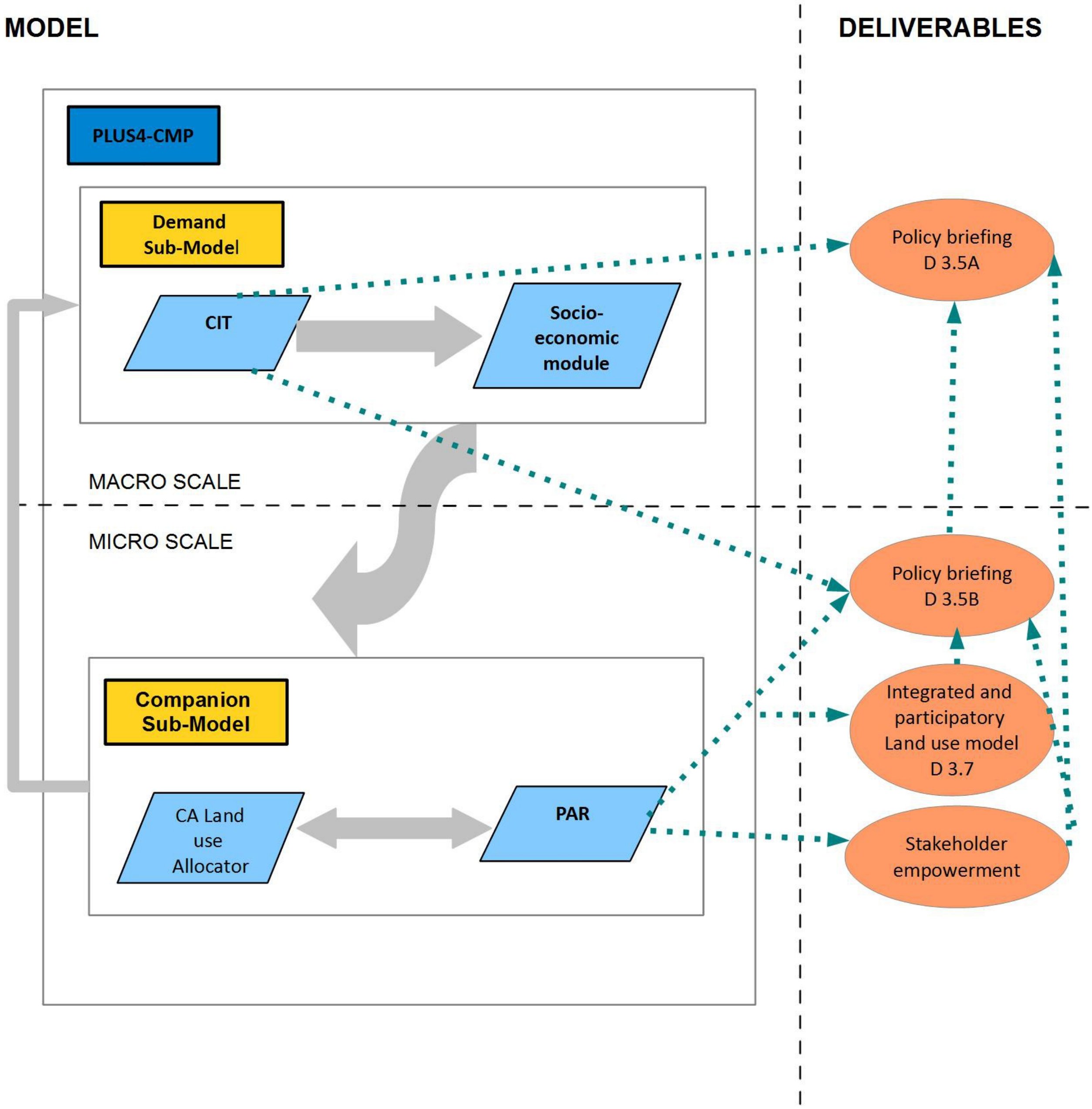

Figure 2: Detailed functioning of PLUS4-CMP relevant to WP3 deliverables

4: PLUS4-CMP Model structure

4.1: Demand sub-model

The first question we have to answer in order to assess the land use change effects of RE deployment in different policy scenarios is how much land is necessary for RELF in each scenario, by both replacement of previous uses or by adding new functions to existing land areas. A land use model is essentially the interaction of three key elements, where land will be allocated, how will this allocation occur, and how much land is required. The land requirement or demand (sometimes called "land claims") must be determined correctly for each scenario on the basis of factors exogenous to the land allocation engine. The demand model will also need to consider whether new RELF can be allocated in existing land areas. It is anticipated that more multi-functionality of land use will take place in the Netherlands case study area than in Spain, so some difference in the operation of the system across the two case study areas is anticipated. Nevertheless, the capacity to deal with multi-functionality is a key part of the demand module. It may be possible to build different configurations of the demand module (e.g. maximum multi-functionality versus no multi-functionality) to explore the consequences of the different ways in which land may change.

Land use demand will therefore be determined in a separate sub-model that sits over the CA land use allocator. The demand sub-module is a function of the CIT policy analysis results that are used to modify initial demand from externalities such as the economic climate or policy maker's targets. The model as proposed here is a simulator, not an optimization or “best-outcome” model, so the demand fed in through externalities is not important as long as a range of options (scenarios) are considered to account for various possible situations (e.g. poor performance of markets and low targets vs. good performance of markets and ambitious targets). CIT policy analysis would indicate whether a particular target is likely to be successfully implemented or not, and if not, to what extent. High land claims will therefore be modified in the demand sub-module where policy analysis indicates that implementation is unlikely. A stochastic element (e.g. Markov chain) should be introduced here to avoid determinism. It is conceivable (not shown in the figures) that the economic module may also feed into the CIT process as part of the policy decision- making context. The demand sub-module also receives feedback information from the CA land allocator allowing demand to be adjusted on the basis of local land claims. See also Appendix I.

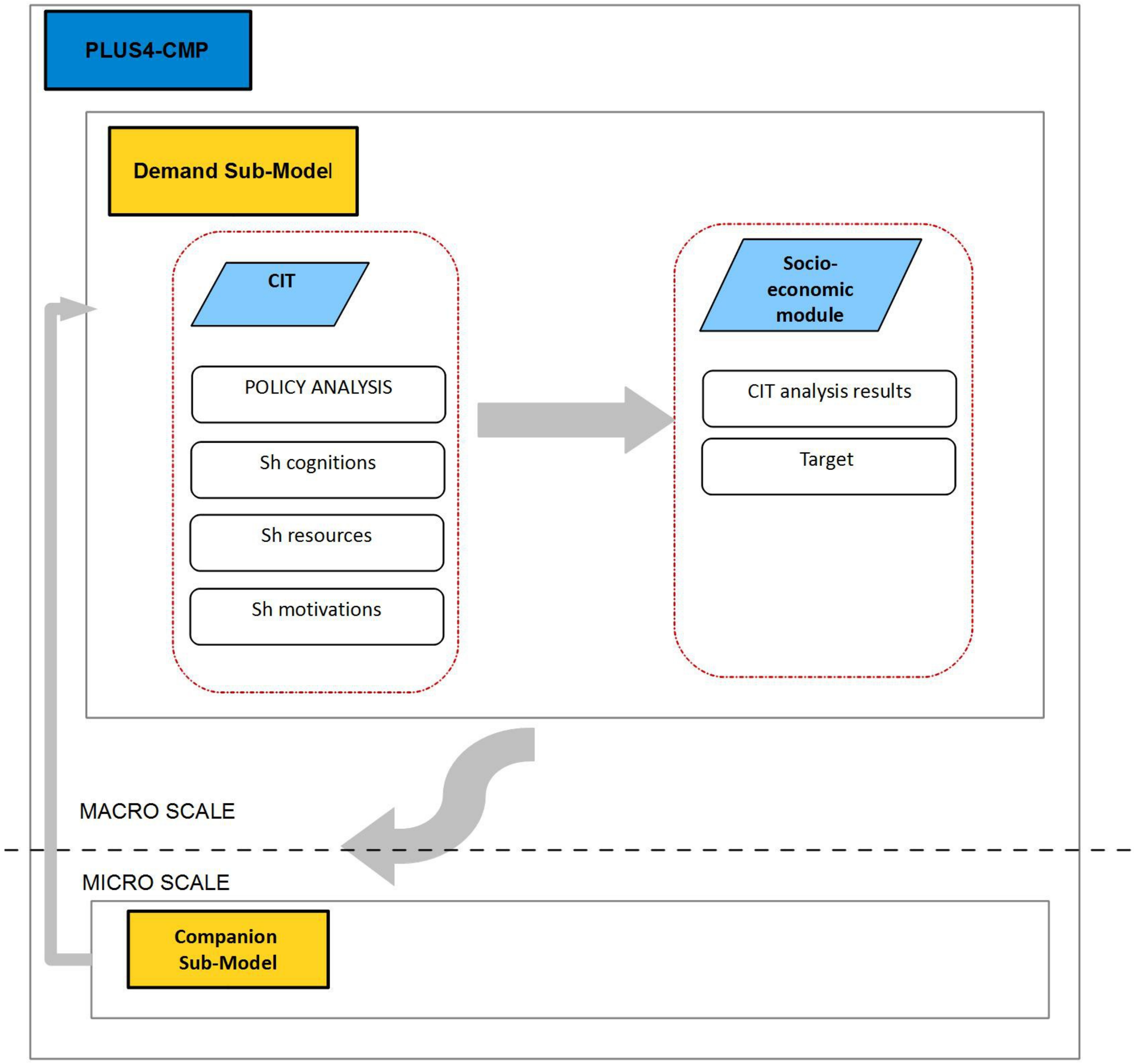

Figure 3: Conceptual structure of the demand submodel. See also Appendix I.(Sh=Stakeholders)

4.2: Companion sub-model

The Companion sub model answers the question of where RELF are going to be deployed. The Companion sub model is carried out taking into account only land use change dynamics inside the case study area, and is considered as working at the micro level, like the micro-scale cellular model of White et al (2000). However, unlike in this model, stakeholders are engaged directly in the model building process (Hewitt et al in revision).

The land use allocation model is parameterized and calibrated using PAR techniques to include stakeholders' knowledge. Model scenarios will also be developed by the stakeholders and serve as inputs for the demand model. Stakeholder interaction will also be incorporated into the model dynamically, e.g. stakeholders previously opposed to certain RELF developments might come round as the problem becomes more urgent; stakeholders originally in favour might change their position as the impacts of RELF implementation become more evident etc…

At the same time, the process gives us the opportunity to develop PAR methodology to improve stakeholders' empowerment in relation to RE policies during the workshops, mainly by improving knowledge and by reinforcing the relationships between the regional stakeholders.

4.2.1 Suitability submodel

"Suitability" used to be determined in the land use change models by a set of characteristics of a specific area that causes any influence on the land use of this area. These include biophysical properties (temperature, altitude, rain...) or socio-economic properties (distance to roads, population density, employment index...). The interpretations of the suitability concept depend on the change dynamic that is being modelled.

The suitability sub-model based on ANN has the function to estimate the most suitable land for RE location through a probabilistic method based on a prototype that uses a self-learning algorithm to determine weight values for every portion of land represented by a cell. ANN have been mainly used to model the land use changes (see Almeida, 2008; Pijanowski et al, 2002), however for this approach it has taken advantage of this probabilistic method to compute the suitable areas for the land use classes. The suitability in this case is estimated only using physical characteristics like solar radiation, wind velocity and other objective measures to classify the land respect its properties for any kind of RE production. The self-learning procedure can also be combined with stakeholder-based evaluations of suitability for particular land areas.

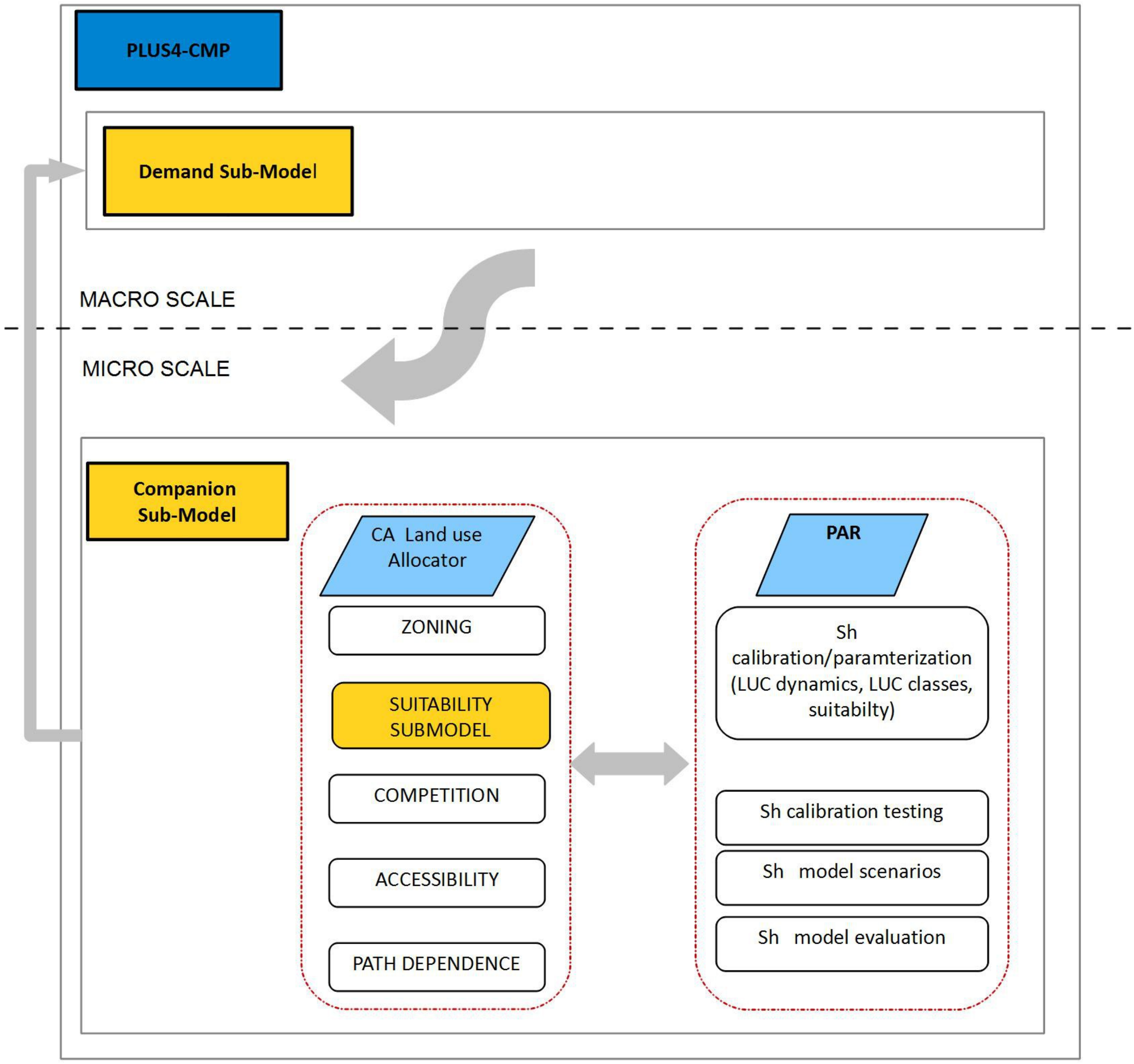

Figure 4: Conceptual structure of the companion submodel (Sh=Stakeholders)

5: Conclusions

The model design and specification presented reflects the result of a series of discussions between all WP3 team members and will be shared with all COMPLEX team members prior to the model design consultation session scheduled for Tuesday 19th November. Significant changes are expected as a result of this session. This document is presented together with Milestone 3, which outlines a series of key issues for discussion during this meeting.

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APPENDIX 1. GENERATING LAND CLAIMS IN THE DEMAND SUB-MODULE