

# A Generic Tooling for Land Consolidation – The concept implemented

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**Key words:** land consolidation, geoinformation, ict tooling,

## SUMMARY

For the previous FIG Working Week scheduled in Amsterdam in 2020, we submitted a paper that explained the concept of a generic tool for land consolidation projects. Since then, the concept was further elaborated based on qualitative interviews with international experts in the field of land consolidation and a discussion thread via social media. Building on the previous paper, this paper will describe the findings and further elaborates the concept. Such a generic tool that can be adjusted or configured to local land consolidation context (e.g. legislation, institutions, land administration systems, tenure) will be valuable for all actors wishing to support land consolidation with a digital tool upon project implementation. With so-called ‘swim-lane’ diagrams, processes and tasks of actors can the use case be visualized in a relatively simple way. To show varieties in land consolidation practice two different use cases in ‘swim-lane’ diagrams are included to describe a project from start to end. Then, two or three essential steps in the process were chosen to further detail in separate ‘swim-lane’ diagrams. Such diagrams help to discuss variations and commonalities across countries and continents upon the implementation of land consolidation. As such, these diagrams are a useful tool to develop towards a ‘proof of concept’, i.e. developing models, build a piece of software, to validate the concept and that will showcase the potential (and perhaps pitfalls) of a generic tool for land consolidation.

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## **1. INTRODUCTION**

### **2.1 Aim of a generic tool**

Land consolidation is applied in many countries to coherently optimize the land use in a particular area. Based on the exchange of land rights between landowners, land users or other right holders according to the tenure system in place, land will be reallocated to reduce land fragmentation for agriculture, to improve the protected areas for nature conservation or biodiversity, to optimize water management or to increase the livability of rural areas, among others. Due to variations in geographical, socio-economic, and legal contexts and as a legacy of the past, land consolidation practice across the world is diverse. Nevertheless, the main underpinning principles of land consolidation are similar.

These commonalities in land consolidation practice triggered further exploration of the concept of a generic tool that can be adjusted to the local context. Such a generic tool is expected to benefit countries introducing land consolidation as a means for rural development, but not having tools available yet to support the implementation of land consolidation projects and programs. Also, for countries with established tools it could be beneficial. Currently, each country works with its own tool to support land consolidation projects. Developing, maintaining, updating, and renewing tools requires sufficient resources like expertise, time, and money. Joint use of a tool will reduce the quantity of resources needed.

In this paper, we will elaborate on the concept of a generic tool to support the implementation of land consolidation projects as explained in the paper for the previous FIG Working Week (Louwsma et al., 2020). The aim of a generic tool is to provide on the one hand a generic basis, building on the commonalities in land consolidation and on the other hand can be adjusted to cater for the differences. In this paper a few variations in land consolidation processes will be presented and the impact of these variations for the generic tool will be discussed.

### **2.2 The concept explained**

In the context of this paper, the generic tool consists of many standardized, yet configurable, modules that together make the tool. A module, in a software-based land consolidation tool, represents separate and interchangeable components, i.e., modules, which depend on code and data to deliver a particular functionality. The configuration of the modules refers to the modification or changes in the system settings so that the tool better reflects the requirements of a particular implementation of the software (Land Equity International, 2020). In addition to this, the tool can be customized by extending or building new modules in case the local situation demands so. However, customization of the tool is out of scope of this paper.

Figure 1 explains the concept of the generic tool by analogy of using the example of designing a house. Out of many options, one can choose the material, the type of window(s), roof and

door(s). All components together create a unique combination to match the user's demand. The selected components must be aligned and compatible to fit well together. Similarly, for a land consolidation project one can select the needed modules, place them in the right order and adjust individual modules according to the local context to meet the requirements as set by the legal framework, tenure system, existing data sets, project purposes and process etc. The output of a module will function as input for the subsequent module, so the compatibility between modules is important.

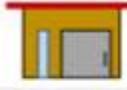
Material	Window	Roof	Door	House
Bricks	No Window	Pointy	Sliding	A. 
Wood	Single window	Flat	Single	B. 
Concrete	High window	Asymmetric	Double	C. 

Figure 1 How to configure the generic tool – an example

## 2. METHODOLOGY

Based on the described concept (Louwsma et al., 2020), qualitative interviews with five experts in the field of land consolidation were conducted to verify the concept and gain more in-depth knowledge about the diversity in land consolidation practices. The interviews centered on the application or absence of GIS tooling, the context (e.g. land administration, land market, legislation), the role of stakeholders, and the land consolidation project itself (e.g. objectives of land consolidation, willingness and conditions to exchange parcels, constraints, rights for allocation). Gathered information has been used to design ‘swim lanes’ that display the interaction between the land consolidation process, the generic tool, the stakeholders (right holders, the responsible authority, and court), and the data needed. Designing ‘swim lanes’ is a method to visualize all interactions needed. Each ‘swim lane’ represents a particular process in a particular context. In line with variations in land consolidation practice, the number of possible ‘swim lanes’ equally varies with practice.

## 3. SWIM LANES

To show the variety in land consolidation practice, this section presents two examples of land consolidation processes that the generic tool aims to support. Variations between the two

examples occur in the selected modules, the sequence of the module, the actors using the tool, and data needed. Figures 2 a-c and 3 a-b show respectively ‘swimlanes’ of two different land consolidation processes in relation to the configuration of the generic tool. The swim lanes identify individual steps supported by the GIS tool and the interaction needed by various stakeholders, in this case the right holders (mostly landowners and users), the responsible authority (land consolidation committee, government, surveyor), and the grievance mechanism (court adjudication). The swim lanes are slightly simplified regarding the actors mentioned. For example, only one authoritative body is mentioned in the swim lane to indicate that there is often one responsible authority, which – depending on the international context – can be a land consolidation committee, a government body, or a surveyor. In some countries the tasks can also be divided among multiple actors. In such a situation, the swim lane should include each responsible actor and their tasks and activities related to the generic tool. The right holders are mentioned as one group and refer to the legitimate landowners and users that are directly involved due to the land rights that they hold in the delimited area for consolidation. Apart from this group, there might also be other stakeholders that have an interest in land consolidation. For now, these are not considered to be using the generic tool but can be informed and participate through other channels.

Figure 2 a, b and c show an extensive land consolidation process whereby the responsible authority has a prominent role in shaping the process in accordance with legislation and other conditions and prescriptions that may apply. The reallocation plan for example is prepared by the responsible authority based on the input (wishes) from the right holders. Figure 3 a and b on the other hand show a relatively short process where right holders follow an iterative process of participation upon the making of the reallocation plan. Also, an extra step is included to verify the information in the land administration by a public inspection or the like. The latter is important for example when the land administration system is not up to date or complete.

Figure 2 and 3 both show the role of the generic tool in a land consolidation process at a relatively detailed level. However, the swim lanes can even be extended in more detail to grasp each single step to be taken in the process and the implications for the generic tool regarding input and output of data and the required functionality. Drawing the reallocation plan is still sort of a ‘black box’ in the process shown in figure 2. It only shows the input needed for the reallocation plan with the generic tool, but how it is generated by the generic tool remains opaque. Practice shows that multiple options exist to draw the reallocation plan. Here, we will elaborate three different options. First, the reallocation plan can be drawn by an expert, most likely the surveyor, based on the submitted wishes of involved right holders. Second, the reallocation plan can be drawn fully or partly automated with dedicated software using optimization algorithms. Third, the reallocation plan can be jointly drawn with involved right holders. The latter often involves an iterative process of negotiations and based on a set of rules as displayed in Figure 4. Apart from the reallocation plan, other process steps and modules can be further elaborated such as configuring the project database based on the tenure system, the form and type of participation of the right holders and required information to be exchanged between the right holders and the generic tool, or the valuation process.

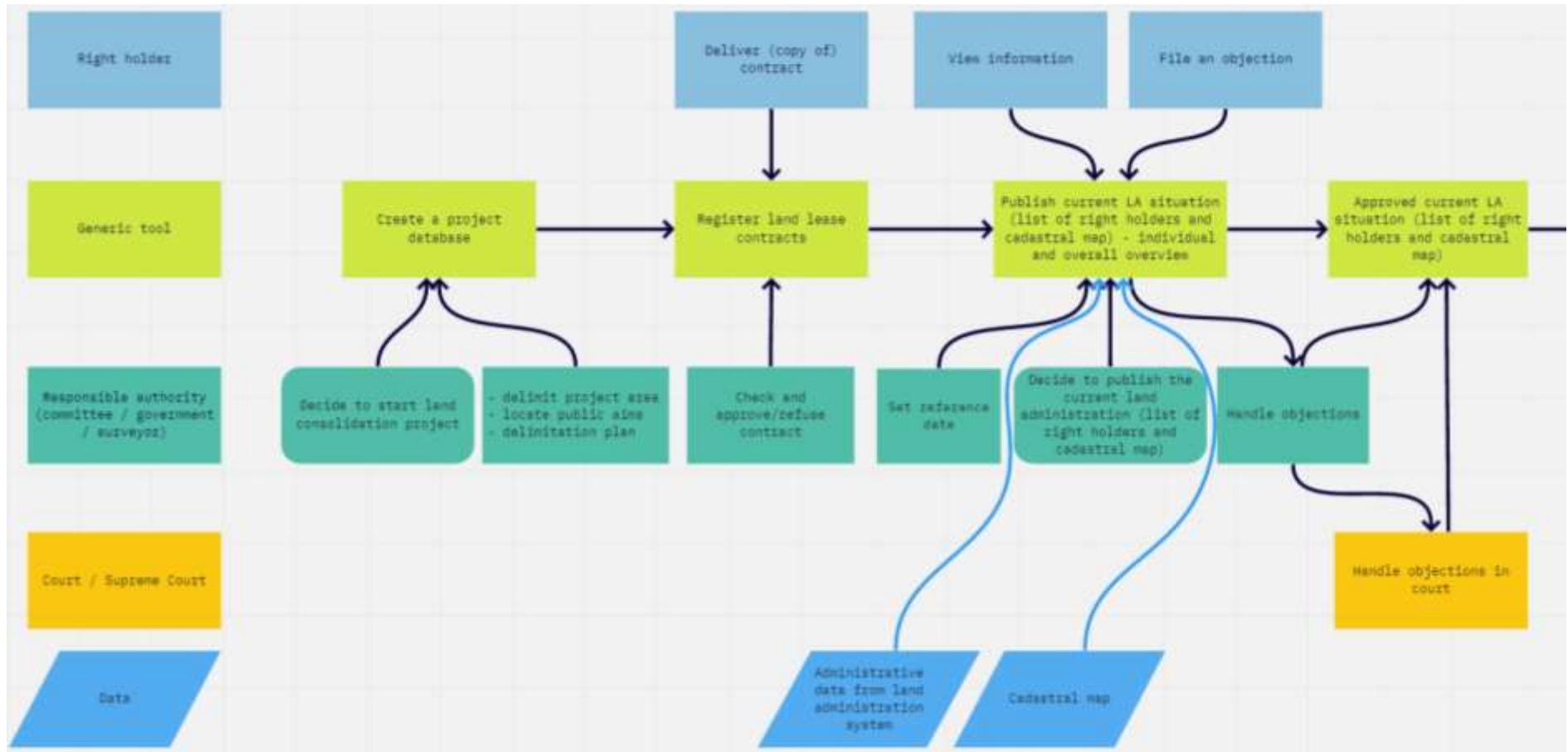


Figure 2a Example extensive land consolidation process – part 1

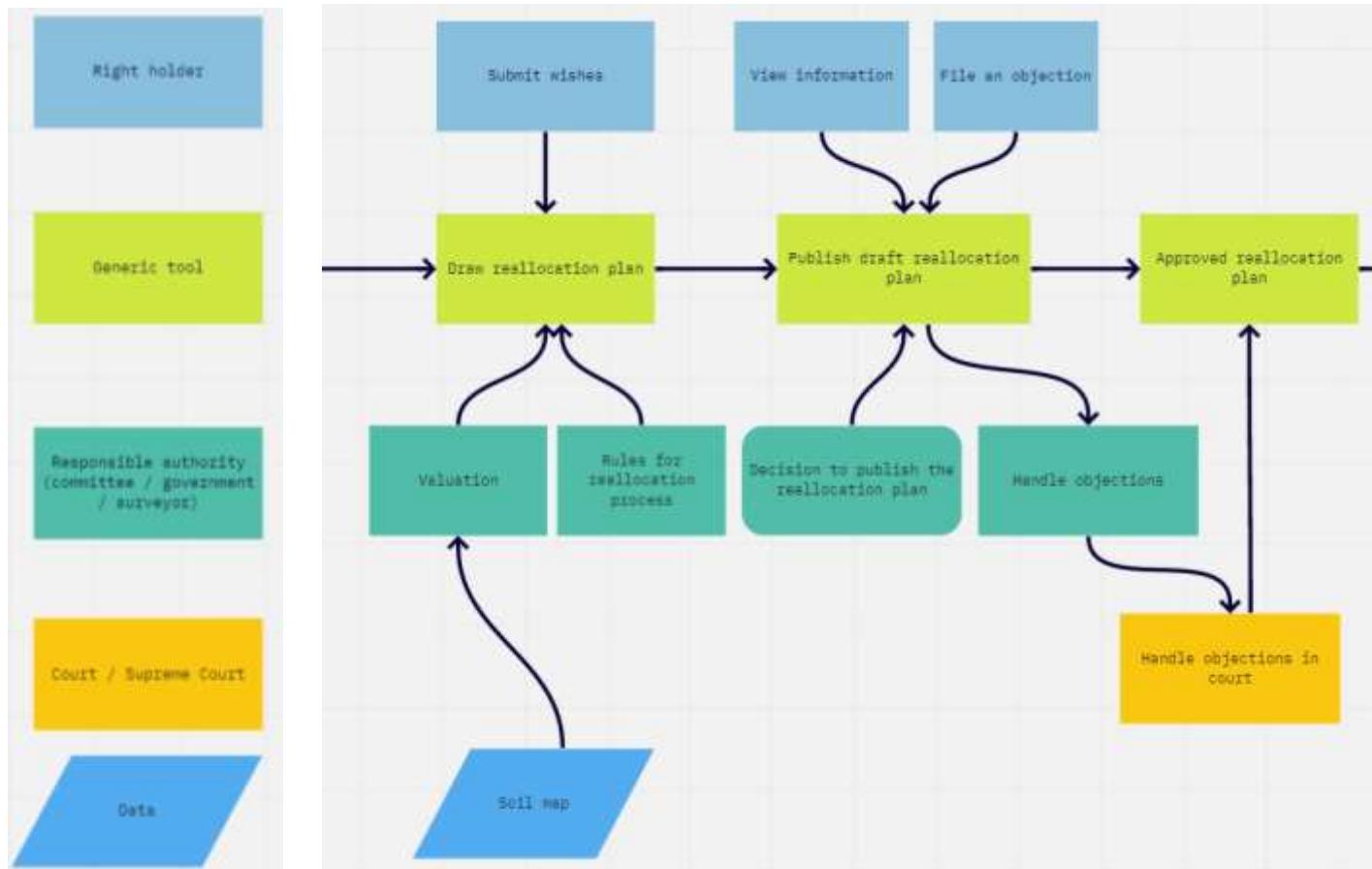


Figure 3b Example extensive land consolidation process – part 2

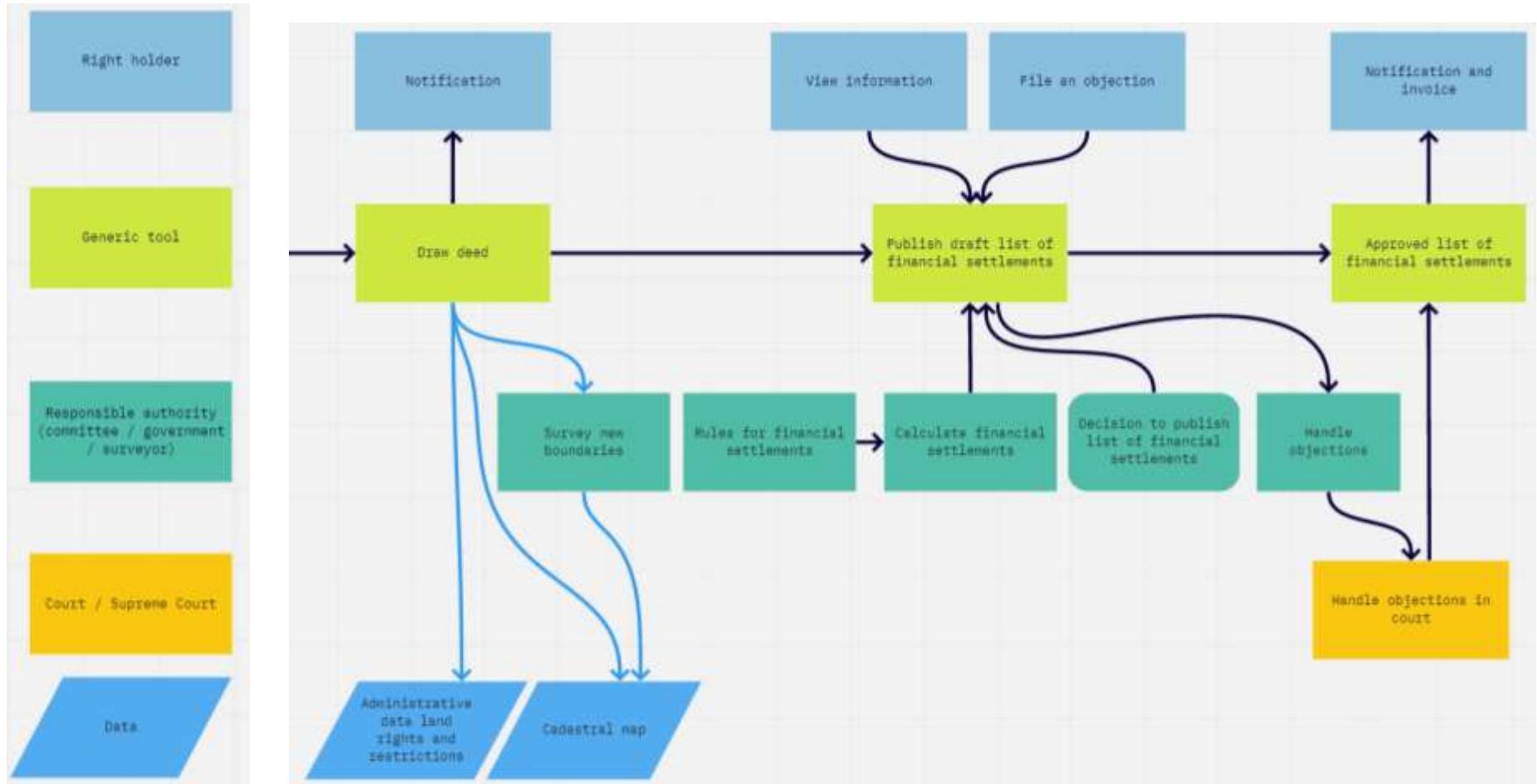


Figure 4c Example extensive land consolidation process – part 3

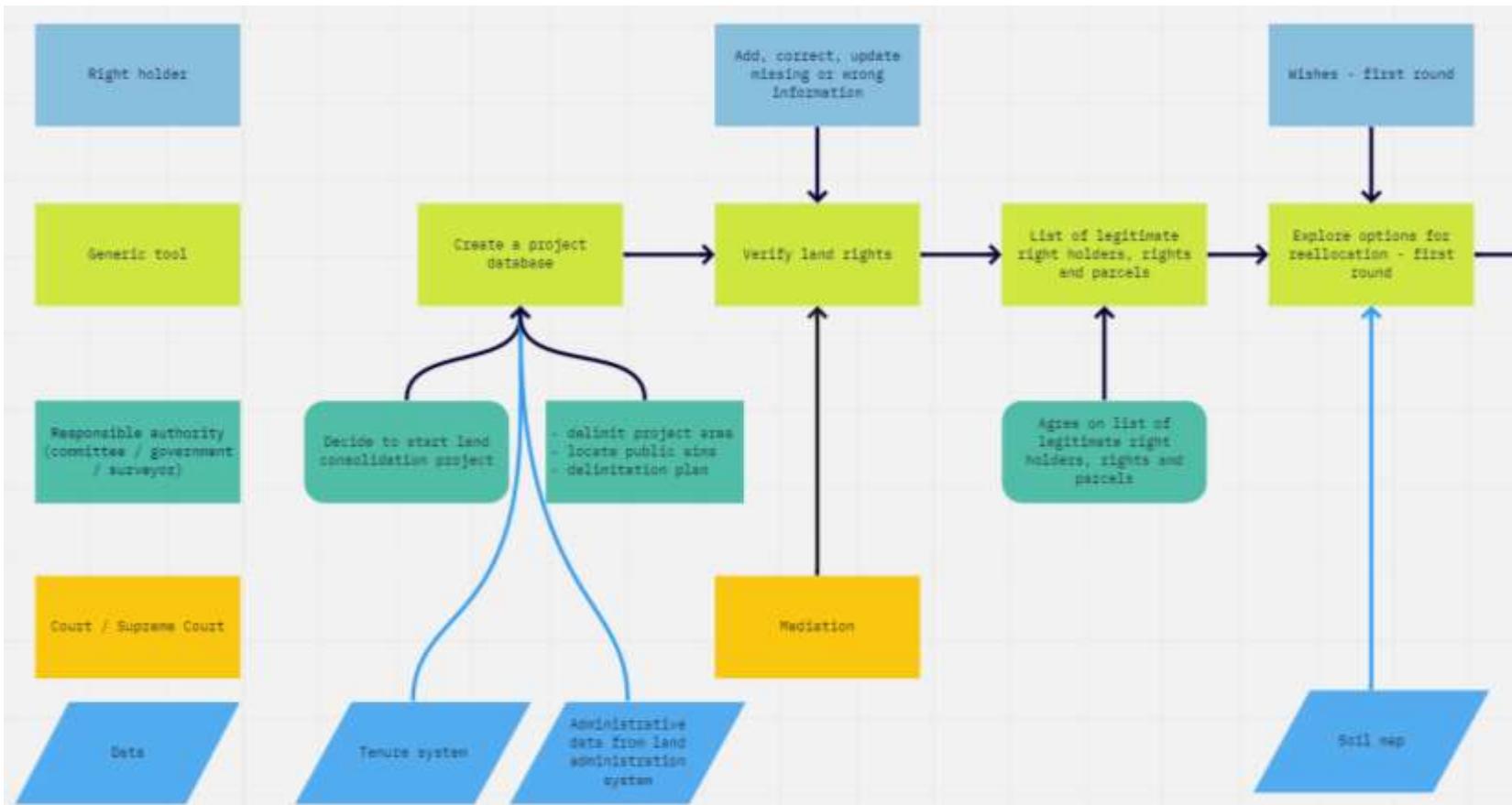


Figure 3a Example short land consolidation process – part 1

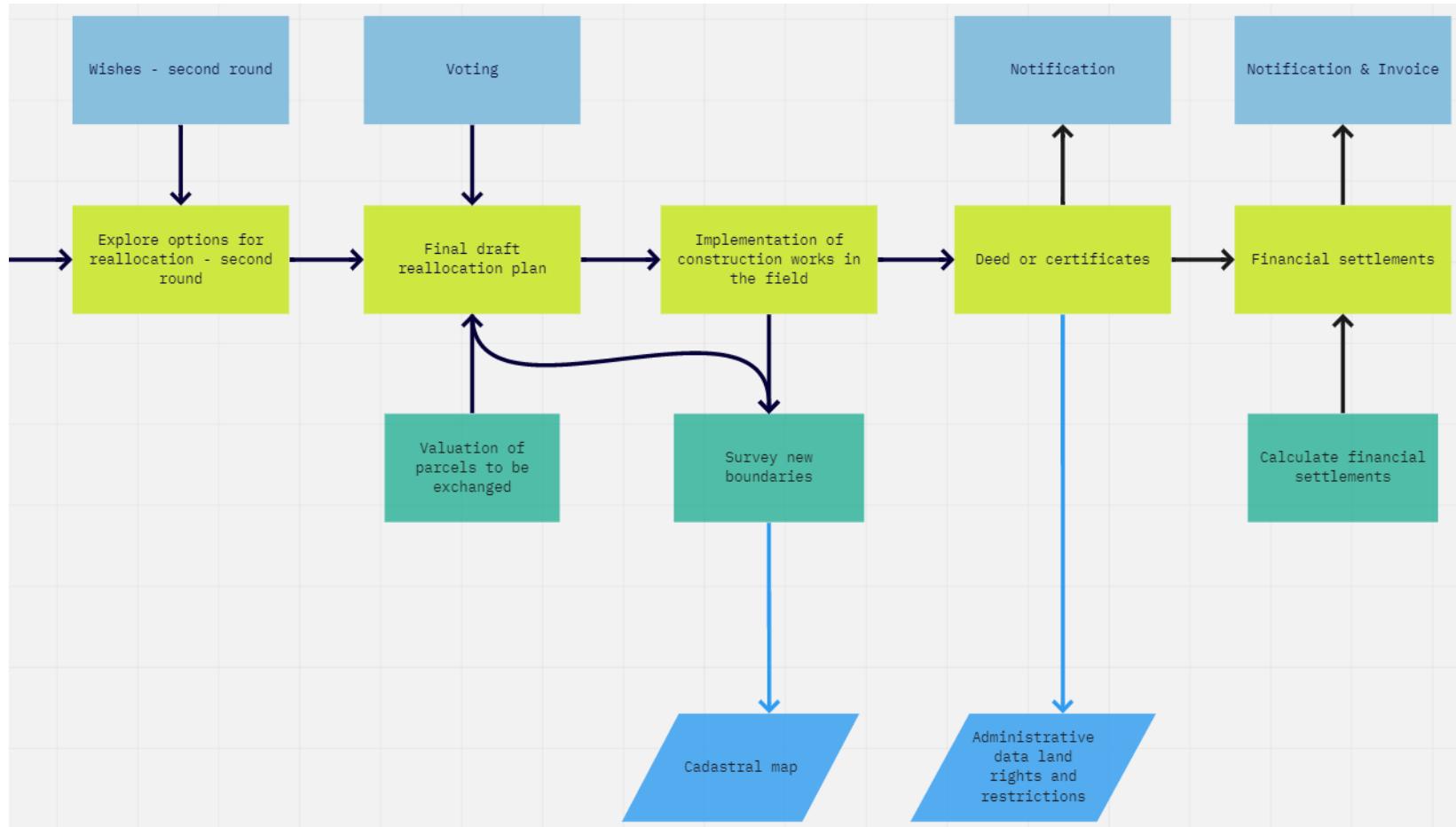


Figure 3b Example short land consolidation process – part 2

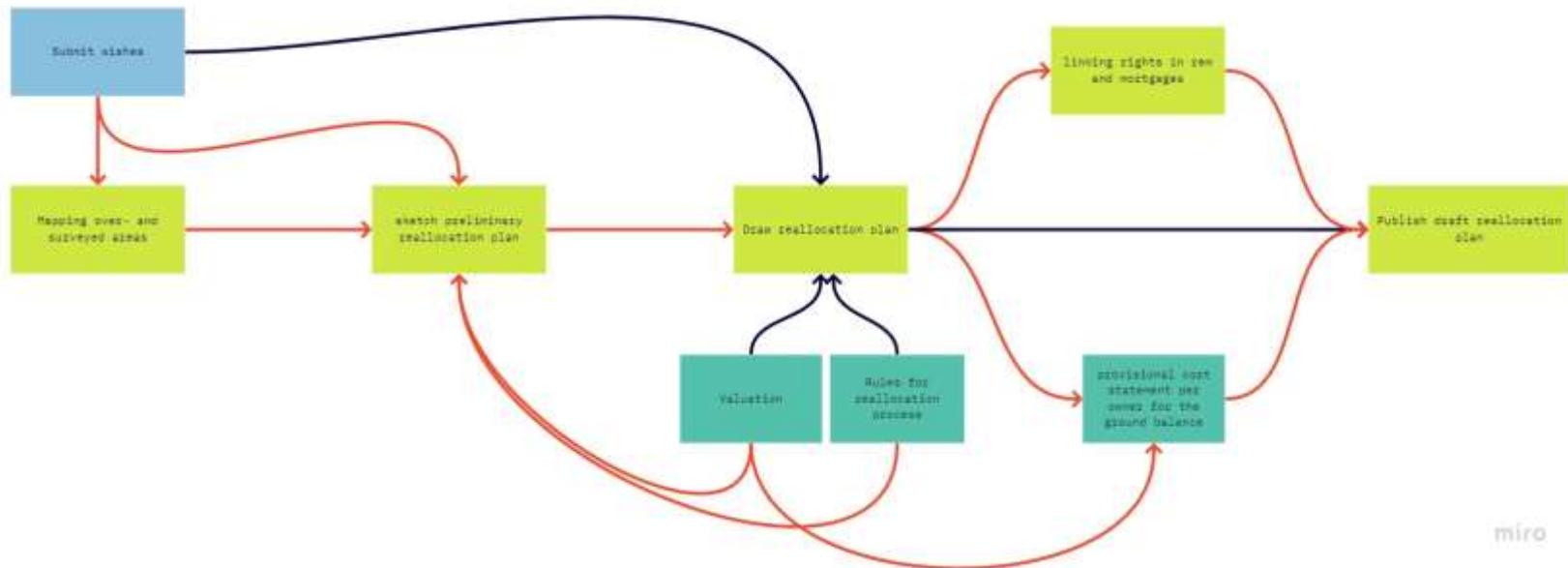


Figure 4 Example of detailed process to create a reallocation plan

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## 4. ARCHITECTURE & DESIGN PRINCIPLES OF FUNCTIONAL LAYERS

Analysing the swim lanes, it appears that the generic tool can be split up into six different functional modules supporting the land consolidating process:

1. Project administration module
2. Land administration module
  - Existing situation
  - Reallocation scenarios
  - New situation
3. Reallocation engine module
4. Deed / title engine module
5. Financial administration module
6. Communication / participation module

The project administration module relates to the process (workflow) of the land consolidation project. The module is for facilitating and tracking project data and progress. These include the project start, project number, the area involved, the objectives to be achieved. Other functionality includes recording actions in the process, the order of the actions, monitoring deadlines and deliverables.

The land administration module entails all functionality needed to support the land consolidation project from a land administration perspective. Land administration is described as the process of determining, recording and disseminating information about the relationship between people and land. The land administration module should preferably be based on the Land Administration Domain Model (LADM), ISO 19152 (Lemmen et al., 2015; Van Oosterom et al., 2013), which in a standardized way describes the relationship between people and land. The core functionality of this module relates to the exchange of land rights between right holders to optimise the land use according to the described objectives in the land consolidation project area. A description of the land rights in the existing situation preferably is based on the information recorded in a land administration system. Any omissions or gaps can be complemented by assembling information from other sources, such as involved right holders, government agencies or other entities. Together, they will provide a complete and up to date project database recording all land rights in the area under consolidation, which forms the basis for the exchange of land rights. The land rights that right holders have in the existing situation in principle determine the right for allocation of land rights in the new situation (after the exchange of land rights). Further research should show how the LADM can be applied in this tool.

The reallocation engine module is an advanced module that generates proposals for a new situation that are typically based on the existing situation (that determine the right for reallocation as well), the established rules for reallocation, prevailing legislation, regulations, valuation of land, objectives regarding the optimisation of land use, and the wishes of the right holders. Depending on the local context some of the above variables might not be applicable, whereas in other contexts other variables may be added. Proposals for reallocation may be

generated automatically, based on algorithms (Demetriou et al., 2013 and 2012; Lemmen et al., 2012) or can be drawn manually based on expert judgement. The output of the reallocation engine – the new allocation – can be stored in the land administration module.

The deed or titles module creates the documents needed to formalise the new situation and register the rights into the land administration system. It can be drawn and presented to the responsible authorities according to the standards.

The financial administration module relates to the financial aspects of land consolidation. Financial settlements can accommodate differences in the amount of allocated land, the quality of allocated land, or any other settlement of assets or constraints related to the reallocation such as irrigation, cables and pipelines, pollution, excessive shade and the like. In some practices, right holders are requested to contribute to land consolidation projects' process costs in proportion to their benefit.

The communication or participation module is responsible for all functions related to exchanging data and information between involved stakeholders. The two most important ones are, on the one hand, the affected right holders in the designated land consolidation area, and on the other hand, the responsible authority. For example, the existing situation, the proposed new allocation, and the financial settlements can be published for and validated by involved right holders and other stakeholders with the communication module. Right holders have the possibility to object when they disagree. In view of privacy considerations, not all information has to be publicly available. Personal information might be disseminated only for those involved, e.g. by using a personal account to access this information in the communication or participation module. Another important phase that is supported with this module, is the collection of wishes and other relevant information (e.g. polluted soil) from the right holders regarding the new allocation.

There is a variety in land consolidation processes, according to Louwsma et al. (2020), involving an extensive and a less vast number of steps. With the example of Figures 3 and 4, the classification as described in Table 1 can be considered. Depending on the context and further in-depth study of variations in the processes, the table can be extended with additional modules or functionality.

*Tabel 1 – Modules used in an extensive and a short land consolidation process (X - mandatory, o - optional )*

Module \ land consolidation process	Extensive	Short
Project administration	X	X
Project - Land administration	X	X
Existing situation	X	X
Publish existing situation	X	o
Reallocation module	X	X
Publish new situation	X	o
Deeds or Titles engine	X	X
Financial administration	X	X

When choosing the applied process for a project, a configuration module is available to configure the steps taken for each project and involved functional modules needed for these steps. The individual functional modules can be configured according to the process used. Because a land consolidation project works with privacy-sensitive information, identity and access module are provided, too. This module regulates the access and use of the land consolidation tool. The identity and access module use, if possible, the national population and companies register linked to a national identification system.

In summary, a land consolidation tool is created with a configuration module for the configuration of the land consolidation process, the supporting modules, and the possibility to connect to external sources (Figure 5).

The aim is to create a tool that is modular, flexible and configurable. Each module can consist of smaller modules and facilitates management and maintenance. After all, the module is only modified when extending or replacing functionality, but the wiring with other modules remains the same. Sometimes a module is specifically designed and coded because it does not exist. Sometimes a module could be replaced by existing software packages such as a project or financial administration when it fits well with the land consolidation objectives.

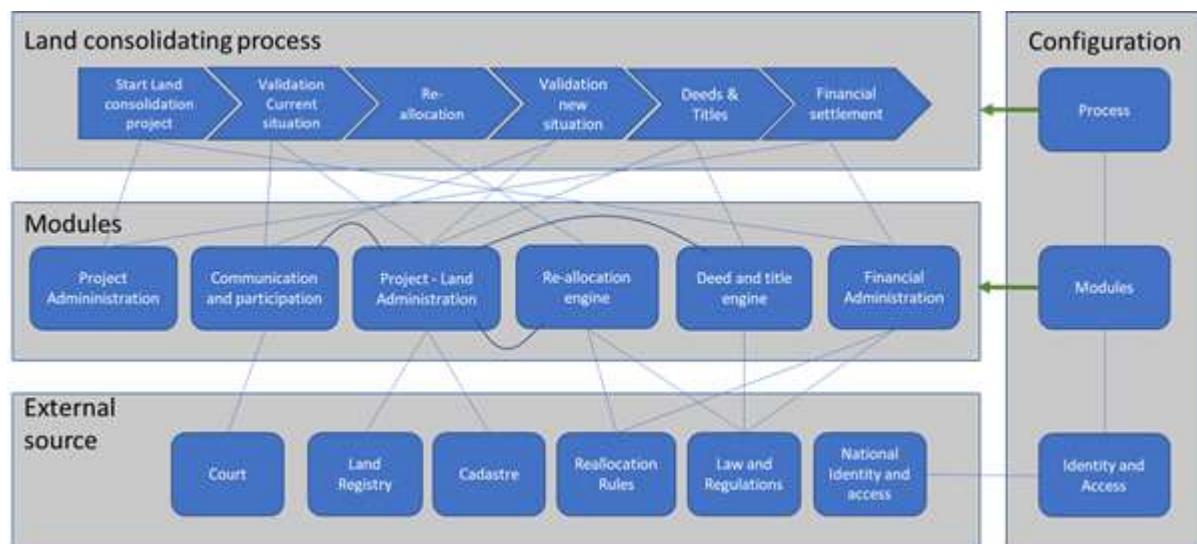


Figure 5 – The architecture of the land consolidation tool

## 5. THE WAY FORWARD

At this stage, we investigated the feasibility of the development of a generic tool focusing on the conceptual options. For the development of a generic tool for land consolidation, a few preconditions apply. First, demand from various countries and/or responsible authorities must be large enough. Without sufficient demand, no positive business case will be possible. Second, appropriate technical solutions must be available to cater for the diversity in land consolidation practice and required functionality, while not compromising on user friendliness and usability.

of the tool. Thirdly, a business partner must be willing to further invest in the development of the tool, to produce an affordable off-the-shelf product that can be configured to the local context either with the help of a professional or within the organization based on own expertise. Overall, the generic tool can fill a gap and prevent responsible authorities for re-inventing the wheel in each country by providing an off-the-shelf product that can be configured to the local context. With multiple customers, it will become more profitable since the development costs and maintenance costs will be distributed over multiple parties. This means that only the configurable part will leave the responsible authority with additional costs at their own expense. All costs related to generic functionality should in general be lower than developing from scratch a customized tool for each individual country.

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## BIOGRAPHICAL NOTES

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