Info Note

Designing a modular approach towards innovation

Example: Developing and scaling Climate-Information Services

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Key messages

- Food system transformations will require a new approach towards innovation to be able to deliver impacts at scale.
- Innovations need to be context-specific and respond to myriads of different famers' needs.
- Modular design is a 'new' way to design, bundle and scale innovations.
- This Info Note outlines the main principles and phases of modular design, with the example of Climate Information Services (CIS).
- Special attention would need to be given to aspects of inclusion, data ownership and a potential misuse of the approach to scale unsustainable practices.

Ingredients of innovation systems that deliver impact at scale

There is increasing consensus among the development and climate action community that the transformation of our food systems will both require and entail new technologies, organizations, and ways of working together. Recent global stakeholder dialogues in the run up to the UN Food System Summit 2021 and the COP26 have developed a shared vision, in which national and regional hubs shall develop, test, and scale innovations to promote better integration of data and digital systems that facilitate a transformation in food systems (Koerner et al. n.d.).

However, challenges remain for innovations to be adopted by farmers (as 'end users'), as they need to be context-specific and respond to diverse end-users needs (Barrett et al. 2020). For example, Climate Information Services (CIS) that enable farmers to adapt to unfavorable climate and weather conditions, need to respond to different types of farmers, farming systems, agroecological contexts, and livelihood strategies, increasing the complexity and efforts required in designing and delivering "actionable" services.

In the following, the Info Note will introduce the concept of 'modular design' as a methodology that can help on one hand to increase the variety of products or services offered to users, while on the other hand reducing the complexity for the product or service designers and providers. We will illustrate the concept with an example of designing and scaling CIS by outlining the five main phases to be undertaken for modular products or services. Finally, we will shortly discuss possible limitations or pitfalls of using such a modular approach.

'Modularity' as a new way to design, package, and scale innovations

The concept of 'modular design' is a general set of design principles widely used by private sector actors with the aim to increase the offer made to users ('external variety'), while reducing the complexity for the product- or service providers ('internal variety').

In a nutshell, modular design is about decomposing an innovation into its different parts ('components'), analyzing the relevance and interdependencies of these components, and then recomposing these components into modules (Figure 1). Components are parts that work

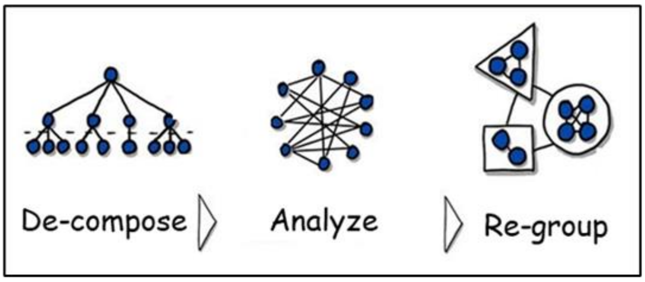

Figure 1: Modular design, adapted from MB Collaborations, www.mb-collaborations.com

together to form a functioning item. From there, different stakeholders can use, re-use, reconfigure, or repurpose these components or entire modules (Ernst 2005), thus multiplying possible uses, and/or accelerating the process from innovation development to scale.

For example, a personal computer as modular system consists of different modules (e.g., monitor, keypad, disc player) which can be quickly changed. These modules again consist of different components (e.g., motherboard, central, or graphics processing units). These components can also be changed, but this would require more technical expertise, and to reopen the modules. In the context of agricultural research for development, modular approaches could be useful for downstream science applications, like climate services or digital applications.

Reducing time and costs of innovation design and development

The concept of modularity can be applied widely to any system, be it an ecological system, cellular metabolism, traffic flows, a power grid, or an economy (Marta 2017). Modularization saves time and efforts by:

- multiplying design options (including re-purposing) through mix and match of modules;
- allowing localized adaptation by non-expert users through bottom-up modularity;
- allowing decentralized design processes and parallelism in testing (Naik et al. 2020);
- therewith also creating new business opportunities through outsourcing modules across the value chain (Ernst 2005).

However, modular approaches also have **limitations and trade-offs**, that need to be considered carefully:

- Creating new business opportunities for some, may also reduce the unique selling position, or relevance, of others. In the context of science, risks of 'oversharing' could be mediated by establishing which components must not be changed, and which ones can be modified by the users (Landor 2017).
- Stable standards and design rules may also have the opposite effect of slowing down of innovation when they 'predict too much' and thereby lock-in institutional strategies.

Therefore, 'design rules need to be firm enough to encourage modular innovation and recombination – but loose enough not to be constraining to the evolution of the system (Sabel and Zeitlin 2004)', and to maintain the independent modules' resiliency.

Example: Climate Information Services

CIS can support farmers, agricultural value chains and governments to take strategic, seasonal or immediate decisions on planning and managing agricultural production (Born et al. 2021). Many public and private initiatives experiment with innovative ways to develop and

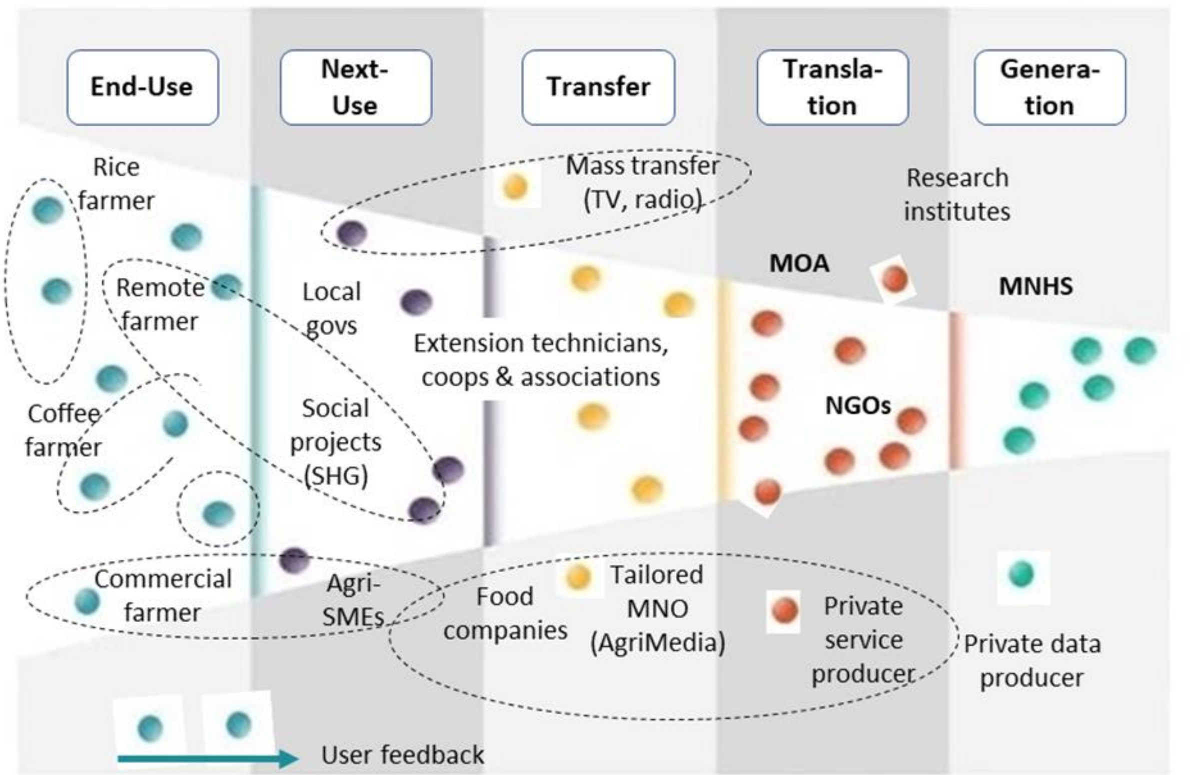

Figure 2: The innovation landscape of the CIS value chain (own graphic)

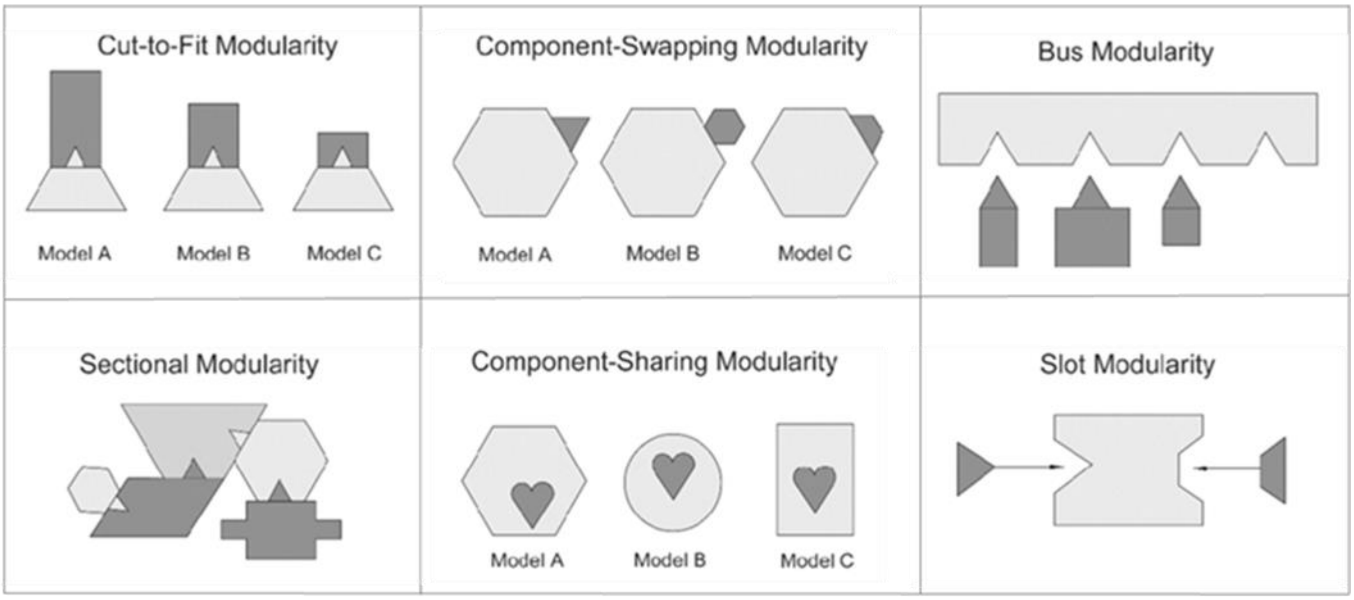

Figure 3: Different types of modularity, adapted from Brax and Toivonen (2007).

scale CIS, but often remain at project or pilot levels lacking mechanisms for scaling and long-term sustainability.

Challenges on the information supply side include e.g., data gaps, limited institutional capacities for climate modeling and for cross-disciplinary research and collaboration. On the services demand side, challenges touch upon end-users' adaptive capacity enabling changes in behavior and agricultural practices, but also on addressing the differences in livelihoods context and strategies, cultural aspects, and gender and languages (Hansen et al. 2019).

Generally, there is a mismatch between the current supply and potential demand for CIS. Albeit the climate and weather information supply are mostly generated at national levels by statal national-level meteorological institutions, the full process of translation into advisories, dissemination and access of the information is not fully accounted for in the service design. Implementation requires a myriad of actors across different levels working together for the service finally being used by farmers.

Along the CIS 'value chain' a diversity of climate-informed products and services should address different needs of multiple next- and end users in terms of content (advisories) and frequency of delivery, formats, and communication channels (Figure 2). Furthermore, to sustain such services on the national level, beyond the lifetime of projects, CIS portfolios (of products and services), need to be underpinned with business or financing models and scaling mechanisms.

Explaining types of modularity with the example of CIS scaling pathways

There are different ways to structure modules and components. Brax and Toivonen (2007) suggest six different forms (*Figure 3*), which might be useful to illustrate different scaling pathways:

Cut to fit modularity: Spreading the use of the same type of data and CIS to more locations and beneficiaries with the components and modules remaining largely unchanged. However, this is only applicable within the same agricultural, climate and socio-economic conditions.

Component swapping / sectional modularity: Targeting CIS to different purposes and contexts will entail to adapt or modify the provided products and services, and their transfer channels, either by swapping components of an otherwise unchanged service, or putting all components newly together.

Bus – or slot modularity: Governmental or institutional policies and regulations that level the playing fields, could be seen as bus- or slot modules. Equally, this could be all kinds of vehicles that could link and/or accommodate different components or modules, e.g., business models that offer different components or modules, that can form innovation bundles.

Component-sharing modularity: Central to most, if not all, modules of CIS will be a certain component of climate or weather data. These might also be needed in different resolution levels, for which again a cut-to-fit modularity could be considered.

How to design for modularity

The key goal of realizing modular designs is thus to group strongly interacting components or parts together and separate weakly interacting ones. For example, regarding CIS, crops and agro-ecosystems might be strongly interdependent factors, while the access to digital infrastructure might have a weaker relation to these factors. The most crucial step is to identify the boundaries of each system that shall be modularized, and the logic in which to decompose the system into different modules and their components, which then can be used, re-used, re-packaged, or re-purposed (Ethiraj and Levinthal 2005).

Developing a modular architecture for the CIS value chain

The following five-phase-guide is adapted from the MB Collaborations Modular Management Series (https://mb-collaborations.com/en/modular-system (retrieved 26 October 2021), which is to the knowledge of the authors is currently the most detailed, openly accessible guide available. These phases will be outlined, using the example of CIS value chains. The phases I – IV are further illustrated in Figure 4.

Important to note, though, that the whole 'toolkit' of modular design consists of approximately 70 tools and 20 methods to choose from and to adapt in each phase.

I. Defining common objectives

The objectives and a common vision of the modularization strategy are decisive for developing a modular product or value chain architecture. For example, a national portfolio of CIS might need to accommodate the different goals of the key actors: economic departments might focus on value chains of prioritized cash crops, while welfare departments might focus on the most vulnerable small holder farmers. Disaster and risk reduction departments might prioritize early warnings. While generally, governments would aim for social and economic impacts, private sector actors would be more profit-oriented and need viable business models. Design teams should therefore represent the main stakeholders' perspectives.

II. Strategic portfolio analysis

With these different objectives in mind, the next step will be an analysis of the current product or service portfolio (in this Info Note: CIS), as well as the wished future portfolio. Aim is to prevent complexity already at the beginning of the value chain, while also providing for sufficient flexibility, since also end-users needs will change over time. The main steps are:

Analysis of current situation of product portfolio: Analyzing existing product program structure, trends, and economic key figures. With regard to CIS, key figures could be e.g., costs of investment and implementation, reach and impact indicators, and approaches, mechanisms and methodologies to reach farmers (the CIS last-mile).

Future analysis of product portfolio: Identifying future trends and success factors, analyze and evaluate future scenarios. Regarding CIS, trends might be e.g., increasing digitalization, or planned future investments in extension services.

High-level analysis of internal variety: Determine existing product components and variants. and evaluate the re-use potential of components between different product families. For example, a component of CIS could be the mode of delivery, with variants then being SMS, radio, TV dissemination. Potential for re-use could then be to use the same information provided via TV also for SMS services, or for TV but different crops (as different 'product family').

III. Defining the best fit module cut

This phase is the 'heart of the process', where main crucial components are defined, and composed into modules. This module cut will then form the reference frame for all product varieties. Differently than the previous phases, this phase concentrates on the different end-user needs, and the main factors that influence their decisions.

Identifying main components (external variety): Identifying the factors that influence current and future users' decisions. These can come partly from the portfolio-analysis, focus on users' needs and experience cycles, rather than on (or: adding to) static indicators. This exercise will result in different user groups/segments with different preference profiles. With regard to CIS, factors that would influence users' grouping could be e.g., the different crops and production systems, eco-systems, climate extremes and variability, but also the farmers' livelihoods, language, infrastructure and markets. User profiles are developed with tools and methodologies that lend from design thinking, e.g., users' value propositions, customer journeys and -experience cycles.

The correct decomposition is decisive and will depend on the (mix of) module cut method(s). The right granularity must be found, and all variants of the product family must be captured, e.g., in a variant tree. This can also be an iterative process.

Grouping components into modules (internal variety): Components are then grouped based on their relevance, and their interdependencies. There are different ways to arrive at the best suited grouping of components into modules, depending on the designers' respective goals, products or value chains, and capacities. Thus, modules could be based on components interactions ('Design Structure Matrix'), on social or technical driving forces ('Modular Function Deployment'), or on their functional structure ('METUS method').

Regarding CIS, main functions that could structure modules could be the different purposes ('uses') of the CIS products, different modes of dissemination ('transfer'), entailing different ways of formatting and packaging ('translate'), and consequently, feed from different data sources and -formats ('generation').

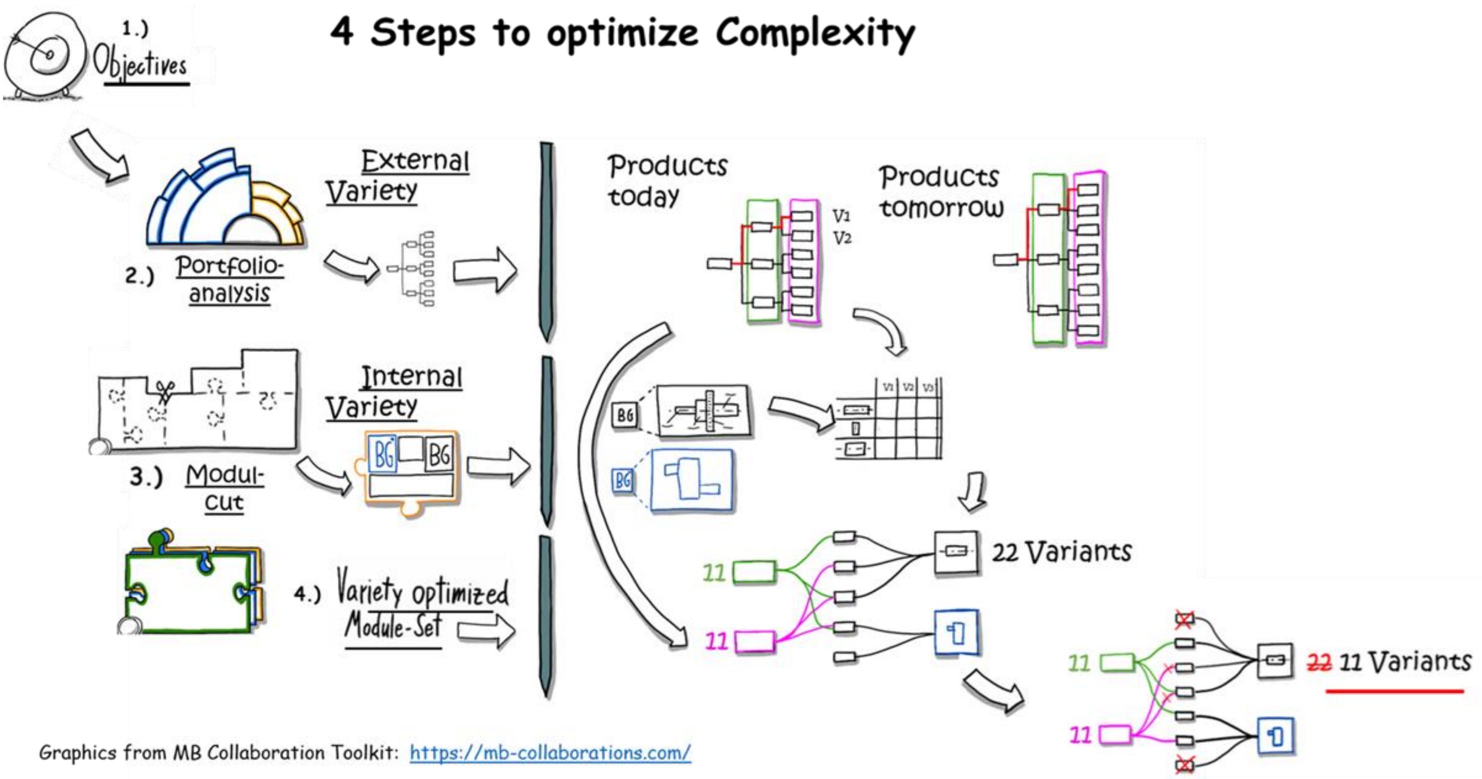

Figure 4: Four steps to optimize Complexity, adapted from MB Collaborations

IV. Variety optimization of the module set

Finally, to find the most feasible balance between offering a variety of different products and services, while reducing complexity as much as possible, the variety of the module sets need to be optimized. The main steps are:

Mapping of interdependencies between internal and external variety: How will a change of a user-related variable (e.g., change of crop), influence the technical characteristic (e.g., content of advisory) of the component (e.g., SMS service)? This can be made transparent, e.g., by using a visual tool such as a variance-analysis diagram (VAD).

Variety reduction: Finally, the number of emerging varieties is reduced by prioritizing the strongest and most relevant dependencies, thus creating modular product families. For example, farmers with access to internet could technically be served by the digital product family of CIS. If, however, the translation of digital services into the local language of a small group of farmers would require more effort and resources than training the respective extension technicians, it would be more efficient to serve this farmer group by the ‘offline’ (personal extension) product family.

V. Organizational processes

This process of creating a shared modular product- (or service-) architecture will result in visualizations, road maps and distributed stakeholders’ roles and action plans, that facilitate the evaluation and implementation of the new portfolio. For example, a national portfolio of CIS could be composed of different but complementing portfolios and road maps of the different key stakeholders, from the delivery of CIS all the way to how (and by whom) the respective data is generated, packaged, and translated.

Discussion

Modularization processes are established in series of workshops with relevant stakeholders and users. Time and resources must be invested in ensuring that vulnerable and marginalized people can be properly represented. However, a critical role will be to build in feedback loops, e.g., adding an interactive component to digital modules, where farmers could rate the services, and/or suggest new ones. This could help to ensure that the product- or service set-up remains relevant to changing needs and uses.

For example, with increasing digitalization, more users could switch to online applications, which might entail extending these applications to other regions or crops. Feedback loops could also provide wins for user engagement and -learning components, and increase data collection points, e.g., through crowdsourcing data on the impacts of CIS. At the same time, safeguards must be built in right from the start on how to responsibly generate, disseminate and use farmers’ data and ensuring their data ownership.

A modular design approach could be used in the context of developing a national portfolio (menu) for CIS in Vietnam and/or Southeast Asia region. Main critical question would be if such approach, even if developed and applied to deliver impacts at scale, would be able to cater for the context-specific needs of smallholder farmers, and not lend itself to be mis-used as a scaling vehicle for large-scale, unsustainable practices and farming schemes.

The project team plans to pilot an adapted approach for Vietnam in 2022, which will require to generate the respective instruments and data, engagement with the relevant stakeholders, and last not least, the demand for a modularized national CIS portfolio.

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