RESEARCH PROGRAM ON Livestock
CGIAR

Smallholder farmers, food security, and livelihoods: exploring trade offs and synergies using farm household characterization data

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1. Abstract

In this paper we show results of recent household level analyses of smallholder farming systems. We make use of existing databases across a range of low and middle income countries, as well as a substantial quantity of new data collected with the Rural Household Multiple Indicator Survey (RHoMIS), the combined total of this comprising more than 40,000 farm household observations in 25 countries. We show how we used these data to i) identify and quantify key drivers of food security; ii) quantify some of the possible trade offs between achieving food security and rising out of poverty versus social and environmental indicators; iii) explore how synergies between off farm income and on farm investment drive the rapid changes going on in smallholder households and; iv) finally we explore possible farming futures using household level data and simulation models.

2. Context and challenge

Achieving sustainable food security (i.e., the basic right of people to produce and/or purchase the food they need, without harming the social and biophysical environment) is a major challenge in a world of rapid socio- economic and environmental change. In sub-Saharan Africa (SSA), production on smallholder farms is critical to the food security and the livelihoods of the rural poor and is in many low and middle countries the main contributor to national food production. National policies and local interventions can have profound impacts on the opportunities and constraints that affect smallholders but need to be informed by adequate evidence on how they affect food security and sustainable development. A complication in generating such evidence is the large diversity within and between smallholder farming systems. Agroecological conditions, markets, and local cultures determine land use patterns and agricultural

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management across regions, whereas within a given region, farm households differ in many ways, including resource endowment, production orientation, ethnicity, education, skills, and attitude toward risk.

In recent years we have followed a two-pronged approach investigating the diversity of farming systems, households, and the roles of on- and off-farm activities relating to food security and poverty, work that can also be used to quantitatively evaluate progress we are making towards achieving several of the Sustainable Development Goals: in particular SDG 1 (no poverty), 2 (zero hunger), 5 (gender equity), 12 (responsible consumption and production) and 13 (climate action). The first of the two pronged approach was the collation of farm household characterization data collected with cross-sectional surveys to build up a database of more than 20,000 farm households in SSA, followed by definition of viable indicators of food security across the whole database, and analysis of the diversity of farm households and drivers of food security in different systems. The second prong, based on experiences of re-using and analysing data from the first approach, was development of our own efficient and harmonized farm household survey tool - the Rural Household Multiple Indicator Survey (RHoMIS). The RHoMIS tool has experienced a very rapid uptake by a wide range of research and development partners since its conception in 2015, and by now we have built up a harmonized database of more than 18,000 farm households in 18 countries. Such a large database provides an immensely rich resource to derive descriptions linking indicators of food security, poverty, dietary diversity, gender equity and land use to the socioeconomic and biophysical environment of the smallholder farmers.

Here we present a snapshot results from a series of analyses using these two types of databases (collated household survey data and the RHoMIS database), to explore the drivers of food security (sections 1, 2 and 3), quantify some of the possible trade offs between achieving food security and rising out of poverty versus social and environmental objectives (section 4), explore how synergies between off farm income and on farm investment drive the rapid ongoing changes in these smallholder systems (section 5) and finally explore possible farmer's futures using an ex-ante impact assessment model (section 6). For more detailed descriptions of methods, analyses and results we refer to a series of papers and book chapters in the last section.

1. Variations in farm size across sub Saharan Africa (SSA)

One of the key factors in which smallholder farms vary across SSA, both on the small and regional scale, is their farm size. To further quantify this variation we produced farm size distributions based on the database of more than 13,000 household records from surveys in 17 different countries published in Frelat et al., 2016 (Fig. 1). Two things stand out: first, there is a large variation in farm sizes in each given country; second, the distribution of farm sizes differs drastically between countries. In each site there is a substantial number of households on small farms, but in some sites, especially in Burundi, Rwanda, DRC and western Kenya, a large number of farms are extremely small. In Burundi and Rwanda, for example, almost 50% of the farms smaller than 0.3 ha. The results show that in this dataset more than 75% of the farms are smaller than 2 ha (a commonly used threshold to describe smallholders), but it is also clear that such a number is not very informative given the large regional differences in farm size distributions. In Central Africa a meaningful threshold would be 0.5 ha, in East Africa 1.5 and in dry West Africa 5 ha makes more sense to separate the land scarce households from the relatively better off ones. Building on this work, other analyses (e.g. Ritzema et al. (2017) and Paul et al. (2018)) have shown that the

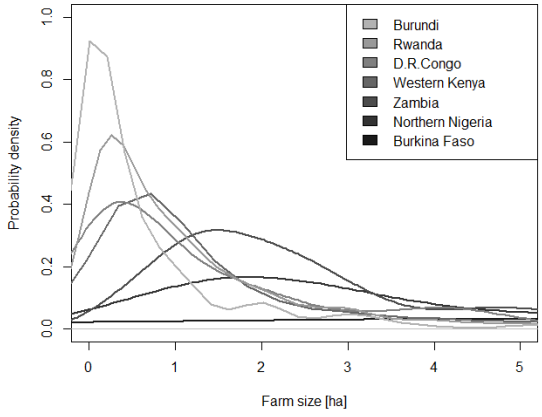

Figure 1: Farm size distributions of smallholders in several contrasting countries based on the data of Frelat et al. (2016) across sub Saharan Africa

availability of land is one of the most important factors that determine whether crop intensification options can really make a difference for food security and poverty reduction.

2. What are the consequences of differences in farm size for food security?

One would expect a strong relationship between food security and farm size in smallholder households given their strong reliance on agricultural production. In Frelat et al. (2016) we showed that farm size is an important driver of food security in smallholder systems and quantified a farm size threshold above which the likelihood of a farm household being food secure (Fig. 2). However, this farm size threshold is strongly mediated by the amount of livestock that the household owns, resulting in a farm productive resources curve, rather than a single farm size threshold. Not surprisingly, the farm productive resource threshold curve shifts substantially when market and agro-environmental factors are taken into account (Fig. 2). When farmers have good market access (which often occurs in regions with favourable agro-ecological conditions and high population density), a small size of the farm can be sufficient to produce and/or purchase enough food to feed the family. With good market access farmers are able to generate cash through the production of high value crops and buy the food they need, alongside the cultivation of staple food crops. Combining the results of Fig. 1 and 2 shows that a significant proportion of smallholders in SSA face difficulties in achieving food security given their small farm sizes. Increasing market access could potentially increase the ability of these smallholder households to feed the family on relatively small parcels of land allowing the potential of intensification practices, cash crops and livestock to be utilised.

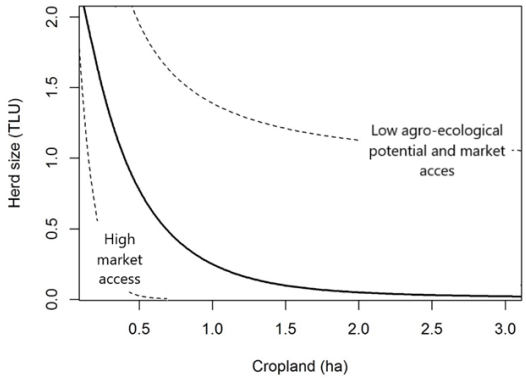

Figure 2: Farm size thresholds for achieving food security for an average family size. The bold line is the average curve for all systems in sub Saharan Africa. The other lines represent systems with specific characteristics.

How do farm strategies drive food security?

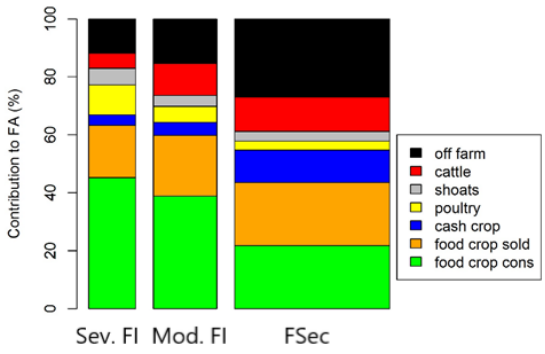

Figure 3: Livelihood activities of different food security groups. FA is Food Availability, the indicator we used to represent food security. (Sev. FI: severely food insecure; Mod FI: moderately food insecure;

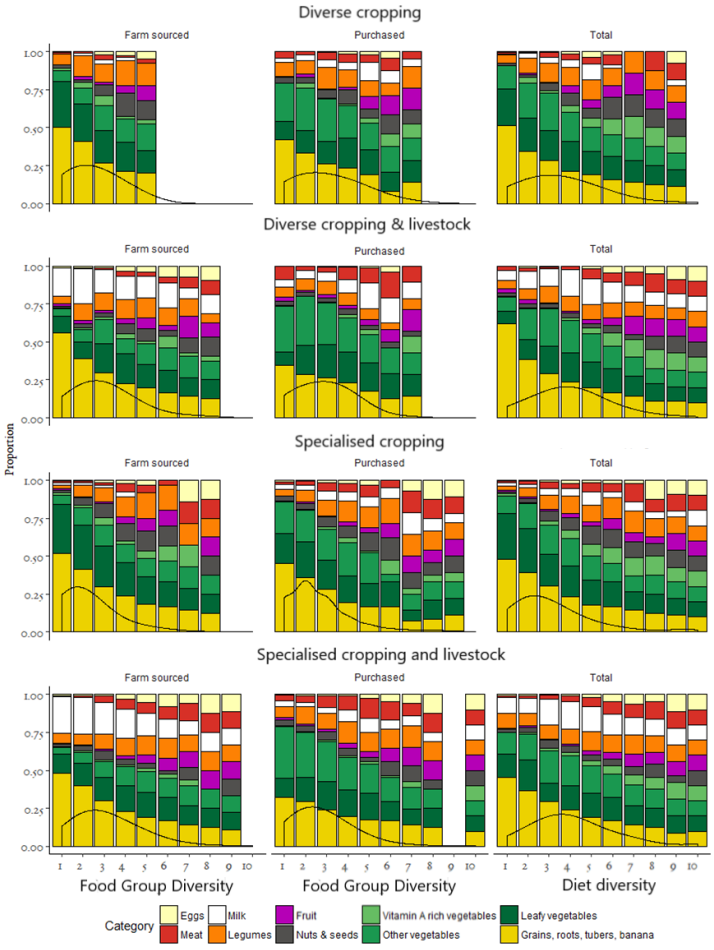

Figure 4: Food group composition of the farm sourced (left) and purchased (middle) parts of consumed diets (right) for four contrasting farm types in sub Saharan Africa.

Besides their endowment of productive resources, the various strategies farmers follow to produce food and money from their on- and off-farm activities determine food security as well. An example of the analyses we performed to quantify this is given in Fig. 3. For the same dataset of Frelat et al. (2016) we determined the relative contributions of various farm household activities to food security. To illustrate the association with overall food security we categorised all households into three food security classes (severely food insecure, moderately food insecure, and food secure) and quantified the contribution of different activities to food security using the potential food availability indicator. Clear differences are visible between the three food security groups. Increasing off-farm income appears to be most important for achieving food security. Amongst farm activities, increasing market orientation of crop production, through cash crops and sales of food crops, appears to contribute most to greater food security. The contribution of livestock was relatively conservative, with a total contribution of about 20% across all food security classes. Within this overall contribution of livestock, though, there was a clear shift away from poultry to cattle as food security increased. The contribution of consuming self-produced decreased from 45% for the severely food insecure households to 22% in the food secure households. Clearly more intensive cropping and livestock systems with more inputs and higher market orientation are key for the food security (and income) of smallholder farm households.

Another, more nutrition oriented way to look at food security is to analyse dietary diversity, the food groups consumed, and how it differs across different farming systems and livelihood strategies. In Fig. 4 we show results for 4 contrasting farm types, based on analyses of RHoMIS data in 8 countries in SSA. We show the results of two pathways of achieving diverse diets for each farm type, i.e. producing food on farm and consuming it (the 'farm-based' route) or selling farm produce or generating off farm

income, and then buying food (the 'purchased' route). Important to note is – of course – that these pathways do not have to be mutually exclusive. The food group breakdown (Fig. 4) shows that in contrasting farm types the pathways towards diverse diets are different, for example in the farm types with livestock present milk consumption taking place in almost all families, even when diets are not diverse. In the crop based farm types milk has to be purchased, but this only happens in families with higher dietary diversity scores, which form a minority in the population. This shows that in smallholder systems the production system does influence what people eat, and that following a purely cash oriented pathway to increased dietary diversity may not be as beneficial as encouraging diverse production for consumption, with some cash incomes.

3. Several key trade offs faced while trying to increase food security

Increasing food security through production intensification and sales of agricultural produce can go hand-in-hand with adverse effects on other social and/or environmental indicators. Here we show two examples of analyses that try to identify and quantify these potential trade offs. First, we assessed the relation between market orientation (% of farm produce sold) and gendered control of household resources, using a rapid gender indicator we developed representing the control women have over the benefits (food and income) generated by on and off farm activities. This is one of the indicators we quantify in the household survey data collected with RHoMIS. Across a wide range of different systems in West and East Africa, there is a strong negative relationship between the level of market orientation and this overall female control indicator (a case study from Kenya is shown in Fig. 5). Underlying data analyses showed that for a wide range of crops (e.g. maize, beans, cow pea, vegetables) and some livestock products (especially wholesale of livestock but also sales of meat) a switch from subsistence (consumption) orientation towards sales is goes hand-in-hand with a strong decrease in the control women have over the activity and its benefits. Only for few crops and livestock products this decrease in control is more moderate (for example legumes and eggs) indicating that some interventions aiming to increase sales do not automatically have to lead to adverse gender equity effects, especially if sales are managed through non-formal arrangements.

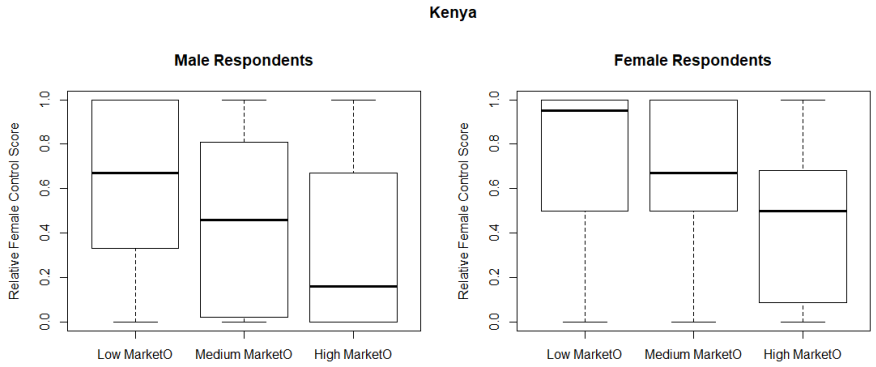

Figure 5: Trade off between market orientation (MarketO) of the agricultural livelihood and the overall female control over the benefits of farm activities

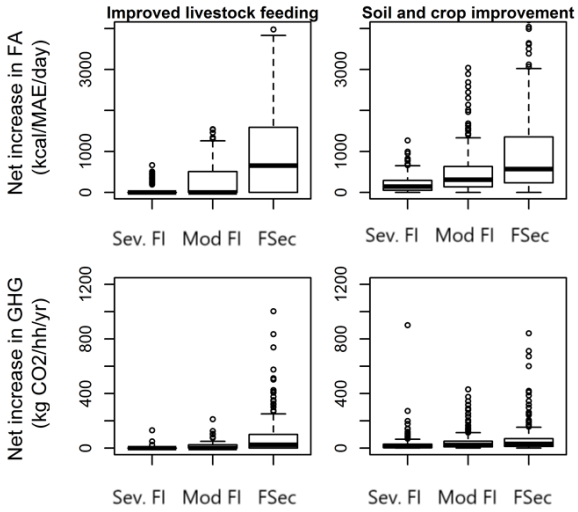

Figure 6: Trade off food security – GHG emissions (Sev. FI: severely food insecure; Mod FI: moderately food insecure; FSec: Food Secure)

A potential environmental trade off facing efforts to improve food security through production intensification is the association with increases in greenhouse gas (GHG) emissions. In a recent study in Rwanda (Paul et al., 2018), we performed scenario and intervention analyses using the data from the household characterization database. Our analyses (Fig. 6) showed that intensification of crop and livestock production leads to substantial increases in absolute amounts of GHG emissions estimated with a TIER 2 approach. It does not lead to increases in emission intensities, i.e. the amount of emissions per unit of product for the most food secure, while for the food insecure households, with lower productivity per unit land and per animal it leads to significant decreases in emissions per unit crop and livestock product.

4. Synergies between generating off farm income and on farm investments

Besides this type of static analysis of the current state of smallholder farming we also monitor on-going change in smallholder systems. A substantial part of smallholders are often seen being caught in a so-called poverty trap, and literature suggests that it is extremely difficult to lift poor farmers out of this trap (see for example the results of the previous section, e.g. Fig. 6, and Ritzema et al., 2017), where production increases of more than 200% and extra product value addition is needed before the poorest farmers can become food secure. To test this view we revisited in 2016 farmers originally surveyed in 2012 in four contrasting sites in East Africa, a region of rapid economical development. In contrast to earlier work, our results showed that the farm households surveyed are highly dynamic, and that the poverty trap discussion is a simplified representation of reality: more than 70% of the households surveyed changed their food security and/or poverty status over that period, with households improving or deteriorating in status (Hammond et al., submitted). Key drivers of the observed change was access to off farm income and the ability to market crop and livestock produce, with off farm income either being used as a way to 'escape' small scale farming or as a means to invest in production intensification. These results showed that off farm activities therefore are not necessarily competing with on farm activities, but actually can allow farmers to purchase inputs (seeds and fertilizer for crops, vaccines and fodder for cattle) and thereby increase production and generate more value.

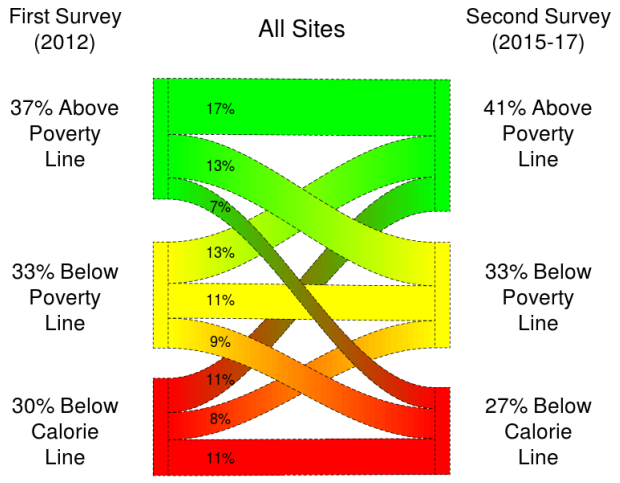

Figure 7. Change in food security and poverty status in households surveyed in 2012 and 2016.

5. Exploring options for sustainable intensification in smallholder systems

The databases we have put together in combination with the analyses we are producing help us to explore options for sustainable intensification, best fits for specific farm types, and what this means for potential futures of smallholder farming. We do this through empirical analyses of farming strategies and household welfare indicators (as in Fig. 4 and 6). A further example is shown in Fig. 8, which explores a widely held hypothesis that diversifying production leads to better nutrition of food insecure smallholders. Evidence in the scientific literature is scarce, and circumstantial, but using our RHoMIS farm household characterization database we were able to show that households with greater production diversity consumed more diverse diets, but only if they were mainly subsistence oriented (therefore with a relatively low market orientation and low access to off farm income). This shows that promoting production diversification as a silver bullet that will benefit all smallholders is a strong simplification and can lead to disappointing outcomes, but that it can be a powerful approach to improve the diets of the most vulnerable households that have low market access and limited off farm income (this finding is also reflected in the results of Fig. 4). Failing to focus adequately on the diversity of production can lead to negative outcomes in terms of dietary diversity and thereby nutrition, with the findings of both Fig. 4 and 8 stressing that outcomes depend on farm context.

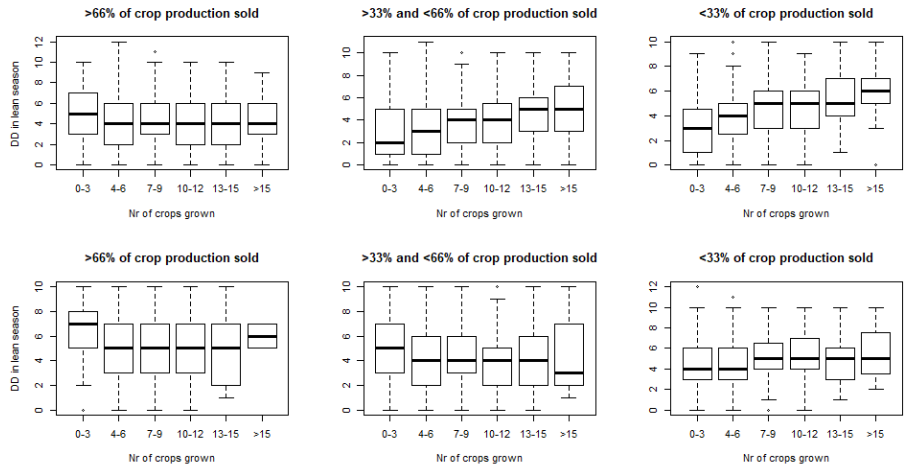

Figure 8. Relation between dietary diversity in the lean season and diversity of crops grown for households with less than 10% of their income based on off farm income (upper three graphs) and more than 10% based on off farm income (lower three graphs)

We also explore farm futures quantifying the possible pros and cons of intensification options for different farmers in different locations through ex-ante analyses. An example is shown in Fig. 9. In this work (Henderson et al., 2018) we quantified which intensification options can improve the profitability of smallholder farms in Burkina Faso now and in the future. To do this we used a PMP (positive mathematical programming) farm household model in combination with data from our farm household characterization database. Each individual household was included in the analysis, thereby giving us critical insight into the variation of responses that households can show. We also incorporated the likely production and price effects of the predicted climate change for the region, giving us insight into the consequences of the interactions between production resources, climate and socio-economic developments that farmers are likely to face for the coming decades. The results show that best options for farmers to intensify their production now are not the best ones if climate change effects become serious, and that therefore diverse packages of intensification options are needed to best serve smallholder production for the near future.

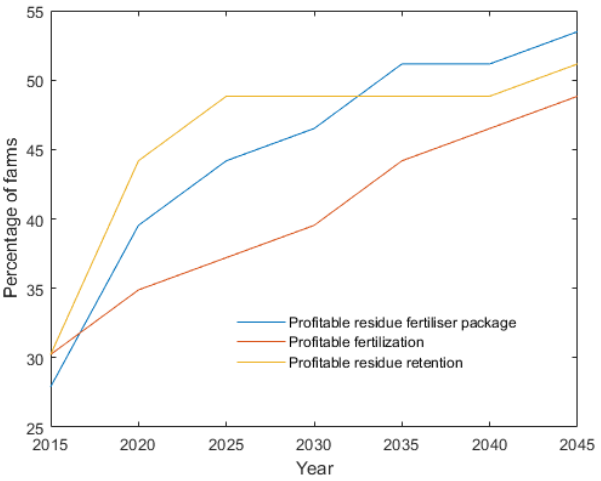

Figure 9: Percentage of farm households in Burkina Faso for which certain production intensification options are profitable or costly over time. Based on Henderson et al. (2018).

3. Partnerships

Partnerships were essential to build up these data sources. The collation of existing household survey databases was achieved by partnerships within the CGIAR and with other international research partners. The RHoMIS tool was taken up by both research and development partners, thereby allowing us to build a new, unique, harmonized farm household characterization database. Results of RHoMIS applications are used by iNGOs like TreeAid and OneAcre Fund to improve their targeting of interventions. For example, in an intensive collaboration with TreeAID RHoMIS results are used in their Monitoring, Evaluation and Learning (MEL) strategy in projects in Burkina Faso, Ghana and Ethiopia. Our toolbox of data collection and analyses methods thereby generates locally relevant information that is used for setting baselines, monitoring progress and targeting interventions by our partners, while it allows us to build a large harmonized database that can be used for a wide range of strategic analyses, quantification of the progress towards achieving the SDGs in rural areas and explorations of farmers' futures.

4. Lessons learnt, including knowledge gaps and good practices in employing these approaches at scale

The analyses presented here are a first step in exploring trade offs and synergies at farm level, and part of on-going work. While these analyses present individual case studies, we are now making progress to analyse these results in a spatial contex to quantify better for which farmers where these results hold, what the consequences are for SDGs and

how interventions can be better targeted to achieve better SDG outcomes. We do this by coupling our results to indicators derived from large scale survey efforts like the Worldbank's LSMS-ISA effort and data sources like the DHS data, which normally give less detail (and often lower data quality, e.g. Fraval et al., 2018) than targeted survey applications like RHoMIS, but better spatial representativeness. An essential element in our work is harmonization of data collection and indicator quantification methods. The progress we made and the power of our analyses were based on this, while it also made data collection and MEL a much more straightforward process for our development partners. Another key word for the successful uptake of RHoMIS is 'flexibility'. Harmonization without the necessary flexibility to make tools and analyses fit-for-purpose would not lead to uptake of the methods by our partners. It is a delicate balance to strike (i.e. harmonization versus flexibility) and not all of our potential partners agreed with the (tough) decisions we sometimes had to make to ensure that indeed harmonized information as collected. To continue to stress that harmonized approaches lead to powerful and easily re-usable 'big' data is essential.

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