Stockholm Environment Institute

Understanding multi-level drivers of behaviour change

A Cross-impact Balance analysis of what influences the adoption of improved cookstoves in Kenya

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1. Introduction

Improved cookstoves have the potential to bring benefits for human development in parts of the world where people primarily cook using traditional biomass fuels, such as wood, charcoal and dung. The burning of biomass causes significant negative health effects and an estimated four million premature deaths annually (Bruce and Smith 2012). A shift to improved, or cleaner, cooking technologies could bring multiple development benefits, mostly for women and children, in addition to mitigating the significant negative effects for public health, air quality and forests that the burning of biomass causes (IEA 2014).

Adopting a new cooking technology requires a significant effort from the user, who must be able to find out where to buy the new cookstove and afford to purchase one, and then learn how to cook on the device. Often, this requires the adoption of entirely new cooking practices, including modifying the way food is prepared. It may also change the flavour and texture of food. The everyday behaviour and decision-making of users are crucial determinants of whether an improved cookstove is adopted.

In order to understand how adoption of an improved cookstove can come about, we need to learn more about the factors that influence household behaviour and choice in relation to the adoption of improved stoves. We know that the factors that determine adoption operate on different levels, such as national policy support, customer-focused business models, locally available payment modalities and personal motivation. While we know that all these factors matter, we have only a limited understanding of how they influence each other to sustain adoption, and how the current situation might shape future developments. This paper attempts to address that gap.

When working across different levels of society, from household to community, to sub-national and national, two common and related problems are communication and consistency. Issues such as different terminology and different interpretations of the same terms often hinder mutual understanding and collaboration. Hence there is a need to develop a "common language" when trying to develop understanding between levels. In addition, multi-level analyses can often run into problems in establishing consistency of findings between the different levels. This is especially the case when working with more than two levels: if a statement about level A is consistent (or in harmony, the exact meaning of which is defined below) with a statement on level B, and the statement on B is consistent with a statement on level C, it does not automatically follow that the statement about A is consistent with the statement on C. In cases like this it can be useful to use semi-quantitative methods to provide a precise and common frame of reference for the multi-level analysis. However, a combined qualitative-quantitative methodological approach needs to be applied with caution.

A shift to improved, or cleaner, cooking technologies could bring multiple development benefits, mostly for women and children

1.1 Purpose of this paper

The research described in this paper is part of the Behaviour and Choice Initiative, a multi-year research initiative by the Stockholm Environment Institute, funded by the Swedish International Development Cooperation Agency (Sida). The initiative explores the factors that influence household choice and decision-making, with a specific focus on the uptake of technologies, services or changes of practice that lead to sustainable outcomes. It does so using case studies of drivers of behaviour and a range of analytical approaches. This paper relies on empirical data on the drivers of adoption of improved cookstoves in Kenya.

The paper outlines an approach for synthesizing empirical data from different analytical levels using the Cross-impact Balance (CIB) method (Weimer-Jehle 2006; see section 2) in a way that is epistemologically consistent and documents its application. In so doing, we contribute a systemic view of how behaviour change with regard to the adoption of an improved cooking technology may – or may not – come about. Furthermore, in order to explore consistent stories of behaviour change, we combine CIB with Scenario Diversity Analysis (SDA) (Carlsen et al. 2016a; see section 2) as suggested by Kemp-Benedict (2012). Combining CIB with SDA allows us to reduce what might potentially be half a million combinations of scenarios – what we refer to in the paper as scenario kernels – to just four scenarios, which represents quite an efficient reduction.[1]

1 Each of the four scenarios is a stand-alone narrative that depicts a particular future for the Kenyan clean cooking sector and is constructed from a number of scenario kernels.

This combined approach can help build a more comprehensive policy perspective than is achieved by leaning solely on analyses from a single analytical level. Systematically combining and exploring insights from different levels also lays the foundations for a deeper understanding of how a policy intervention at one level might influence an outcome at another level. This knowledge can inform policymakers, development practitioners and other sector actors on how programmes can be designed and implemented to respond to the combination of drivers that operate at different societal levels. Insights can also be used to build a conceptual framework that is applicable to multi-level determinants of household behaviour change across geographical settings, technologies and socio-cultural contexts.

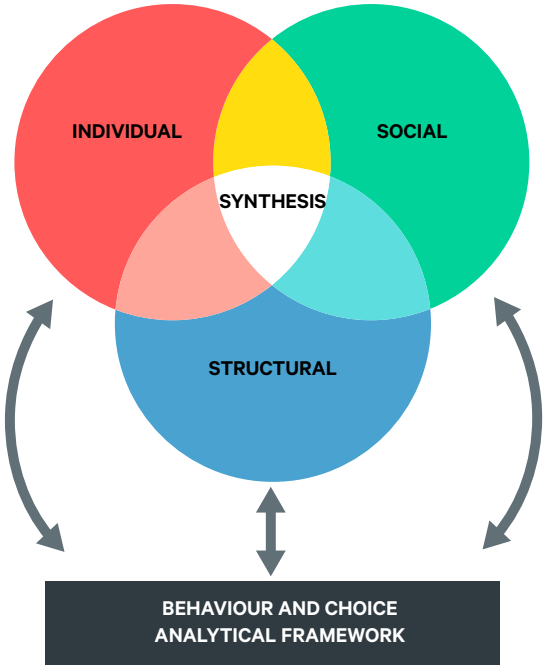
The work presented in this paper should be understood as one step in a longer process of synthesizing our empirical findings. The next step will be to engage with our key stakeholders in Kenya to check the validity of the drivers and states we have identified, and to solicit feedback on the scenarios generated. Based on this feedback, a subsequent paper will be produced targeted at policymakers and practitioners working to increase access to cookstoves.

Section 1.2 describes the structure of the Behaviour and Choice Initiative and provides an overview of the three work packages used to organize the empirical work. Section 2 describes the CIB methodology, the key steps in its application and how CIB was used in this paper, including how SDA was used to ensure a diverse spread of scenarios. Section 3 details the four scenarios that resulted from the application of these methods. Section 4 discusses the strengths and weaknesses of the approach and reflects on how to improve the methodology in the future by involving local stakeholders at different stages of the process.

1.2 Empirical foundation of the paper: research conducted by the Behaviour and Choice Initiative

This section briefly describes the empirical research that informs this paper. Research has been conducted in three work packages: (a) factors at the individual level within the household that influence the adoption of improved cookstoves, in work package 3; (b) the effects of social relations on the adoption of improved cookstoves, in work package 4; and (c) actor-structure relationships that influence the adoption of improved cookstoves, in work package 5. To cover the behavioural drivers relevant at each level, each work package proposed its own methodology.

Figure 1. Methodological approach of the Behaviour and Choice Initiative



Factors influencing individual behaviour at the household level

In work package 3, we examined what motivates individuals to purchase improved cookstoves and adopt them as their main or only stove for daily cooking (Jürisoo and Lambe 2016). We used insights from cognitive psychology and behavioural economics, which tell us that individuals typically make decisions based on non-economic rationales, combined with a behaviour change framework developed by (Goodwin et al. 2015) Known as the Clean Cooking Interventions Framework, it is a framework for behaviour change that is frequently used to design and/or implement cookstove interventions. We conducted 19 interviews over five days with women in Kiambu County, Kenya, who had purchased and/or started to use improved cookstoves, which all came from the same supplier.

Our findings show that the women generally purchased the stove for one of three different reasons: the prospect of saving money and/or fuel, the aesthetic appeal of the stove, or the added convenience of cooking on a cleaner and faster stove. At the point of purchase, many testified that their decision to buy the stove was supported by weighing the available facts against each other, and making an informed, rational decision to acquire the stove.[2] However, once in their homes, the women's motives for learning how to cook on the stove were primarily determined by emotions, expectations and situational factors, such as the ease of use of the stove, whether it performed as expected and whether support was available should something go wrong. This tells us that, in order to support the formation of new cooking practice, cookstove implementers need to use a range of different motivators to meet users' needs at different points in their "journeys" with the new technology. For the full study see Jürisoo and Lambe (2016).

The role of social relations in the adoption of improved cookstoves

Work package 4 explored the effects of social relations on the adoption of improved cookstoves by individuals (Vulturius and Wanjiru 2017). The study combined social cognitive theory with the same empirically based framework of behavioural change techniques used to understand internal factors in work package 3 (Bandura 1986; Goodwin et al. 2015). The empirical work consisted of surveys of 40 improved cookstove users in Kiambu County and Nairobi, Kenya who had purchased improved stoves from two different suppliers. The surveys were conducted during four meetings that took place in April 2016. The survey included open and multiple-choice questions about users' socio-economic and demographic status, and users' level of satisfaction with the stove and the implementer.

The results show that the differences in the levels of satisfaction and adoption between customers of the two different suppliers can be partly attributed to the strategies implementers used to market their product and offer support to users. Results also show that payment modalities can not only lower the short-term financial burden of the acquisition of improved cookstoves, but also offer users better access to technical support. The findings also suggest that satisfaction with improved cookstoves and implementers has a favourable influence on whether users recommend to their peers that they should also adopt the new technology. Lastly, the results identify a social multiplier effect: implementers can be successful in promoting improved stoves by encouraging existing users to recruit new users from among their peers. For the full study see Vulturius and Wanjiru (2017)

Structural relationships

This work package focused on understanding the current state of the improved cookstoves sector in Kenya, any points of weaknesses for the vibrant sector to identify and how the array of actors, interests and norms engaged with the energy sector influence and sustain it (Atteridge and Weitz 2017). We combined Technology Innovation Systems (see e.g. Bergek et al. 2008; Barnett et al. 2008) and political economy theory (O'Brien and Williams 2007) to achieve a holistic view of the cookstove sector as a system of many different functions and processes, as well as explanatory factors for why these functions and processes play out in the way they do.

2 Although the decision-making process could be described broadly as lexicographic in nature – insofar as the interviewees reported choosing the stove based on perceived valuable attributes strongly associated with an aspirational product, the Philips cookstove, we did not attempt to study the how the filtering process worked in decision making beyond describing how frequently the key attributes were reported.

We conducted 22 interviews with a cross section of stakeholders chosen on the basis that they have a connection to, or at least a vantage point from which to observe, the evolution of the clean cookstove sector in Kenya. Interviews were conducted with policymakers, entrepreneurs, community activists and funders, as well as representatives of national government ministries, the private sector, development cooperation agencies, donors, Kenyan organizations and international NGOs with a local presence in Kenya. For context we also interviewed a few households that cook with biomass and a representative from a development cooperation agency with long experience of energy policy in the region. The interviews were conducted in February 2016.

This paper suggests explanations for the limited success of efforts to encourage the adoption of clean cookstoves in Kenya to date, and identifies where future efforts might be concentrated to most effectively support wider diffusion. The paper concludes that the sector remains a nascent innovation system, and that its main weaknesses from a technology innovation perspective are a lack of strategic direction, low levels of legitimacy among the government and consumers, and weak levels of knowledge accumulation and learning. Technological choices and business models are influenced by a normative focus on health benefits, and by the strong influence of external actors in the absence of meaningful government engagement. The analysis suggests that the Kenyan clean cookstove sector is at a delicate stage and highlights that, in future, donors, development partners and government might shift resources and focus away from entrepreneurial experimentation, of which there is quite an amount going on, to address the more critical gaps described above. Fiscal incentives introduced in 2016 and work on the country's Sustainable Energy for All action plan are signs of greater engagement with household energy. In the interim, international financial support will remain critical and could be particularly helpful for addressing learning gaps, including resourcing a local knowledge hub. For the full study see Atteridge and Weitz (2017).

2. Cross-impact Balance Analysis

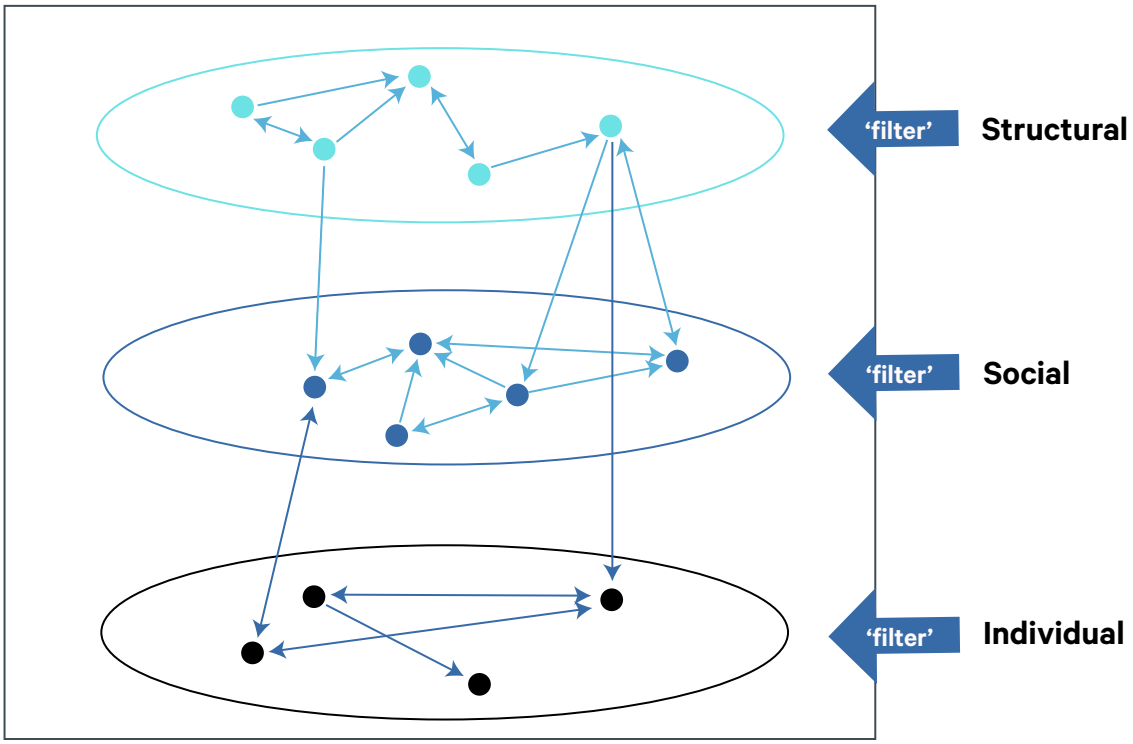
In order to combine insights from the different work packages described above, we used CIB analysis. This section describes what CIB is and how it was applied in this paper. As the application of the methodology drives the analysis of the data, the data analysis that underpins the scenarios (which are presented in section 3) is also included in this section.

2.1 What is Cross-impact Balance Analysis?

CIB analysis is a semi-quantitative methodology for evaluating qualitative expert insights in complex multidisciplinary systems in order to construct scenarios for the studied system (Weimer-Jehle 2006). Scenarios can be constructed in many different ways. Here we applied a method based on morphological analysis, where combinations are expressed by means of drivers and associated future states (Zwicky 1969). A driver is defined as a key factor that influences behaviour in favour of or against the uptake of an improved cookstove. The time frame is defined as the five-year period from the time the analysis was conducted (2016). A state is a statement about how a driver can play out in that future.

The CIB method provides a structured qualitative discussion around the relationship between individual states of drivers that is useful for deepening knowledge and clarifying perceptions about the dynamics of drivers and their interactions. In addition, an explicit forward-looking balanced structure of drivers can be provided by identifying future states of drivers. Third, the method produces combinations of states of drivers where each state reinforces the other states. These sets of states can serve as pillars around which scenarios for uptake can be elaborated and for which supportive policy options can be developed and assessed. The orientation towards the future, in combination with a quantitative identification of states that reinforce each other, allows us to draft scenarios for what we think the future might look like, given our understanding of the present. Fourth, as these sets of states of drivers will include drivers from different levels of society, the CIB methodology allows us to explore the influence of drivers across scales (see Figure 2). This adds another dimension to the issue of linking scenarios across scale which has hitherto mostly been discussed along the lines of linking different time- and geographic scales (Zurek and Henrichs 2007). Schweizer and Kurniawan (2016) recently introduced the concept of 'linked CIB' as an extended CIB method for building consistent scenarios across scales.

Figure 2. Conceptual overview of the relationship between drivers at different levels



2.2 Identifying drivers and states

The first step in a CIB analysis is to identify drivers for the system under study. The process is expert-driven, and can be highly participatory or limited to the assessment of individual researchers. Next, states are identified for all drivers. Choosing one state for each driver achieves a system description of one possible combination of the chosen drivers and associated states. This allows us to make a collection of several different combinations of states, where each state is assigned a single value. This is illustrated in Table 1 for the case of four drivers, each with two or three associated states.

Table 1. Drivers and states with one possible combination (A1, B1, C2, D1).

Driver A	Driver B	Driver C	Driver D
State A1	State B1	State C1	State D1
State A2	State B2	State C2	State D2
State A3	State B3		State D3

In the example, all drivers except driver C have three possible states. In this table, there are 54 possible combinations (3*3*2*3).

Method used for this paper

The work package leads identified drivers and states at each analytical level and fed them into a joint matrix. This allowed us to systematically detect influence between drivers and states irrespective of analytical levels (while keeping track of the level of origin), recognizing that drivers at one analytical level do not operate in isolation from drivers at other levels, but are parts of the same system. This ensured a holistic picture of drivers influencing behaviour on the uptake of improved cookstoves. The drivers and states provided the 'common language' across the three levels of analysis. The drivers and states for each work package are summarised in Tables 2–4. A detailed description of the drivers and states is provided in Annex A.

Table 2. Drivers and states influencing individual behaviour in the household

No	Driver	States
3.1	Financial incentives	1) time limited subsidy; 2) subsidy; 3) no subsidy
3.2	Presence of and trust in local partner	1) strong or 2) weak presence and trust
3.3	Social status	improved cookstoves: 1) are seen; 2) are not seen as modern and aspirational products
3.4	User influence in the design	stoves: 1) are co-designed; 2) are not co-designed
3.5	Level of financial autonomy of women within the household	Financial autonomy of women is 1) low 2) medium 3) high

Table 3. Drivers and states influencing social relations

No	Driver	State
4.1	Information channels	Information channel to reach customer was: 1) none; 2) broad; or 3) targeted
4.2	Payment options	Payment options available to the customer: 1) upfront payments; or 2) payment in instalments
4.3	Customer support	Type of support available to the customer: 1) none; 2) minimal; or 3) intensive
4.4	Strength of user community	The user community was either 1) weak or 2) strong
4.5	Peer recruitment	Peer recruitment was either 1) passive or 2) active

Table 4. Drivers and states influencing structural relations

No	Driver	States
5.1	Actor leading the improved cookstove agenda	The main sector actor is: 1) private sector; 2) government; 3) international institution; 4) carbon finance entrepreneur; or 5) NGO
5.2	Kenyan government role	Kenyan government 1) actively supports the sector; 2) passively supports the sector; or 3) opposes the sector
5.3	Global Alliance for Clean Cookstoves (GACC) presence	The GACC 1) still present in Kenya beyond 2017 or 2) withdraws from Kenya
5.4	Institutional and sectoral learning	Among actors within the sector there is: 1) no sharing of information or lessons learned; 2) information sharing only; or 3) accumulation and sharing of knowledge

2.3 Analysing the interactions between states

The second step is to analyse the interactions between states. For this paper, the work package leads convened for a one-day workshop to analyse the interactions between states. During the workshop, work package leads were asked whether a certain state of a driver would promote or restrict a certain state of another driver (Weimer-Jehle 2006). To do this systematically, the following guiding question was used: "Given driver A, state B, are you more likely to see driver C in state D, E or F in a five-year time frame from now? Based on the work package leads' assessment of the data collected, a judgement was made on which combinations of states were more or less likely to coexist in future. The following scale was used to assess influence:

+3: Strongly promoting influence

+2: Moderately promoting influence

+1: Weakly promoting influence

0: No influence, or unsure.

-1: Weakly restricting influence

-2: Moderately restricting influence

-3: Strongly restricting influence

In this way, an assessment was made of the consistency between all pairs of states, across all drivers. The results are captured in a Cross Impacts Matrix (see Table 5).

2.4 Scenario consistency

The third step is to identify scenarios that are consistent. This means that combinations of states must be are both quantitatively and qualitatively consistent, in that every state is chosen so that no other state of the same variable is more strongly preferred by the combined influence of the other variables in the system, and the story holds together and provides a feasible narrative. Consistent combinations of states provide the building blocks for formulating a narrative to describe a future scenario. To explain what consistent scenarios are, Table 5 provides a simple example of a Cross Impact Matrix with three drivers, each with two states.

Table 5: Example of a Cross Impact Matrix

		Driver A		Driver B		Driver C	
		State A1	State A2	State B1	State B2	State C1	State C2
Driver A	State A1			–1	1	3	–3
	State A2			–2	2	0	0
Driver B	State B1	1	–1			–2	2
	State B2	–3	3			1	–1
Driver C	State C1	2	–2	–1	1		
	State C2	–3	3	2	–2		

BOX 1. EXAMPLE OF HOW CONSISTENCY BETWEEN STATES WAS ASSESSED

In WP 3 a key driver of cookstove adoption was identified as **(3.2) presence and trust in a local partner**. For this driver, the following two states are possible:

3.2.1 Strong presence and trust: In this state, it is likely that a strong presence of a local partner, reciprocated by user trust in that partner, will lead to high uptake rates of advanced biomass cookstoves.

3.2.2 Weak presence and trust: In this state, it is likely that a level of lower trust in and presence of the local partner will lead to lower usage rates.

To conduct Cross Benefit Analysis, we began with state *3.2.1 Strong presence and trust: In this state, it is likely that a strong presence of a local partner, reciprocated by user trust in that partner, leads to high uptake rates of advanced biomass cookstoves.*

We then we checked this state against every other state identified across all WPs (for a list of all states see Table 2) by asking ourselves how likely it is that in five years' time these two states will coexist in the Kenyan cookstove sector? For each combination, a value was assigned depending on the level of influence of one state on the other.

For example, if driver *3.2.1 (Strong presence and trust: In this state, it is likely that a strong presence of a local partner, reciprocated by user trust in that partner, leads to high uptake rates of advanced biomass cookstoves)* is present five years from now, how likely is it that we will see driver *5.2.1, Kenyan government plays an active role in clean cookstove sector.* **In this case we assigned a value of 0: no influence**.

We then took the same driver 3.2.1 and conducted the same thought experiment, this time checking the likelihood of driver 3.2.1 coexisting with driver *5.2.2 (Kenyan government plays a passive role in clean cookstove sector).* **In this case we assigned a value of +1: weakly promoting influence**.

Finally, we took driver 3.2.1 and checked it against driver *5.2.3 (Kenyan government opposes clean cookstove sector).* **Here we assigned a value of –1 weakly restricting influence.**

The combined value across the three 0+1-1 = 0

In a Cross Impact Matrix, influence runs from rows to columns. For instance, state A1 has a strongly promoting influence on C1 (3) and state C1 has a moderately promoting influence on state A1 (2). When assessing influence, the CIB method requires that the states be exhaustive and mutually exclusive. For this reason, the influence weights must sum to zero across rows (as explained below), which they do in Table 5.

Let us look at the combined influence on state A1. For driver B there are two options: with state B1, A1 gets supported by 1 and with state B2 by -3. Hence for state A1, B1 is the preferred choice. A similar argument for driver C results in the conclusion that state C1 is the favourable choice. With these choices made for drivers B and C, A1 receives a total support of 1 + 2 = 3. The conclusion is that a scenario combination like (A1, B1, C1) is consistent because for each driver, the state with the highest number was chosen (B: 1 > –3 and C: 2 > –3).

This analysis started from the perspective of driver A, meaning that we looked for the best possible scenario combination for driver A in state 1, and did not perform a systemic analysis of all the three drivers together. What if we started from B and assumed B1 for this driver as was demanded from driver A? We then see from the B1 column that in order to get maximum support for B1 we require A = A1 and C = C2 (total support –1 + 2 = 1). Hence, starting with driver B the preferred choice for a consistent scenario combination is (A1, B1, C2), which is a different choice from (A1, B1, C1). This simple example illustrates the systemic features of the interactions between the targets.

Method used for this paper

The matrix populated during the workshop contained 14 drivers and 35 associated states. This resulted in a total of 466 560 possible combinations of interactions between states. It is very difficult to provide a digestible overview of such fine-grained interactions, so we have therefore omitted the full Cross Impact Matrix table.[3]

To provide an overview of the interactions identified, we have instead constructed a simplified Cross Impact Matrix (Table 6) that shows how the different drivers (but not states) relate to each other. This matrix is a simplified interpretation of the full Cross Impact Matrix as it subtracts the more fine-grained information about how the states influence each other, and instead focuses only on whether there is any interaction between each pair of drivers.

Table 6. Simplified Cross Impact Matrix

	3.1	3.2	3.3	3.4	3.5	4.1	4.2	4.3	4.4	4.5	5.1	5.2	5.3	5.4
3.1	■		■	■		■	■		■	■	■			■
3.2		■		■		■		■	■	■		■		
3.3	■		■			■			■	■	■	■		
3.4			■	■				■	■	■	■			
3.5	■				■	■			■	■	■			
4.1	■	■		■		■		■	■	■		■	■	
4.2							■	■			■	■		
4.3		■				■		■	■	■	■	■		
4.4		■	■	■		■		■	■	■		■		
4.5		■	■			■		■	■	■		■		
5.1	■		■	■		■		■			■	■	■	■
5.2	■	■				■			■	■	■	■	■	■
5.3	■		■			■					■	■	■	■
5.4	■										■	■	■	■

As with the Cross Impact Matrix, influence runs from rows to columns. A matrix element is grey if there are any non-zero entries in the corresponding block in the Cross Impact Matrix. For instance, there is an influence, either promoting or restricting, from driver 3.1 (financial incentives for using improved cookstoves and pellet fuel) to driver 4.2 (payment options) (grey), but 4.2 does not influence 3.1 (white). Influences between drivers within a work package are highlighted in the three boxes across the diagonal demarcated by a thick black line.

The matrix provides us with a number of observations:

On average, each driver has an influence on six other drivers. Drivers 3.1 (financial incentives), 4.1 (information channels), 5.1 (actor leading the improved cookstove agenda) and 5.2 (Kenyan government role) are the most influential drivers.[4] This can be found by counting the number of grey boxes that appear in the respective rows.

Looking across the other dimension, that is, along the columns, we see a wider spread but the average number is still six. Thus, the drivers are on average influenced by six other drivers. Some drivers are influenced by many drivers, especially drivers 4.1 (information channels) and 5.2 (Kenyan government role). Driver 3.5 (financial autonomy of women within the household) is not influenced by any other driver, but it influences five other drivers. Driver 3.5 is also the driver with the biggest difference between "influenced by" and "influence on" (or vice versa).

3 Available from the first author on request.

4 This statement does not take into account the degree of influence, i.e. the scale –3,..., +3. It only assesses how many drivers are influenced.

Although it was not connected to an explicit hypothesis, we were interested to know whether the interactions within analytical levels would be stronger or more tightly coupled than the interactions between levels. Out intuition told us that this would be the case since our work package leads would have a better understanding of interactions within "their" levels of analysis, and also because these drivers exist at the same physical scale and can therefore be assumed to be more closely linked, for example more often considered jointly in governance processes. The matrix shows, however, that it is generally speaking difficult to see any such pattern. The three boxes highlighted in bold across the diagonal are generally not more populated than the rest of the matrix. One exception is the drivers from work package 5 (structural relationships), where each driver is influenced by and influences all the other drivers within the work packages (all the matrixes in the box are grey). Work package 4 (role of social relationships in adoption of improved cookstoves) is less internally connected and work package 3 (factors influencing individual behaviour at the household level) even less so. One reason for this could be that the theoretical approach chosen for work package 5 highlights system interactions at the specific level more strongly than the approaches chosen for work packages 3 and 4. Furthermore, we see that the drivers from work package 3 have a strong influence on the drivers from work package 4 (17 of the 25 boxes are grey, or 68%) and that the drivers from work package 3 have a weaker influence on the drivers from work package 5 (35%). This could suggest that the influence of individual behavioural drivers plays out more strongly in relation to peer effects than to societal structures.

2.5 Identifying consistent scenarios across the three levels

The fourth step is to identify scenario combinations or kernels that reinforce each other and make a selection of which kernels to use for drafting scenarios.[5] In order to find scenario kernels that reinforce each other, the net effect of the combined influences must be analysed. We demonstrate this with a simple example below.

Table 7 shows the eight possible scenario kernels for the three drivers: (A1, B1, C1), (A1, B1, C2), (A1, B2, C1), and so on. For each such scenario kernel we need to calculate the combined influence on the states. As an example, consider the first scenario kernel (A1, B1, C1). If driver B = state B1 and driver C = state C1, as is the case for this scenario kernel, state A1 gets 3 in total support, as in the example above. If driver A is state A2 it gets the combined support of –1 –2 = –3 (see the next matrix element). Similarly, for the next combination (A1, B1, C2) the support for driver A = state A1 is 1– 3 = –2. In this way the combined support for all eight state combinations can be calculated.

In each row, the pre-selected combination is indicated in bold type (see the lower part of Table 6). In line with what is described in section 2.4, the chosen state must be compared with the alternative for each driver.

Table 7. Example of consistent scenario combinations

	A		B		C	
	A1	**A2**	**B1**	**B2**	**C1**	**C2**
A1			–1	1	3	–3
A2			–2	2	0	0
B1	1	–1			–2	2
B2	–3	3			1	–1
C1	2	–2	–1	1		
C2	–3	3	2	–2		
A1,B1,C1	1+2=3	–1–2=–3	–1–1=–2	1+1=2	3–2=1	–3+2=–1
A1,B1,C2	–2	2	1	–1	1	–1
A1,B2,C1	–1	1	1	–1	4	–4
A2,B1,C1	3	–3	–3	3	1	–1
A1,B2,C2	–6	6	1	–1	4	–4
A2,B2,C1	–1	1	–3	3	1	–1
A2,B1,C2	–2	2	0	0	–2	2
A2,B2,C2	–6	6	0	0	1	–1

5 This paper refers to a combination or family of scenarios as a scenario kernel

For the first combination, driver A and C are OK (3 > –3 and 1 > –1), but for B a shift from B1 to B2 would increase the support from –2 to 2. Hence, this is not a consistent scenario kernel. It should be noted that a simple shift of driver B from B1 to B2 will often, but not always, produce inconsistencies in other parts of the network (compare A2, B1, C2 with A2, B2, C2). This shift will decrease the combined support for driver A = A1 from 3 to –1 (B = B2 –> –3 and C = C1 –> 2, i.e. –3 + 2 = –1) making A2 a more favourable state for driver A. Shifting driver A too creates additional problems in yet other parts of the network.

The two consistent scenario kernels are marked in red: –1 < 1, –3 < 3, 1> –1: OK; 2 >–2, 0 is not better than 0, 2 > –2: OK.

How the calculations were made for this paper

We used computer software (ScenarioWizard) to identify 19 scenario kernels from the 466 560 possible combinations found by the algorithm. These 19 scenario kernels form the starter-set for the subsequent qualitative analysis and drafting of scenarios. (For an overview of the 19 scenario kernels see Annex 2.)

Let us look at some characteristics of those 19 scenario kernels, based on the frequencies of states in the scenario kernel shown in Table 8. First, some of the states are not represented in the set of 19 scenario kernels, for example drivers 3.2 to 3.4 and 4.2 marked "0" in Table 8. Second, 14 of the 35 states were not used. If states do not show up in the set of 19 consistent scenarios, it is an indication that these states do not get as much support from other states compared to other combinations.

Table 8. Frequencies of states in the set of 19 scenario kernels

	Frequency of states in the set of 19 scenarios (%)				
Driver	**State 1**	**State 2**	**State 3**	**State 4**	**State 5**
3.1 Financial incentives	5.3	94.7	0	–	–
3.2 Presence and trust in local partner	100	0	–	–	–
3.3 Social status	100	0	–	–	–
3.4 User influence in design	100	0	–	–	–
3.5 Financial autonomy of woman within the household	26.3	42.1	31.6	–	–
4.1 Information channels	0	21.2	78.9	–	–
4.2 Payment options	0	100	–	–	–
4.3 Customer support	0	52.6	47.4	–	–
4.4 Strength of user community	100	0	–	–	–
4.5 Peer recruitment	100	0	–	–	–
5.1 Actor leading the improved cookstove agenda	26.3	73.7	0	0	0
5.2 Kenyan government role	100	0	0		
5.3 Global alliance for clean cookstoves presence	0	73.7	26.3		
5.4 Institutional and sectoral learning	0	63.2	36.8		

2.6 Selecting diverse scenario kernels for writing scenarios

The fifth step is to identity which scenario kernels to use when drafting scenario narratives. We used scenario diversity analysis, a method that allows us to ask how similar or different the scenario combinations are. The basic idea of scenario diversity analysis is described in Carlsen et al. (2016a: 59–75) and the method is elaborated on in a context of robust decision-making in Carlsen et al. (2016b: 155–64).

The aim for a broad span reflects the basic idea that scenario-based analysis is about robustness in the sense of supporting the search for strategies that work reasonably well in a wide range of external conditions (see e.g. Van der Heijden (2005) and Lempert (2007). Theoretically, such a broad span could be achieved by working with very large scenario sets, but for communication purposes it is often useful to limit the number (Bradfield et al. 2005). Hence, a selection has to be made.

A measure of distance between scenario combinations was defined: the distance between two scenario kernels is zero if all states are the same; 1 if all states except one are the same; 2 if all states except two are the same, and so on. For 14 driver (5+5+4) scenarios, the theoretical span of this measure is from 0 to 14. Table 9 shows all the distances between the 19 scenarios using this measure.

Table 9. Distance matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1		2	1	2	3	2	3	2	3	5	4	6	1	3	2	3	4	3	4
2			1	1	1	2	2	4	4	3	4	5	3	1	2	2	3	3	3
3				1	2	1	2	3	4	4	2	5	2	2	1	2	3	2	3
4					2	2	1	4	3	4	4	4	3	2	2	1	3	3	2
5						1	1	5	5	2	3	4	4	2	3	3	1	2	2
6							1	4	5	3	2	4	3	3	2	3	2	1	2
7								5	4	3	3	3	4	3	3	2	2	2	1
8									1	3	2	4	3	5	4	5	6	5	6
9										3	3	3	4	5	5	4	6	6	5
10											1	2	6	4	5	5	3	4	4
11												2	5	5	4	5	4	3	4
12													7	6	6	5	5	5	4
13														2	1	2	3	2	3
14															1	1	1	2	2
15																1	2	1	2
16																	2	2	1
17																		1	1
18																			1

Table 9 can be used to identify ‘families’ of scenarios, that is groups where the scenario kernels are very similar (the distance is only 1). For instance, scenario kernels 3 and 6 only differ in one driver (4.3, minimal vs. intensive); and scenario kernels 14 and 15 only differ in one driver (3.5, low vs medium). It can also be used to identify ‘families’ of scenario kernels where the kernels are as different as possible. The largest spread between two scenario kernels is 7 (between 12 and 13). By choosing families of scenario kernels that have as large a spread as possible, we were able to write scenarios that illustrate diverse futures and hence that are qualitatively different but are nonetheless systematically consistent. This gives an indication of the span of the “consistently possible” futures derived from pairs of states that also reinforce each other from a systems perspective.

Method used for this study

A scenario diversity analysis provided the following results: From the 19 scenario kernels, a "scenario family" with three kernels can be chosen in 969 different ways. Hence, there are 969 sets of scenario kernels to choose from. Four scenario kernels can be chosen in 3876 different ways. Four sets are maximally spanning in terms of diversity if we include three scenario kernels. Two sets are maximally spanning if we include four scenario kernels.

Table 10. Families of scenarios

Scenario family	Scenario kernels	Mean distance	Min. distance
A	5, 12, 13	5	4
B	8, 12, 14	5	4
C	8, 12, 17	5	4
D	1, 12, 17	5	4
E	8, 12, 13, 17	4.67	3
F	9, 12, 13, 17	4.67	3

We made a qualitative assessment of the different alternatives in a workshop setting. To ensure maximum diversity, we delimited ourselves to the families that included scenario kernels 12 and 13 as they were the most diverse (7). We opted for "Family E", as scenarios 8 and 17 together constitute interesting variants of 12 and 13. Scenario 8 provides an account of a stronger private sector with a medium level of financial autonomy for women in the household. Scenario 17 provides a stronger presence of the national government and international institutions, but with a low level of financial autonomy for women within the household.

3. Scenarios

This section presents the four scenarios. The scenario numbers correspond to the scenario kernels presented in Annex B, which also gives a full overview of the drivers and states included in the respective scenarios. The scenario narratives were written by one individual, with comments and input from a committee comprised of the work package leads. Our goal in creating the scenarios is to engage key stakeholders in the Kenyan cookstove sector, in particular government actors, NGOs and development partners, to consider how changes could be made to the current system to bring about an increase in improved cookstove uptake. The aim was to construct scenarios that are sufficiently detailed and compelling to allow stakeholders to visualize whether and how the required changes could be made. Given the goal of the scenarios, the CIB method was used to ensure that the resulting scenario kernel only included scenarios of successful cookstove uptake.

3.1 "A thriving market with enabling support from the government and happy customers, albeit with limited information sharing between actors" (no. 12)

There is no subsidy available for improved cookstoves and, unless distributors offer payment modalities, more advanced stoves, such as forced draft biomass pellet cookstoves, are primarily affordable only to higher income segments of the population. "Default" cooking technologies in Kenya, such as the KCJ[6], are widely used. Nonetheless, a thriving market for cookstoves has emerged, and cookstoves of varying efficiency levels are being sold to consumers of different income levels.

The level of financial autonomy for women within the household is high, creating an environment where, regardless of income, many households prioritize the purchase of an improved cooking device. Improved stoves are seen as modern products and there is a clear aspirational value attached to owning and using one. The cookstoves on the market have often been co-designed with users, and are therefore easy to use, and generally appreciated and trusted technologies. Improved stoves are marketed and sold by a local distributor that is highly trusted and has a strong presence in the local community. The retailer also provides after-sales support to customers who require it. This actor could be a local NGO, a micro-finance institution or a private company.

Private sector actors provide the most momentum in the sector, and a significant number of large-scale manufacturers are present in Kenya. The larger companies focus their business on the demographics where the financial returns are most likely to be high, and this is thought to be in middle- and high-income households. These manufacturers develop and promote more efficient technologies that can be manufactured at scale, and actively target promotional material at consumers. Stove manufactures are both local and international.

Distributors generally use targeted information channels, which means that advertisements are tailored to specific consumer groups and networks. This has contributed to increased demand for improved cookstoves. Distributors also offer payment modalities, such paying in instalments. This has decreased the need for financial planning ahead of purchase, suggesting that less wealthy consumers are able buy more advanced cookstoves. Distributors offer intensive after-sales support, including home visits, an interactive user manual, and a two-way hotline between the customer and the distributor. Despite recommendations to include an informal peer recruitment system in their business model, distributors have not picked up on this. As the user community is strong and information is frequently shared between users, there is potential for improved cookstoves to gain further momentum locally if such a system is established.

The Kenyan government has developed a policy framework that provides clear strategic direction and incentives to actors in the sector. It has also put in place standards for different types of improved cookstoves. The Global Alliance for Clean Cookstoves has withdrawn from Kenya, and a large private sector company, or association of businesses, now acts as the coordinating entity within the sector, with a mandate to report on business development and consult with the government. Nonetheless,

6 The *Kenya Ceramic Jiko*, known as the KCJ, is a charcoal stove with a metal exterior and a clay lining. It is made by local artisans and widely available for use in Kenya. The word Jiko means "cookstove" more generally, but often refers specifically to the KCJ.

there is limited institutional learning within the sector. Actors only share basic knowledge about their activities, but no detailed evaluations or analyses of impacts over time. If the exchange of information and lessons learned could be intensified, there is significant potential for the sector to prosper further. However, such a development is unlikely given the limited incentives for private businesses to share their knowledge and innovations.

3.2 "Basic business models are compensated for by a time-limited subsidy and active sharing and learning within the sector" (no 13)

There is a time-limited subsidy for all improved cookstoves and fuels sold in Kenya, meaning that stoves are made available to private consumers at reduced prices. The subsidy is provided by the national government, which has increased its active support for the sector compared to five years before. The subsidy makes stoves of all efficiency levels available to various income groups.

The level of financial autonomy of women in the household is medium, which means that many families prioritize the purchase of improved stoves. One reason for this is that improved cookstoves are seen as modern products that provide a flavour of a better life. As one woman living in Kiambu County noted in a recent interview: "Owning this type of stove gives people hope". Improved cookstoves generally enjoy a good reputation because all stoves on the market have been co-designed with users and are therefore intuitive to use and appreciated by most. This is an improvement on five years earlier, when many users struggled to get the stove to work once purchased.

Despite the subsidy for improved stoves and fuels, many distributors still offer customers the option to pay in instalments. This is valued by many, in particular those who do not have the disposable income to pay for a more expensive stove upfront. Distributors primarily use broad information channels, which means that not much has changed in their marketing strategy in the past five years. Distributors remain relatively inattentive to after sales follow-up and there is little targeted after-sales support in place.

In lieu of active support from the distributor, a strong user community has emerged, and users help each other with everyday problems encountered while cooking. The stoves are distributed by a highly trusted organization that facilitates meetings between different user groups, thereby helping to build a strong community of practice. Nonetheless, there is little peer recruitment taking place, which suggests that users' willingness to promote the stove could be enhanced further, perhaps by using more targeted distribution channels and active after sales follow-up.

As was the case five years before, the Global Alliance for Clean Cookstoves is present in Kenya and leads the improved cookstove agenda. A market-based approach to technology development and dissemination is promoted. Like five years ago, there is a high prevalence of smaller, project-based interventions, rather than significant scaling-up of the market and market actors.

Even so, there is significant accumulation and sharing of knowledge within the sector. High quality evaluations of improved cookstove programmes and initiatives are ongoing, and the lessons shared from these reviews are likely to contribute to a further strengthening of the sector. Compared to five years before, there is a greater sense of cooperation among different actors, and a strong platform for public sector-private sector collaboration. The friendly environment within the sector has also helped cooperation partners to identify where and how to use resources to promote the sector.

3.3 "Private sector actors lead the sector with active government support, without any visible effects on marketing approaches" (no. 8)

There is a time limited subsidy in place at the local level, which means that stoves and fuel are sold to private consumers at reduced prices. The subsidy is provided by the national government, which has increased its active support for the sector compared to the situation five years before. The subsidy has made stoves of higher efficiency levels available to lower income groups, and these are now more widespread than they were five year ago. The level of financial autonomy of women in the household is

medium, meaning that many families prioritize the purchase of improved stoves. One reason for this is that they are seen as aspirational products that are modern and provide a flavour of a better life. Another reason is that the stoves on the market have been co-designed with users, so they are intuitive to use and appreciated by most.

Despite the national level subsidy, many distributors still offer customers payment modalities. The opportunity to pay in instalments is appreciated by many, in particular those who do not have the disposable income to pay for a more expensive stove upfront. Like the situation five years before, local distributors tend to use broad information channels and do not pay much attention to after sales follow-up. Once customers have purchased a stove, they are left with few supporting mechanisms to help them use the stove correctly and consistently.

Nonetheless, and perhaps in lieu of active support from the distributor, a strong user community has emerged, where customers help each other with the everyday problems they encounter while cooking. One reason for this could be that the distributor is a highly trusted organization that facilitates meetings between users, helping to build a strong community of practice. Despite this, there is little peer recruitment going on, suggesting that trust in the product could be enhanced further, for instance by using more targeted distribution channels and more active after-sales follow-up by the distributor.

The Kenyan government has recently put in place a policy framework that provides a clear strategic direction and incentives for actors in the sector. The government has also put in place standards for different types of improved cookstoves, ranging from more to less advanced stoves. This makes it easier for customers to compare the stoves available on the market. It also makes it simpler for Kenyan stove producers to export their products to other markets.

The Global Alliance for Clean Cookstoves has withdrawn from Kenya, and an association of businesses acts as the coordinating entity within the sector. The main role of the business association is to liaise with the government on the current state of the sector, report on business development, and provide input on how improved cookstoves can contribute towards realizing the Kenya Vision 2030.

Notwithstanding the existence of a trusted public-private partnership, there is, similar to the situation five years ago, limited institutional learning within the cookstove sector. Actors share some basic knowledge about their activities, but not any detailed evaluations or analyses of impacts over time. While the presence of a business association and the active support of the government have provided better transparency in terms of “who is doing what”, the sector’s long-term development would probably benefit from more proactive information sharing among actors.

3.4 “User-centred products and distribution models, with a large presence by the government and international organizations” (no 17)

There is a time limited subsidy in place at the local level, which means that stoves and fuel are sold at reduced prices to private consumers. The subsidy has made stoves of all efficiency levels available to different income groups, regardless of the payment modalities offered by the cookstove distributor. The subsidy is provided by the national government, which has increased its active support for the sector in recent years.

The level of financial autonomy of women in the household is low but a sizeable number of families are prioritizing the purchase of improved stoves, although not as many as would have been expected in a scenario where women’s financial autonomy was higher. One reason for this is the time limit on the subsidy on improved cookstoves and fuels put in place by the government. Another reason is that improved cookstoves are considered aspirational products that are modern and give a flavour of a better life. A third reason is that all the stoves on the market have been co-designed with users, which means that they are intuitive to use and appreciated by most users.

Trusted local actors with a strong presence in the local community promote, sell and provide after-sales support for improved cookstoves. Depending on the location, this actor is an NGO, a micro-finance

institution or a company. Distributors generally use targeted information channels, which means that the messaging is tailored to specific consumer groups and networks. This has increased sales and demand for improved cookstoves compared to five years ago. Almost all the distributors also offer payment modalities, such as paying in instalments. In combination with the time-limited subsidy, this has decreased the need for financial planning ahead of the purchase, so that even consumers who would normally not prioritize buying an improved cookstove are doing so. The after-sales support provided by most distributors is intensive, and includes home visits with one-on-one support, an interactive user manual, and a two-way hotline between the customer and the distributor.

Despite the presence of a strong user community characterized by active information exchange between cookstove users, distributors have not capitalized on it to develop an informal peer recruitment system. Experience from other countries in the region shows that an active peer recruitment system would be likely to increase the demand for and use of improved stoves even further. The recruitment system could take the form of financial incentives to customers that convince a friend to buy a stove, such as discounts on their instalments, vouchers for pellet fuel, free repairs or training for ambassadors to perform after-sales support in their neighbourhood.

The Global Alliance for Clean Cookstoves is still present in Kenya and leads the improved cookstove agenda. A market-based approach to technology development and dissemination is being promoted, which is similar to the situation five years ago. There is a high prevalence of smaller, project-based interventions rather than a significant scaling-up of the market.

There is significant accumulation and sharing of knowledge within the sector. For instance, high quality evaluations of improved cookstove programmes and initiatives are being conducted, which will allow future efforts to build on previous lessons. Compared to the situation five years ago, there is a greater sense of cooperation among different actors. This has provided a strong platform for promoting a public-private partnership between the government, development organizations and private sector actors engaged in the cookstove sector. The good-natured environment within the sector has also helped cooperation partners to more easily identify where and how to use resources to promote the uptake of improved cookstoves.

4. Discussion

4.1 What do the scenarios add to this exercise?

The scenarios are both an analytical tool and a method for engaging people. None of them are true in the sense that, as Bell (1997) posits, there "can be no facts about the future". However, by systematically combining insights on drivers of behaviour at different societal levels, the scenarios provide an overview of how drivers that have been studied in isolation – but in reality are interlinked - might interact in the future. These insights can be useful from an analytical perspective when the intention is to piece together findings that lean on different theoretical and methodological foundations, for instance when building a conceptual model. From a practitioner's perspective, a better understanding of how drivers interplay at different societal levels enhances the chances of identifying areas where policy interventions are needed, for instance, to address systemic bottlenecks or capitalize on identified synergies.

One of the strengths of the methodology is that it provides a structured way to synthesize expert insights across different levels of analysis in a way that is epistemologically consistent. The expert- driven nature allowed us to assess influence across work packages, and demanded that we try (harder) to understand the implications of the findings from other work packages and their potential spillover effects. The process of picking drivers and associated states required work package leads to engage intensively with each other's theoretical and methodological approaches. This ensured that the quantification of qualitative data, while not always entirely frictionless, was done in a transparent and thorough manner. This strengthened our mutual understanding of the systemic influence of drivers at different levels on people's behaviour and choices in relation to the adoption of improved cookstoves. Although it is not possible to conduct a full counterfactual analysis, it is possible to evaluate the value added by taking this approach compared to an alternative approach that does not include scenario construction. For example, we could compare the scenario method applied in our study with a Technology Innovations Systems (TIS) approach, which has been applied in the past by SEI to understand the determinants of technological change at different levels of society in the context of cookstove adoption (Atteridge, Weitz and Nilsson 2013). The TIS framework is useful for identifying gaps or weaknesses in a given technology innovation system, but does not generate insights about the future development of a system or sector. When compared with TIS as a method of understanding the dynamics of change in a system, CIB and SDA add value by allowing stakeholders to think freely but in a structured and systematic way about how things might be in the future.

Finally, we acknowledge that there is a current debate over whether scenario processes should continue to strive for neutrality or such processes should anticipate the political and/or social implications of the scenarios, which poses "great challenges to conventional ideas of scientific neutrality"(Beck and Mahony 2017). Our position is that scenario processes should strive for neutrality, and that increased transparency is key in such efforts. Using systematic techniques such as CIB and SDA is one way of increasing transparency in scenario building (Carlsen, Klein, and Wikman-Svahn 2017).

4.2 Insights on influence across analytical levels

When compared, the four scenarios present an array of different futures for the improved cookstove sector in Kenya that, despite their qualitative difference, have comparable systemic features – they are equally stable and none of them are more strongly preferred by the system as a whole. This suggests that, unless interventions to steer development in the direction of a particular scenario are put in place, each of the four scenarios is as likely to happen in the future as any of the others, based on the experts' assessment of the material gathered. As such, the main point of using scenarios is not to identify the most likely future, but to span possibilities. The likely future is probably somewhere in between all four of them. The scenarios provide some indication of what such interventions could be, and the full work package write-ups provide additional suggestions. Suitable interventions could also be explored in a workshop format with stakeholders.

In spite of having chosen the four most diverse scenarios, there is limited variety in the combination of drivers and states that make up the scenario combinations. For instance, many drivers in each work package only appear in one state. In work package 3, the drivers "presence and trust in local partner" (driver 3.2), "social status" (driver 3.3) and "user influence in the design" (driver 3.4) appear in the same state in all four scenarios. This is also the case in work package 4 for the drivers "strength of the user

community" (driver 4.4) and "peer recruitment" (driver 4.5); and in work package 5 for the driver "Kenyan government role" (driver 5.2). If we had opted selection criteria that favoured the inclusion of all states, as opposed to choosing the most stable scenario combinations, we would probably have seen a bigger diversity in states at all levels.

Notwithstanding the limited variety in the combinations of drivers and states in the respective work packages, the drivers and states included are not static when combined with drivers and states from other work packages. This highlights that state combinations do not occur independently of each other, and can help highlight possible synergies across levels that would not have been discovered within individual work packages. For instance, the combinations "broad information channels" (driver 4.1, state 2) and "minimal customer support" (driver 4.3, state 2), as well as "targeted information channels" (driver 4.1, state 3) and "intensive customer support" (driver 4.3, state 3) both coexist with two states for driver 5.1, "the private sector leading the improved cookstoves agenda" and "an international institution leading the improved cookstoves agenda". This could suggest that the type of actor leading the improved cookstove agenda nationally is unlikely to directly steer the sector towards a situation where only one type of marketing and customer support model features. As such, developments at the analytical level may – or may not – have spillover effects on another level, and even if there are spillover effects the direction may not be a given at the outset.

Despite the quantitative consistency of the scenarios, there are nonetheless some qualitative discrepancies, or combinations of states that "feel" counter-intuitive in all scenarios. For instance, even though improved cookstoves have been co-designed with users (driver 3.4), are seen as modern (driver 3.3) and the user community is strong (driver 4.4), peer recruitment remains passive (driver 4.5) in all scenarios. Given the positive momentum built up around the product and between users, one would have expected trust in the product and a sense of belonging among users to have had spillover effects that sought to expand the user community, for instance through active peer recruitment. This discrepancy could be addressed in future iterations by reassessing how states influence each other, or further deepen our understanding of how different drivers and states play out in relation to each other through additional empirical studies.

4.3 Limitations of the methodology

The process of identifying drivers and states – but notably states – was at times both difficult and time-consuming. As the work packages had been designed as stand-alone studies, and not tailored to this synthesis exercise, the empirical material did not provide an automatic blueprint for what the drivers and states should be. Furthermore, as experts only participated in gathering and analysing findings for their own work packages, our common understanding of how the different work packages influenced the system as a whole was limited. While the drivers could be extracted from the empirical data relatively easily, states were primarily identified through intuitive thinking and discussions among work packages leads. The methodology further demanded that the states should be mutually exclusive, meaning that they could not coexist. While this served the quantitative model well, it was not always congruent with reality. For instance, both the presence of and the level of trust in the local distributor (driver 3.2) are in reality likely to take many different states depending on the location, the person, the timing of the intervention, and so on, and several states are therefore likely to coexist.

Scenarios can be used to facilitate structured discussions among experts and stakeholders. Importantly, such workshop settings can be a dynamic meeting place for different sector actors to gain a better understanding of each other's perspectives. For the scenarios presented in this paper, stakeholder views were gathered when the empirical material for the various work packages was collected. One limitation of the paper is thus that the scenarios have not been tested with stakeholders and other sector experts. Instead, work package leads have acted as a filter between the stakeholders and the scenario narrative. In future iterations, to enhance the robustness of the method, it is recommended that scenarios, or even drivers and states, should be validated with stakeholders at a relatively early stage in the process For instance, getting stakeholders' input on the selected drivers and states could be a useful "ground-truthing" exercise that could lead to a more informed assessment of how states influence each other. This work is planned to take place in 2017.

The interactions described in the scenarios are the outcome of a structured process that assesses qualitative data in a semi-quantitative way. The interactions are based on expert judgement, and therefore the outcome is subjective by default. This “educated guessing” is nonetheless the best available input for processing the available data transparently, in a systematic and trackable way. Each identified interaction between drivers and states could merit a whole study on its own, and the aggregate analysis can never replace the analysis of individual drivers and the standalone merit of individual work packages. This paper presents a first step towards understanding how the different analytical levels are connected, by providing an overview of the systems’ interactions as one analytical entity. This can serve as one of many inputs into how to govern the uptake of new technology within a society.

5. Conclusion

This paper has presented a systematic and transparent way of synthesizing qualitative empirical material on the drivers of behaviour that influence the adoption of cookstoves in Kenya. The material works on three different analytical levels in a semi-quantitative way using the CIB method. It has identified drivers of behaviour at each analytical level, and assessed how different states of these interactions influence each other with regard to improved cookstove adoption. We have also identified the most stable and diverse combinations of such states, and used these as a basis for drafting four scenarios about how multi-level behavioural drivers can influence the uptake of cookstoves in Kenya within a five-year time frame.

The scenarios provide an overview of how the different levels connect and highlight the synergies – and stumbling blocks – that appear when drivers of behaviour from different levels influence each other. The analysis adds a system perspective to empirical work that was designed to study a single analytical level in isolation. This "systems overview" can be used as a basis for informing strategic decisions about the future direction of the improved cookstove sector in Kenya and could also be used as a vehicle to explore the effect of the implementation of a certain policy, such as a financial subsidy, on specific strata of society. Importantly, the linkages between different analytical levels can also serve as input for scholars interested in conceptual models of multi-level drivers and the systems dynamics around behaviour change.

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Annex A: Drivers and states per work package

Drivers and states internal to the individual

The drivers for work package 3 were identified partly from a theoretical framework for behaviour change frequently used in cookstove interventions (Goodwin et al. 2015), and partly from the empirical data collected. The most prominent behaviour change techniques used in Kiambu County are identified below.

3.1 Financial incentives

This driver refers to the behaviour change techniques "reward and threat", and specifically to whether financial incentives have been used to create incentives for the purchase of advanced cookstoves. The importance of using financial incentives to stimulate purchase receives strong support in the literature (see e.g. Levine and Cotterman 2007; Lewis and Pattanayak 2012). The driver was observed strongly in the case location. All users who had purchased a cookstove had taken a loan from VEP, the micro-finance institute that acted as the wholesaler of the advanced cookstoves. Most households had also been given a free bag of pellet fuel at the time of purchase. This driver can take three different states:

Time limited subsidy. By lowering the financial barrier to purchase, it is likely, and supported by the literature, that purchase rates of improved cookstoves will increase.

Subsidy for stove and/or fuel: permanent subsidy is put in place.

No subsidy: This state means that no subsidy is put in place. This does not mean that purchasing rates are lower across the board. It could mean that more advanced cookstoves only reach income segments that can afford them, and that lower income groups mainly purchase improved cookstoves of a more basic design.

3.2 Presence and trust in local partner

This driver refers to the behaviour change technique "social support". This means that active support – including emotional support such as trust, and physical support such as bringing the cookstove to the client and providing after-sales services – from the cookstove promoter to the cookstove user can increase the usage rate. This driver was observed strongly in the case location. Many of the interviewees stated that unlike other vendors, VEP was a respectable partner with high morals that would never promote a low-quality product. This driver can take two states:

Strong presence and trust: In this state, it is likely that the strong presence of a local partner, reciprocated by user trust in that partner, will lead to high rates of uptake of advanced biomass cookstoves.

Weak presence and trust: In this state, it is likely that a lower level of trust in and presence of the local partner leads to lower usage rates.

3.3 Social status

This driver refers to the behaviour change techniques "social status" and "identity and self-belief", which assert that the purchase and use of advanced cookstoves can be more easily brought about if the product also has an aspirational value for the user (Lambe and Senyagwa 2015). This tendency was observed among more than half of the interviewees in Kiambu County. Owning a new Philips cookstove gave several users a strong sense of social aspiration, and a feeling that their lives were heading in the right direction. The stove reminded them of technologies purchased and owned by people living in Nairobi. This driver can take two states:

Advanced cookstoves are seen as a modern, aspirational product: This state assumes that owning an advanced biomass cookstove is associated with strong social aspirations, and that this can stimulate purchase and continued use. Usage rates will increase as people associate ownership and use of the stove with a "modern" lifestyle, increased hope and a sense of upward social and economic mobility.

Social status of the advanced cookstove is low, and it is not seen as modern or aspirational. In this state, owning and cooking on an advanced biomass stove has no aspirational value, and does not contribute to increased uptake of advanced biomass stoves.

3.4 User influence on design

This driver refers to whether the cooking technology meets the users' needs and desires, and whether user preferences have been incorporated when designing the stove In Kiambu County, all the respondents complained about one or more features of the design of the stove. This related primarily to technical aspects: how it had to be charged and maintained, how fuel was fed into the stove, the speed of cooking and the fact that the stove had to be monitored while cooking. For many, continuous problems with the use of the stove led them to reject it. This suggests that user participation in the design of cookstoves can help mitigate mishaps related to the user-friendliness of the stove, and that co-design between users and technology developers is important. This driver can take two states:

Stoves are co-designed. In this state, advanced cookstoves are co-designed by users and product developers. The products that reach the market are therefore in line with the users' expectations. They are strongly appreciated and widely used as use is intuitive to the user and can accommodate common cooking practices.

Stoves are not co-designed. In this state, stoves are not co-designed and therefore more users struggle to make the technologies work for them. This state does not mean that adoption of advanced stoves does not happen, but we expect adoption rates to be lower than when co-design happens.

3.5 Financial autonomy of women within the household

This driver refers to women's ability to make financial decisions within the household, in particular when it comes to purchase of (high-end) kitchen appliances. All the women interviewed in Kiambu County reported being able to make purchasing decisions for their households. We know from the literature that the broader enabling context for adopting advanced cookstoves is influenced by the division of responsibilities and power relationships within the household, as well as in society at large, including the wider societal, institutional and cultural structures (Clancy et al. 2012; Pachauri and Rao 2015). This includes the intra-household bargaining power of women, or direct involvement in the household economy. It is an area that merits further research. The driver can take three states:

Low: In this state, women's involvement in the household economy is low. Women are primarily responsible for cooking, but we assume that they will be less likely to purchase and use advanced cookstoves.

Medium: In this state, women have a moderate level of involvement in the household economy, meaning that there is a general trend for there to be some involvement in household decisions. From the perspective of cookstove uptake, this could mean that households are more prone to purchase more basic, lower cost cooking technologies while not favouring adoption of advanced biomass cookstoves.

High: In this state, women's level of financial autonomy is high, and the purchase of advanced biomass cookstoves is more likely to occur.

Drivers and states of the effects of peers

Work package 4 used the same behaviour change techniques from Goodwin et al. (2015) as applied in work package 3. The drivers stem from the framework, as well as the empirical material collected.

4.1 Information channels

This driver relates to the behaviour change technique "shaping knowledge", and relates to how improved cookstove implementers use different means of communication to promote their products to existing and potential users. The driver has three different states: none, broad and targeted. The findings suggest that adoption of improved cookstoves appears stronger when implementers use marketing that directly

targets certain user groups (in the case study members of women's groups and teachers). These results support previous findings and show that upscaling of improved cookstove adoption rates hinges on the successful development of a targeted sales strategy (Sinha 2002; Shrimali et al. 2011). The driver can take three states:

None refers to a situation in which improved cookstove implementers do not disseminate any information about their products to the public.

Broad refers to information dissemination that uses mass media but does not target a specific user group.

Targeted means that improved cookstove implementers are targeting their communication efforts on groups that have identifiable properties: gender, geographic location of residence, income level, place of employment, and so on.

4.2 Payment options

This driver relates to the behaviour change technique reward and threat, and has two states: upfront payment and paying in instalments. Our findings show that payment modalities can not only lower the short-term financial burden of the acquisition of improved cookstoves, but also offer cookstove users access to technical support. Regular loan payments create a longer lasting relationship between users and implementers that can help resolve problems and create opportunities for the adoption of other technologies that help reduce environmental and health-related harm, and increase access to energy. The driver can take two states:

Upfront payments: In this state, all customers have to pay the entire cost of the cookstove upfront. This requires significant financial planning ahead of the purchase, and can constitute an obstacle to purchase.

Paying in instalments: In this state, payment modalities lower the upfront financial burden at the time of purchase, making it easier for prospective customers without high amounts of disposable income to purchase more expensive cookstoves.

4.3 Customer support

This driver relates to the behaviour change technique "shaping knowledge" and is closely related to driver 4.1 information channels. It refers to the degree of after-sales support available to the customer. It has three states: none, minimal and intensive. The results from the survey suggest that user satisfaction strongly depends on the opportunity to receive comprehensive, after-sales support from the implementer after the purchase of the stove. This supports previous studies that have shown that offering intensive support to users increases the likelihood of long-term adoption of improved cookstoves (Sinha 2002; Shrimali et al. 2011). The driver can take three states:

No customer support: In this state, those who have purchased a cookstove but need support to make it work cannot get access to it, and therefore stop using the cookstove.

Minimal customer support corresponds to a situation where the improved cookstove implementer offers some initial training and leaves contact details, but active support after purchase is only provided on request. In this state, usage rates are higher than in the state where no customer support is offered.

Intensive customer support means that the improved cookstove implementers, after giving initial training, actively follow up with their customers and offer additional training and support with problems. In this state, user adoption rates are high.

4.4 Strength of user community

This driver relates to the behaviour change techniques that shape knowledge, social support, identity and self-belief. The driver takes two different states: weak or strong. First, the results highlight the fact that implementers can capitalize on women's group members' shared sense of identity and self-belief to

promote the adoption of improved cookstoves. Second, by targeting women's groups, implementers are also able to draw on an established social network that spreads knowledge and supports users if they have a problems with their stoves. These findings support an earlier study that found that engaging women's groups can be a powerful way to scale-up the adoption of improved cookstoves in the developing world (Hart and Smith 2013). The driver can take two states:

Weak implies that users of improved cookstoves do not exchange information or support each other. This state means that the uptake of advanced cookstoves is not boosted by the effects of the user community.

Strong means that there is a community of users that supports each other with resolving problems with improved cookstoves. In this state, the sale of cookstoves is embedded in an existing social network, such as a women's group, that can contribute to up-scaled adoption.

4.5 Peer recruitment

This driver refers to the behaviour change technique "peer effects" and to whether peers recruit each other. The driver comes in two different states: passive or active. The empirical results confirm previous research that has shown that peer relations can promote a more widespread adoption of improved cookstoves (Pine et al. 2011). Our detailed findings identify a social multiplier effect. Implementers can be successful at promoting improved cookstoves by encouraging their existing users to recruit new users from among their network of peers. The driver can take two states:

Passive means that users may recruit other users, but that improved cookstove implementers are not actively persuading or incentivizing this behaviour.

Active means that improved cookstove implementers have built a strategy around making their own users into sales agents or recruiters.

Actor-structure relationships

Drivers from work package 5 were identified from the political economy literature and cross-checked against the empirical data.

5.1 Actor leading the improved cookstoves agenda.

This driver is about which type of actor is providing most momentum for the sector. This is related to who sets the direction and goals for the sector, and could be based on their market power, importance as a source of finance or another reason. The dominant actor influences normative framing, the development of standards, the types of technologies that are supported, promotional reach and perceived legitimacy among consumers. The driver can take five states:

A clean cooking agenda dominated or led by the private sector would be likely to mean the presence of a significant number of larger-scale manufacturers, and would focus on the demographic where a financial return is most likely, presumably middle- and high-income households; develop and promote higher efficiency technologies that can be manufactured at scale; and actively target promotions to consumers. The stove manufacture could be local or international.

A government-led agenda would probably create greater legitimacy among households (e.g. through campaigns), could support broad and targeted outreach campaigns, could solicit more financial support from the sector, from both domestic revenue and international funders, and would develop a clear and supportive policy framework (standards and fiscal incentives such as tax exemptions).

An agenda led by international institutions would probably continue with a market-based approach to technology development and dissemination, but their involvement would probably also mean the continuation of smaller, project-based interventions rather than a significant scaling-up of the market, and a weak national policy framework.

An agenda led by carbon finance entrepreneurs would probably involve highly efficient stoves disseminated either with the use of subsidies or free to households, with little or no interest in creating a long-lived or expanding market; the market would consist of small ad hoc activities rather than any integrated or holistic sector. Stoves would probably not be locally manufactured.

An agenda led by local NGOs would look similar to one led by international institutions, but with less money to support the sector's expansion, and probably less lobbying power with the national government regarding the development of supportive policies.

5.2 Kenyan government role.

This driver refers to the extent to which the government, either national or county, is engaged in actively supporting, passively supporting or opposing the clean cookstove sector. This influences aspects such as legitimacy among consumers, as well as knowledge coordination and awareness raising activities, and the development of technology standards. The driver can take three states:

Active support for improved cookstoves means active development of a policy framework providing clear strategic direction and incentives to actors in the sector. For instance, if the government implements the United Nations Sustainable Energy for All agenda, where there is a strong focus on livelihoods and access to energy, we would expect strong policy support such as tax exemptions, research and development funding, and coordination of activities with and improving the knowledge base about off-grid renewables including improved cookstoves.

Passive support for improved cookstoves means the government is not working against the sector, but is not significantly involved or providing substantive support either. There are no barriers to other actors operating in or promoting the sector, but the government is not using its resources to implement awareness campaigns, support technology development or overcome bottlenecks.

Opposing the clean cookstove sector means the government has an active agenda to prevent its development. This would have the effect of preventing other actors from working with clean cookstoves, particularly international organizations.

5.3 Global Alliance for Clean Cookstoves presence.

This driver refers to whether the Global Alliance for Clean Cookstoves (GACC) carries out activities in Kenya. Its current mandate is until 2017, and it is uncertain whether it will continue beyond this date. The GACC has a strong focus on health as the basis for promoting the sector and emphasizes high-efficiency technologies. It currently funds the Clean Cookstoves Alliance of Kenya, and provides small grants for behaviour change research and technology development. This driver can take two states:

Continues beyond 2017 would probably to see the health rationale and high-efficiency stoves, along with a market-based approach to stove dissemination, continue to dominate the sector.

Withdraws from Kenya would open up more space for other actors to engage more in coordination of the sector (e.g. to fill important gaps that the GACC is expected to fill at present, even if the GACC is not necessarily doing so, such as important knowledge gaps). It might also allow a wider range of technologies to be considered relevant for the sector, in particular less advanced stoves.

5.4 Institutional and sectoral learning.

This driver refers to the accumulation of knowledge by and among different actors in the sector. This ranges from knowledge about past and ongoing efforts to promote clean cookstoves, to market and customer segments, the types of technologies available, and business models and how successfully they have been implemented. This influences the types of technologies developed, the business models adopted to promote stoves, the emergence or not of a shared agenda and thus the ability to lobby government for supportive policies and eventually to create greater scale in the market. The driver can take three states:

No sharing encourages a fragmented, ad hoc and potentially wasteful approach to technology development and the implementation of new cookstove initiatives. Initiatives find it difficult to get beyond the pilot stage, and do not build on one another.

Information sharing only means different actors make publicly available some basic knowledge about their activities, but not any detailed evaluation or analysis of impacts over time. This would be an improvement on the “no sharing” situation, by at least allowing actors in the sector a better overview of who is doing what and why.

Accumulation and sharing of knowledge means that there are high-quality evaluations of clean cookstove programmes and initiatives, enabling future efforts to build on previous lessons. This would include historical analyses of what has been done in the past. This is also likely to mean a greater sense of cooperation among different actors, and make it more likely that a shared agenda might emerge. It also provides a stronger platform for promoting government engagement, and for helping funders to identify where and how to use resources to promote the sector.

Annex B: The 19 scenario combinations in a comparative matrix

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
3.1 Financial incentives: time-limited subsidy											No subsidy	Time-limited subsidy						
3.2 Presence and trust in local partner: strong																		
3.3 Social status: seen as modern																		
3.4 User influence on design: co-designed																		
3.5 Financial autonomy of women within the household: medium	Low	Medium	High	Low	Medium	High	Medium	High	Low	Medium	High	Medium	:Low	Medium	High	Low	Medium	High
4.1 Information channels: broad	4 Information channels: targeted						4 Information channels: broad		4 Information channels: targeted			4 Information channels: broad	4 Information channels: targeted					
4.2 Payment options: instalments																		
4.3 Customer support: minimal				4 Customer support: intensive			4 Customer support: minimal		4 Customer support: intensive			4 Customer support: minimal				4 Customer support: intensive		
4.4 Strength of user community: strong																		
4.5 Peer recruitment: passive																		
5.1 Actor leading the improved cookstoves agenda: international institutions							5 Actor leading the improved cookstoves agenda: private company					5 Actor leading the improved cookstoves agenda: international institutions						
5.2 Kenyan government role: active support																		
5.3 GACC presence: continues beyond 2017							5 GACC presence: withdraws from Kenya					5 GACC presence: continues beyond 2017						
5.4 Institutional and sectoral learning: information sharing only												5 Institutional and sectoral learning: sharing						

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