

IDENTIFYING ARCHETYPES OF AN ENHANCED SYSTEM DYNAMIC CAUSAL LOOP DIAGRAM IN PURSUIT OF STRATEGIES TO IMPROVE SMALLHOLDER BEEF FARMING IN JAVA, INDONESIA

N.A. Setianto^{1,2,3}, D. Cameron¹, J.B. Gaughan¹

¹School of Agriculture and Food Science, the University of Queensland, Australia

²Faculty of Animal Science, the University of Jenderal Soedirman, Indonesia

³Email: novie.setianto@uqconnect.edu.au

ABSTRACT

More than 70% of the national beef herd of Indonesia is controlled by smallholders, who therefore play a vital role in beef cattle development programs. This paper reports on a study into disappointing results of recent government policy initiatives on practices of smallholder beef farmer groups in rural Java, Indonesia. Despite funding aimed at increasing the national beef herd and domestic beef production through enhancing smallholder productivity, perverse effects of declining reproductive rates and breeding cow numbers are being observed. Smallholder beef farming is a complex system. It involves multiple actors including farmers, farmer groups, farmer households, researchers, government officers, and traders. The interactions of these stakeholders are characterised by power asymmetry, whereby smallholders, whether as individuals or as members of groups possessing social entity, experience less power and access to privileges than other actors. For effective research aimed at system improvement, an approach capable of recognising system complexity, multiple perspectives and social power asymmetry is necessary.

In the body of systems thinking, System Dynamics (SD) is considered to be a powerful tool, as it enables the construction of rigorous models and visualisation of the causal linkages among variables which might influence the system's performance. One of the fundamental essences of SD is the identification of system archetypes: generic systems structures describing the common dynamic processes which characterise the behaviour of the system. System archetypes provide simplified insights into the system's structures. Analysing system archetypes can assist in the identification of system leverage points, i.e. the places where an intervention should have the most influence on systems behaviour.

However, when dealing with a social entity like a smallholder group, SD is considered to be a researcher-centrist methodology, as it lacks the instruments to engage multi-stakeholders' perspectives which are likely to be varied, and is insensitive to the issue of societal power structures. This paper reports on research in which these deficiencies are addressed through complementary application of Soft System Methodology (SSM), which has strength in acknowledging multiple perspectives, and emancipatory Critical System Heuristics (CSH), which can explicitly address power asymmetry, in an effort to enhance SD.

A series of interviews and workshops was undertaken to identify the problematic situation of smallholder beef farming in Java. The main research instruments of Rich Picture development, CATWOE analysis of SSM, and the 12 boundary critique questions

Identifying the Archetypes: Finding Strategies for Smallholder Beef Farming

of CSH were applied sequentially in the problem analysis stage, resulting in a four dimensional structure incorporating motivation, power control, knowledge and legitimacy. Applying SSM and CSH ensured that the perspectives of all stakeholders, including those of the less powerful, were acknowledged, thereby enriching and enhancing subsequent SD modelling.

The structured problematic situation was then used to guide investigation of variables which were thought to be contributory. The results were visualized in a conceptual model which was then translated into a causal loop diagram (CLD) consisting of 17 reinforcing and 13 balancing loops which map the feedback loops of the 4 dimensional situation of the smallholder beef system.

The CLD was then investigated to identify the system archetypes. Five archetypes were identified: *limit to growth*, *shifting the burden*, *success to successful*, *tragedy of the commons* *fixes that fail*. The nature of each archetype is described, and the implications for identification of the possible system leverage points are discussed.

Keywords: System Dynamics, Soft System Methodology, Critical System Heuristics, Smallholder, Beef Farming, System Archetypes

INTRODUCTION

Background

Smallholders play a vital role in Indonesia's beef cattle development programs (Hadi et al., 2002), because they supply more than 70% of the nation's beef production (Boediyana, 2007). This is based on intensively utilised small plots of land with high labour input relative to capital (Overton, 2007). Some policies have been implemented to improve smallholder's performance as part of the government objective to be beef self-sufficient by 2014 (Ministry of Agriculture of the Republic of Indonesia, 2011). However, in 2012 Indonesia still imported 36 kilotons of live cattle and 20 kilotons of frozen beef (DGLVS, 2012).

One of the recent programs to improve smallholders' beef production is the Graduates Support Farmers (GSF) (DGLVS, 2011a, DGLVS, 2011b) This program is specifically designed to promote cattle breeding. Each group is assisted by a university graduate in animal or veterinary science. However, study on the performance of GSF in Central Java Province showed that the program has had disappointing results. As a breeding program, GSF has a low reproduction rate and high calf mortality (Sodiq, 2011, Yuwono and Sodiq, 2010). These difficulties, combined with a significant fall in livestock values had severe financial consequences, as many of the farmer groups which received assistance through the program were disbanded as they suffered from massive decreases in asset value (Sodiq, 2011). Thus, further study was required to identify the factors contributing to the problematic situation as well as to develop strategies to improve the performance of smallholder beef farming.

Identifying the Archetypes: Finding Strategies for Smallholder Beef Farming

Studying smallholder beef farming requires a proper systemic approach because of its characteristics. Firstly, beef farming is a complex system which involves not just biophysical, but also social, ecological, political and economic elements (Snapp and Pound, 2008, Tavella et al., 2012). Furthermore, smallholders engage with a wide variety of actors whose interests are varied (Hounkonnou et al., 2012). Finally, the interactions of smallholders with other actors are typically characterized by power asymmetry because, whether as individuals or as members of groups possessing social entity, they experience less power and access to privileges than other actors (Ayithey, 2006, Hounkonnou et al., 2012). This is particularly true in Indonesia, where asymmetrical power relations are common, leadership styles are mostly top-down, and communication is indirect, averting direct negative feedback (Hofstede, 2001). Acknowledging the smallholder sector as a social system that consists of different stakeholder with a wide variety of interests is one important aspect that contributes to the success of a development strategy (Binam et al., 2011, Kaufmann, 2007). Therefore, as a complex system, smallholder beef farming needs to be studied using not only a system thinking approach but also one that recognises multi-perspectives and acknowledges power asymmetry.

System Thinking Methodology

System Dynamics (SD) is valued for its power to enable production of rigorous models and visualisation of the causal linkages among variables which might influence the system's performance (Rabbinge et al., 1994, Rodriguez-Ulloa and Paucar-Caceres, 2005, Jackson, 2001). However, its lack of instruments to engage multi-stakeholders' perspectives has made SD subject to criticism as a research-centrist methodology (Jackson, 2002, Jackson, 2003). A remedy for this deficiency exists within Soft System Dynamics Methodology (SSDM), which offers the potential to generate rigorous models with strong emphasis on acknowledging multiple perceptions and interests (Rodriguez-Ulloa and Paucar-Caceres, 2005). SSDM combines SD and Soft System Methodology (SSM) (Rodriguez-Ulloa and Paucar-Caceres, 2005).

SSM (Checkland, 1999) is regarded as being sensitive to multiple stakeholders' interests (Hardman and Paucar-Caceres, 2011). Nevertheless, it has been criticized for lacking sensitivity to power structures (Mingers, 2000, Flood, 2000). Thus, to deal with power asymmetry issues which are likely to be relevant to research into smallholder livelihoods, this study offered inclusion of the 12 Questions of Ulrich's Critical System Heuristics (CSH) Boundary Judgement approach to system definition and critique. This involves asking representative system stakeholders a series of '*is*' and '*ought*' questions designed to elicit information about how the system currently functions and how it would ideally function; each of the 12 questions enables contrasting the actual and normative situation of the system from multiple perspectives (Ulrich, 1983, Ulrich and Reynolds, 2010, Ulrich, 1988). The 12 questions relate to four basic boundary issues:

- Basis of *motivation* – Where does a sense of purposefulness and value come from?
- Basis of *power* – Who is in control of what is going on and is needed for success?
- Basis of *knowledge* – What experience and expertise support the claim?
- Basis of *legitimacy* – Where does legitimacy lie?

Identifying the Archetypes: Finding Strategies for Smallholder Beef Farming

The capacity of CSH to explore power asymmetry is that the 'is' and 'ought' mode questions, asked separately of different stakeholders, allow their differing perspectives to emerge, thereby revealing conflicting or even contradictory views and expectations with respect to the four boundary issues.

However, to develop an appropriate strategy, the problematic situation should be explored further to identify its causal relationships. This paper will discuss how to translate the conceptual model into a causal loop diagram, and identify the system archetypes as an effort to characterize the behaviour of the system (Maani and Cavana, 2007, Sterman, 2000).

METHODOLOGY

A series of interviews and workshops with 2 farmers group currently receiving GSF grants have been undertaken to identify and document the problematic situations of smallholder beef farming in Java. Three main research instruments applied in this stage were Rich Picture development and CATWOE analysis of SSM, and the two modes of the 12 boundary critique questions of CSH. Developing the rich picture and performing CATWOE analysis help the participants to portray and define the current farming situation. Further, the 12 questions of CSH assist on identifying and structuring the problematic situation by contrasting *the actual* to *the ideal* situation. Applying SSM and CSH ensured that the perspectives of all stakeholders, including those of the less powerful, were acknowledged, thereby enriching and enhancing subsequent SD modelling. As a result, the current problematic situation in a four dimensional structure incorporating motivation, power control, knowledge and legitimacy was generated (Figure 1).

Next, another set of interviews with the key persons from both farmer groups were conducted to identify variables which seems to contribute to the current problematic situation. Subsequently, the researcher developed the causal loop diagram (CLD) to describe the set of chain of causality which existed in the system (Senge, 1992, Senge, 2006, Sherwood, 2002) including its polarity to describe how those variables are related (Schaffernicht, 2006); a positive (+) or negative (-) sign near the head of the arrow show whether the variables move in the same or opposite direction (Sterman, 2000).

The feedback loops may occur either in a reinforcing (R) or balancing (B) loop type. Reinforcing loops represent growing or declining actions in the systems, while balancing are self-correcting mechanism which counteract and oppose change (Maani and Cavana, 2007, Sterman, 2000). Vensim PLE® software version 5.10e was used to translate the conceptual models into the CLD of the smallholder beef farming system.

The systems archetypes were then identified based on this CLD. Basically, systems archetypes are generic systems structures describing the common dynamic processes which characterize the behaviour of the system (Maani and Cavana, 2007, Sterman, 2000). System archetypes provide a simpler insight into systems structures. Often, analyzing system archetypes can assist to identify system leverage points (Senge, 2006);

Identifying the Archetypes: Finding Strategies for Smallholder Beef Farming

the places where an intervention should have the most influence on system behaviour (Maani and Cavana, 2007). The leverage points can be best reached by conducting open discussion with the group, after all parties are aware of and understood the implication of the intervention to the feedback structure within the embedded system (Sterman, 2000). Thus, identification of the system archetypes which exist in the system is an essential phase in pursuit of the strategy to improve the system performance.

RESULTS

The structured four dimensional problematic situation of beef farming in both groups is presented in Figure 1. It also describes sets of *drivers' variables* which seem to have causal relation to the problematic situation. These were obtained from the workshop session which then further refined with the consultation to the key persons from both farmer groups.

The Causal Loop Diagram were developed by the researcher based on these problematic situations which resulted in a total of 13 balancing and 17 reinforcing loops (Figure 2). These map the feedback loops of the 4 dimensional situation of the smallholder beef system: motivation, control, knowledge, and legitimacy. For brevity reasons, not all feedback loops are presented in this paper. Instead, the system structure existing in the CLD which reflect on the system archetypes will be discussed. Analysing system archetypes can assist in the identification of system leverage points (Senge, 2006) as a reference to generate strategies to improve the system. Nine systems archetypes are typically identified (Senge, 2006): *Balancing Process with Delay, Limits to Growth (Limits to Success); Shifting the Burden; Eroding Goals; Escalation; Success to the Successful; Tragedy of the Commons; Fixes that Fail; and Growth and Underinvestment*. Of these archetypes, five were identified: *limits to growth, shifting the burden, success to successful, tragedy of the commons and fixes that fail*.

Limit to Growth

The *limit to growth* archetype describes a process in which a period of accelerating growth is followed by a period of deceleration (Senge, 2006). Two problematic situations were identified to have this archetype: feed availability and number of sales.

Feed Availability

As mandated by the GSF program, the grant should be proportionally allocated for breeding purposes. More cows allocated for breeding purposes should mean more newborn calves are produced, thus increasing the cattle population.

Identifying the Archetypes: Finding Strategies for Smallholder Beef Farming

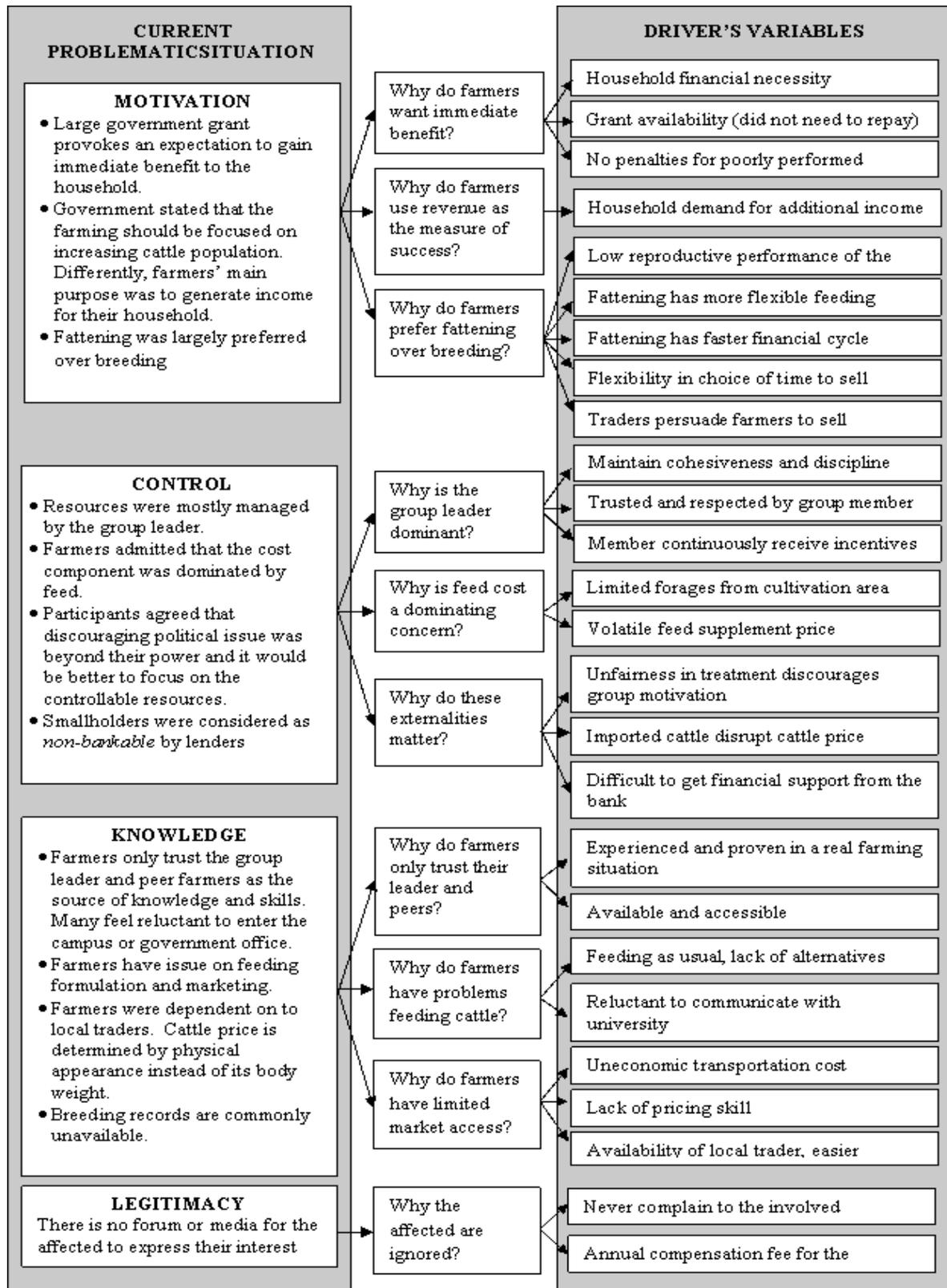


Figure 1. Stakeholders' Perspectives of the Problematic Situation of the Smallholder Beef Farming Generated From Workshop and Interview

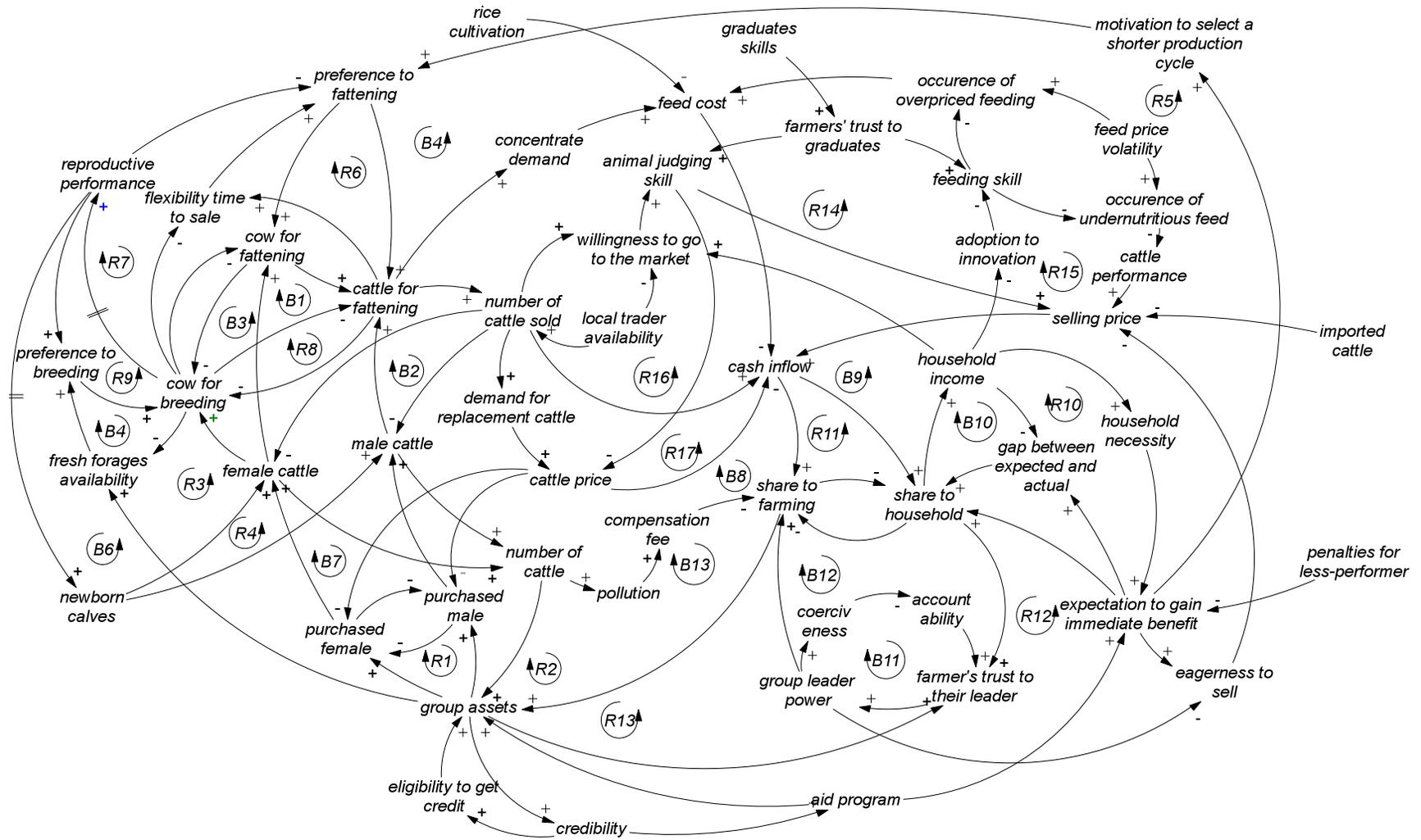


Figure 2. Causal Loop Diagram of the Smallholder Beef Farming System

Increased cattle population provides opportunities for farmers to allocate more cows to breeding purposes, and the loop repeats as a reinforcing cycle (R loop in Figure 3). This breeding operation was intended as the engine of growth of the cattle population. However, this loop has an opposite balancing loop. As the population increases, so does their forage consumption. In a ‘cut and carry’ zero grazing situation, without any supporting intervention to increase feed availability, breeding success will be jeopardized.

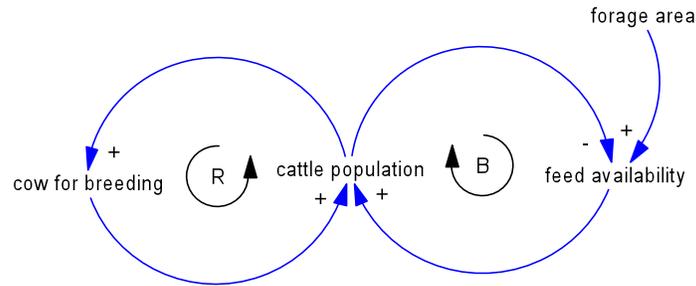


Figure 3. Feed Availability Limit to Growth Archetype

The key leverage point to this archetype is to find an intervention which relaxes or removes the constraint (Maani and Cavana, 2007). Therefore, strategies to increase the availability of feed become one alternative issue to be discussed with the farmers. Currently, both groups have insufficient forage area. Allocating more land for forage is not a solution due to the limited land ownership per person. Some alternative strategies are as follows.

1. Planting high quality grass in the near-by forest margin and river banks. However, conflict of interest with other non-member farmer should be considered.
2. Applying feed preservation technologies such as ammonisation and silage to overcome the forage shortage during dry season.
3. Compost for feeding. Compost can be used as an exchange either for rice bran, other agricultural side product with other farmers or even sold to buy feed.
4. Group leader might start to educate farmers that at some point the group need to allocate profit to purchase feed.

Number of Sales

As previously mentioned, breeding produces calves which increases the cattle population. This reinforcing loop is the engine of cattle population growth. However, it has a balancing loop which limits growth: the number of cattle sold. Increased cattle numbers will provoke farmers to sell more cattle. This eagerness to sell will also be exacerbated by household necessity, with the unintended outcome of a reduced cattle population.

Identifying the Archetypes: Finding Strategies for Smallholder Beef Farming

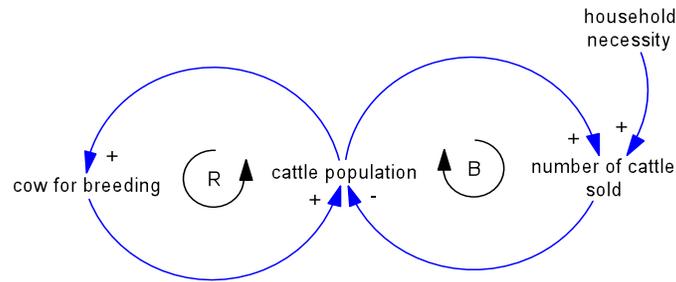


Figure 4. Number of Sales Limit to Growth Archetype

As the key leverage points of this archetype is to remove or reduce the constraints that limit the growth (Maani and Cavana, 2007), the strategy focus could be on imposing limits to the number of cattle sold, or reducing the household necessity on beef farming income, or on both. The proposed strategy for this situation is to establish a group sales mechanism. Each transaction should be approved by the group leader who should have the authority to wisely allocate the cash so that households receive cash inflow, and while also ensuring sufficient remaining cash to purchase replacement cattle.

Experience from the disbanded group showed that once farmers received cash from sale of cattle provided through the government program, it would be very difficult to persuade them to allocate an appropriate portion to purchasing replacements.

Shifting the Burden

The *shifting the burden* archetype represents a situation where people tend to apply an easy fix, rather than a more fundamental solution. Unfortunately, the easy fix has only temporary benefits, but results in altering the symptoms and leaving the real problem untouched and even worsening. Often, the easy fix has side effects which exacerbate the real problem (Senge, 2006). Three *shifting the burden* archetypes were identified within the CLD of beef farming system: demand for income, need to improve cattle population, and pollution problem.

Demand for Income

There is a tendency for people to fulfil their basic needs using the most convenient alternative (Giller et al., 2009). Thus, as perceived household necessity increased with available farm cash inflow, farmers tended to allocate a disproportionate share to their household expenses. This allocation was determined by their household demand, rather than in proportion to the benefit or loss from the sales. This brought consequences of decreasing the share of income allocated back to farm inputs.

Identifying the Archetypes: Finding Strategies for Smallholder Beef Farming

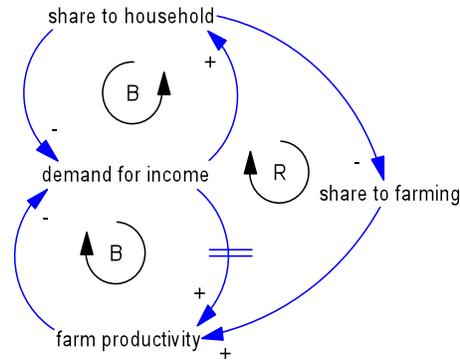


Figure 5. Demand for Income Shifting the Burden Archetype

A more long-lasting and effective solution could be created by improving farming productivity to generate income. However, this would take time to take effect, and would be made more difficult to accomplish once the pattern of increased income allocation to household expenses was established. To achieve leverage of this archetype, the fundamental loop should be strengthened, and the ‘easy fix’ loop weakened (Senge, 2006). The group leader, as the manager of the group farming system, plays a crucial role in sharing a long term vision for farming activities and also in upholding disciplined allocation of cash sharing between household and farm.

A group sales mechanism as proposed in the previous section could be one alternative strategy to strengthen the share of income allocated to farming, which should reinforce the farm productivity. Additionally, to weaken the demand for income from beef farming activity, more income generating activities should be encouraged. Beside the main activity in rice cultivation, almost 30% of the participating farmers mixed beef farming with a fishery enterprise, and many of these were less reliant on beef farming income, and able to set a reasonable earning target from beef at \$0.75 – \$1 per cattle per day. In the contrary, most farmers without fisheries typically did not have earning target. They will maximize most of the earning from beef for their household.

Need to Increase Cattle Population

One of the main concerns of the government when implementing the GMF program was to increase the cattle population (DGLS, 2010). Figure 6 represents the *shifting the burden* archetype related to the issue of increasing the cattle population. The GMF program was able to rapidly increase cattle population because membership of this scheme required farmers to purchase cows, thereby treating the symptom rather than the cause. The more fundamental solution would be aimed at strengthening breeding performance. However, this strategy would require long and continuous support to take effect. Moreover, discussion with the farmers and group leaders indicated that large amounts of cash inflow to the farmer group from the government program, unaccompanied by any obligation to repay, provoked farmers’ expectation to gain immediate benefit from the program.

Identifying the Archetypes: Finding Strategies for Smallholder Beef Farming

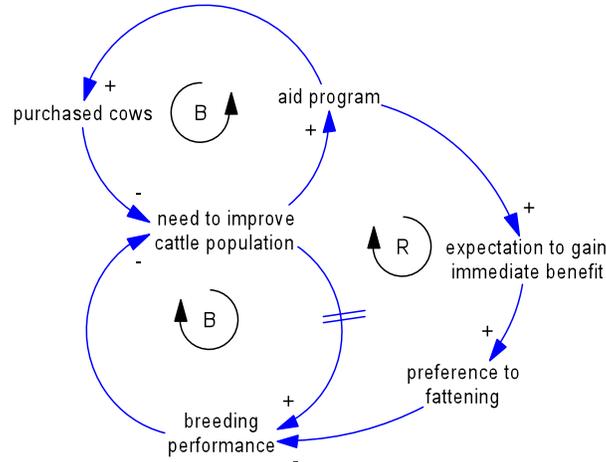


Figure 6. Need to Improve Cattle Population Shifting the Burden Archetype

Although the program focus was on breeding, the absence of penalties for groups which shifted into fattening purposes encouraged others to neglect breeding and change into the more lucrative fattening option. This situation further suppressed breeding success.

The leverage of this archetype should be focused on strengthening breeding performance and reducing dependency on the aid program to purchase cows. This should be complemented by a formal discipline that sanctions the aid-recipient farmer group from departing from the aim of the program. However, this requires government intervention.

At the farmer group level, with the decreasing motivation for breeding, improving breeding performance is rather challenging. A strategy to reduce dependency on the aid program is more feasible. Currently, the state bank is offering agricultural credit scheme with subsidized rate. This can be used as an alternative of funding to purchase cows.

Pollution Problem

As the number of cattle increased, so did their waste production, creating a potential source of conflict with the households living close to the cattle housing. To minimize the conflict, these households received a compensation fee on a yearly basis. However, as the cattle population increases, the potential for conflict will also increase, and this fee may need to be increased, with flow-on effects on reducing cash available for other activities including farmer skills training, for example in waste processing. In the long term, waste processing such as composting would be more fundamental solution to the problem (Figure 7) than paying compensation. Therefore, the strategy to overcome pollution problems should focus on strengthening the management of waste and allocate resources to improve waste processing skill. Composting is an applicable strategy on waste management. Compost has a higher price than raw cattle waste thus has potency to increase the cash inflow.

Identifying the Archetypes: Finding Strategies for Smallholder Beef Farming

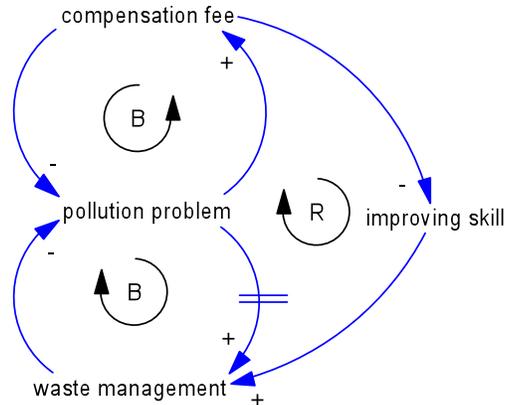


Figure 7. Pollution Problem Shifting the Burden Archetype

Success to Successful

The *success to successful* archetype represents a situation when two activities compete for scarce resources. One activity has relatively greater success than the other, and consequently gains more support, while the poorer performer receives less support (Senge, 2006). Figure 8 depicts the identified *success of successful* archetype related to farmers' preference for fattening rather than breeding.

Based on its main purpose, smallholder beef farming has been categorized into either breeding or fattening purposes (Hadi et al., 2002). In reality, breeding and fattening are conducted at the same time, competing for the same resources. A farmer's preference to operate fattening or breeding reflects the *success to successful* archetype. The previous bitter experience of heavy financial loss from the breeding performance (Sodiq, 2011) discourages farmers from sustaining breeding activities, whereas fattening is able to provide rapid cash inflow to the group, as well as to the farmer. Thus, farmers increasingly prefer fattening instead of breeding. Consequently, more resources are allocated to fattening purposes and fewer to breeding, resulting in more cash generated from fattening, and fewer calves produced from breeding. If this archetype continues, the breeding will cease as all farmers shift into fattening.

The problem with this situation was the likelihood of overestimating the success of the fattening. Occasionally, farmers misjudged cash inflow to their household as an indicator of success. The recommended strategy to overcome the *success to the successful* archetype is to balance the achievement of both choices (Senge, 2006). In this case, farmers should balance the allocation of resources between breeding and fattening. The group leader plays a vital role in reminding farmers that if they focus only on fattening, they will become dependent on cattle traders and fully exposed to the volatility of cattle price movements.

Identifying the Archetypes: Finding Strategies for Smallholder Beef Farming

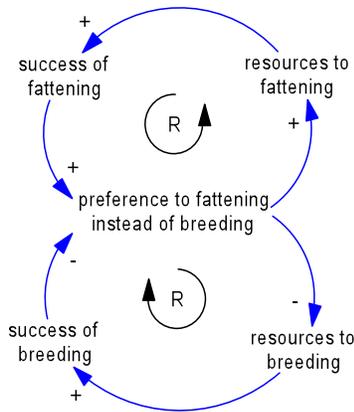


Figure 8. Preference to Fattening Success to Successful Archetype

Tragedy of the Commons

The *tragedy of the commons* archetype expresses a situation when a common desirable individual activity could lead into undesirable destructive consequences over time (Maani and Cavana, 2007). This situation occurs as individuals started to exploit a limited resource. The net gain which is initially earned will diminish over time as resources become over exploited (Senge, 2006). Figure 11 describes the tragedy of the commons situation which occurs in the smallholder beef farming system when more farmers prefer fattening rather than breeding.

A shorter production cycle, flexibility of time to sell and poor reproductive performance provokes farmers to allocate some of their breeding cows into fattening purposes. Thus, farmers sell both male and female cattle, thereby earning greater cash inflow which further prompts them to allocate more of their cows for fattening purposes. Initially, farmers benefit from this cycle. However, this net benefit diminishes over time as more and more cows are sold and fewer remain for breeding. This leads to production of fewer calves which can be used as replacement stock, and consequent increased demand for replacement cattle. After several breeding cycles, increasing demand for replacement cattle without any internal additional supply of calves will increase the cattle price. This cycle will end when all cows are converted into fattening purposes, breeding ceases and farmers must depend entirely on traders to supply their replacement stock.

The recommended strategy for this archetype is to educate everyone involved in the current practices as well as creating a participants-designed peer pressure mechanism (Senge, 2006). In this case, the group leader, especially in group meetings, can play a vital role in reminding farmers if the need to balance the breeding and fattening activities and of the long term consequences of over reliance on fattening. A group sales mechanism as proposed earlier could provide a robust instrument to control this shift from breeding to fattening.

Identifying the Archetypes: Finding Strategies for Smallholder Beef Farming

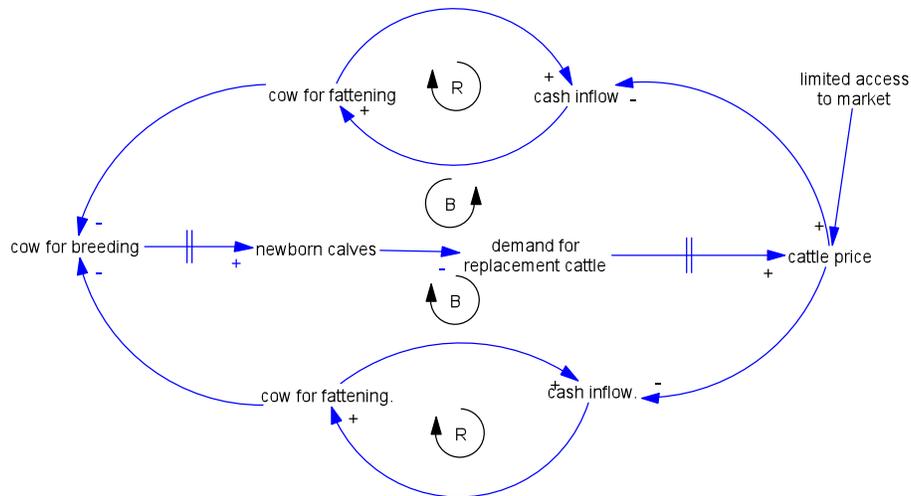


Figure 9. Tragedy of the Commons Archetype

Fixes that Fail

Fixes that fail archetype describes an intervention which seems to be effective, but in the long term, has unforeseen consequences which may require even more interventions (Senge, 2006). The GSF program was designed to increase cattle population as well as farmers' welfare. The grant was allocated to buy male cattle for fattening and female cattle for breeding purposes. Both were designed to increase the cattle population and generate higher cash inflow for the farmers, enabling them to buy more cattle and supplement their farming income, thereby becoming less dependent on aid programs (as shown by B loop in Figure 10).

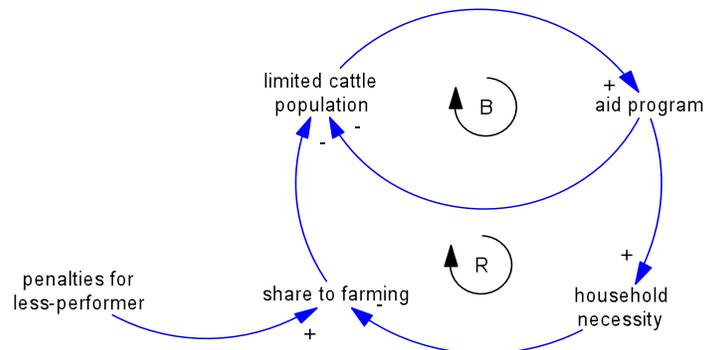


Figure 10. Fixes that Fail Archetype

However, the suddenly increased cash inflow had the unintended result of provoking perceptions of higher household necessity by farmers (Nelson and Consoli, 2010). In order to meet their new perceptions of higher personal and family needs, farmers can easily be dissuaded from fully adopting the assistance program (Giller et al., 2009), in order to allocating a higher share of income to the household rather than to farming

Identifying the Archetypes: Finding Strategies for Smallholder Beef Farming

activities. The absence of penalties for other poorly-performed government-sponsored groups further provokes farmers to reduce the share of income allocated to farming. Consequently, farmers' power to buy more cattle is decreased, and their dependency on the aid program to sustain their farming activity increases (as highlighted in R loop, Figure 10).

The implication of this situation is that although the aid program has been able to improve farmers' total household cash inflow, without learning or having imposed strict discipline to proportionally allocate any inflow back to farming, dependence on further aid program assistance will be unavoidable.

The leverage point of this archetype is to focus on the long term. The "quick fix" should only be applied to "buy time" when the fundamental solution is in progress (Senge, 2006). Buying cattle from the aid program is not a fundamental solution to improve the cattle population. Combination of strategies mentioned previously offer the best potential to help farmers to focus on the long term.

CONCLUSION

The Causal Loop Diagram (CLD) which was developed from the combination of SSM and CSH in the problem structuring stage is able to portray the smallholder beef farming system in a four dimensional structure incorporating motivation, control, knowledge and legitimacy. Accordingly, the CLD was able to better-represents the actual situation than methods offered by any of the individual approaches used alone.

Although, this four dimensional structure increase the complexity of the diagram, SD provides an instrument called system archetype which can be used to help understand the behaviour of the system in a simpler, more accessible way. Moreover, system archetypes often provide guidance to developing effective improvement strategies.

Five systems archetypes were identified: *limit to growth*, *shifting the burden*, *success to successful*, *tragedy of the commons*, and *fixes that fail*. Each archetype requires different management intervention which can be used as proposed strategy to be further discussed with the stakeholders. It is argued that the group leader plays a vital role in the success of the group. However, the proposed strategies should be simulated in the model.

The CLD and the systems archetypes are two basic inputs to develop a dynamic modelling of the system in which the intervention can be simulated. Despite its strength to accommodate multi dimensional aspects, the combination of the methods increases the complexity of the methodology. However, the increased sophistication of the model developed facilitates production of more effective strategy solutions.

Identifying the Archetypes: Finding Strategies for Smallholder Beef Farming

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Identifying the Archetypes: Finding Strategies for Smallholder Beef Farming

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