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Using Causal Loop Diagram as a Qualitative Instrument to Model Smallholders: A Case Study of Goat Farming in Gumelar - Banyumas

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Abstract

Improving smallholder performance remains a seemingly intractable central issue for livestock development in Indonesia. In terms of productivity, smallholder tends to have poor performance. Studying a complex system such as smallholder goat farming requires a systems thinking approach. The objective of this article was to devise an approach that optimises the participation of farmers and other stakeholders in: (1) understanding the overall systems well enough to identify the problematic situations - the situations which participants considered as uncomfortable; (2) develop a qualitative model as the basis to formulate the most feasible strategies for mitigating the identified problematic situation. A series of interviews and workshops involving 27 goat farmer who are member of Kelompok Tani Tunas Mukti in Kecamatan Gumelar Kabupaten Banyumas have been undertaken. As a result, the rich picture was able to be developed by the participant which visualize three main activities of the farmers group; paddy farming, goat farming, and waste processing. The use of rich picture was clearly give a valuable assistance both for farmers and researcher to see how the systems works. Further, asking farmers to express the desired condition during the CATWOE analysis session was also able to encourage farmers to engage and participate in the discussion. The problem was then able to be identified by contrasting the desired to its real current condition. Results of the CATWOE analysis showed that the basic problem of the smallholder goat farming in Kelompok Tunas Mukti was the real current income of the goat farming activities was still under the farmers' expectation. From this a Causal Loop Diagram (CLD) was assembled using Vensim software developed by Ventana Systems Inc. The CLD was build based on two main variables which were the focal of the system; farmers' income and goat population. There were two types of archetypes identified within the CLD; (1) limits to growth and (2) shifting the burden. Discussion of those CLD were discussed comprehensively in the article. The use of CLD as the qualitative modelling provided depth and richness to the findings through the ability of the models to find the feedback loops and describe linkages among elements within the systems. The identified archetypes helps the researchers and farmers to find reasonable strategy to overcome the problem of limited goat farming income.

Keywords: goat farming; smallholders; causal loop diagram; strategy; qualitative modelling

1. Introduction

Improving smallholder performance remains a seemingly intractable central issue for livestock development in Indonesia. Farming at smallholder level in Indonesia is generally a sub-system of a mixed crop-livestock farming system, rather than a production system in its own. Efforts to improve smallholders may be ineffective if wider system implications are ignored (Setianto et al., 2014). In terms of productivity, smallholder tends to have poor performance (Overton, 2011). However, from the point of view of the smallholder, livestock farming, including goat farming, is not merely an economic activity, but also a "culture", a "way of life" that for most farmers extends over generations. It therefore has a multifaceted role that includes income generation, provision of social status, and contributes to household security (Snapp and Pound, 2008). Thus, improving smallholders' productivity becomes an essential step in alleviating farmers' household welfare concerns.

Studying a complex system such as smallholder goat farming requires a systems thinking approach (Maani and Cavana, 2007). The importance of this articles rests on the contribution it can make to formulating feasible strategies which holistically address the real problems of smallholder goat farming in rural area. For a strategy to be "feasible" it needs to be approved by all stakeholders involved, and be based on the resources available in the system. This can be achieved by using model simulations which are able to represent the systemic behaviour of goat farming.

In the body of systems thinking, System Dynamics (SD) is considered to be a powerful methodology for taming the complexity of a system (Rodríguez-Ulloa et al., 2011). However, SD has been criticized as being insensitive to the multiple interests and power structures likely to occur in a smallholder system (Jackson, 2002). Additionally, SD requires a set of rigour data for parameterising the model. Therefore, this article offers an instrument of the SD which is Causal Loop Diagram (CLD) as the basis to develop a qualitative modelling of a smallholder goat farming in Kecamatan Gumelar.

The objective of this article was to devise an approach that optimises the participation of farmers and other stakeholders in: (1) understanding the overall systems well enough to identify the problematic situations - the situations which participants considered as uncomfortable; (2) develop a qualitative model as the basis to formulate the most feasible strategies for mitigating the identified problematic situation.

2. Research Method

A series of interviews and workshops involving 27 goat farmer who are member of Kelompok Tani Tunas Mukti in Kecamatan Gumelar Kabupaten Banyumas have been undertaken which include the following steps: (1) system observation; (2) problem identification; (3) analysis of links and patterns of relationships among elements in the systems; (4) development of a qualitative model; and (5) investigation for several possible scenario interventions. Each stage has its own output. Expected output of the system observation is a rich picture, a hand drawing pictures describing activities and resources available in the surrounding system area. Then, a CATWOE analysis (Checkland and Poulter, 2006) was applied to identify the problem. CATWOE is the mnemonic of Customers, Actors, Transformations, Worldviews, Owners, and Environments. It was used to investigate the desired and the actual condition within the systems. The gap between the desired to its actual condition portray its potential problem. Once the problem identified, then the next step was to build the conceptual model. This conceptual model describe the potential problem and the driving variables which likely affect the problem. The structure of the conceptual model was then analysed further to investigate its pattern and linkages as a basis to be translated to a causal loop diagram as the designated qualitative model. Last stage was observing the recommended strategy based on the model leverage points.

3. Results

As a result, the rich picture was able to be developed by the participant which visualize three main activities of the farmers group; paddy farming, goat farming, and waste processing. Paddy farming was mostly cultivated in a small plot of land area using intensive labour. Tunas Mukti has a total of 215 goats from which 2 breeds were cultivated; Peranakan Etawah (PE) and Jawarandu which also has a blood line to PE. Judging from its exterior, most of the PE in Tunas Mukti were categorized as non-A grade breed which could not be recommended for breeding purposes. Although non-A grade were still have potential for dairy purposes thus generate additional income, farmers in Tunas Mukti did not milk their goat for two reasons; (1) they claimed that they did not have the necessary skills to milk their goat; and (2) the milk production was still very low, so farmer prefer to give all the milk to the pre weaned kids so that the kids could grew better and have a better selling price than kids which did not drink enough milk. Additionally Jawarandu breed were mostly raised to be sold as goat for Iedul Qurban, an annual Islamic fest where demand for goat increase significantly and lead to hit its ceiling price. The last mentioned activity which was the waste processing activity was quite interesting. Waste from goat farming was processed to compost and organic pesticide which has been applied to their paddy farming. Although still relatively small in quantity, but it has potency as the beginning of a self-reliance organic farming.

The use of rich picture was clearly give a valuable assistance both for farmers and researcher to see how the systems works. Further, asking farmers to express the desired condition during the CATWOE analysis session was also able to encourage farmers to engage and participate in the discussion (Table 1). The problem was then able to be identified by contrasting the desired to its real current condition. Results of the CATWOE analysis showed that the basic problem of the smallholder goat farming in Kelompok Tunas Mukti was the real current income of the goat farming activities was still under the farmers' expectation. Farmers desired to have multiple income from their goat farming; daily income from milk selling, quarter-year income from selling weaned kids or young goat, and annual income from selling male as qurban goat. According to discussion during workshop, the problem was driven by the limited number of lactating goats, limited farmers milking skill, limited farmers' skill on feeding, and limited farmers' capital. From this a Causal Loop Diagram (CLD) was assembled using Vensim software developed by Ventana Systems Inc.

Table 1. CATWOE Analysis

Description	Expectation	Actual Condition
Who are the system beneficiaries? (C)	Household, farmers group, farmers, local community	Household, but partially limited
Who transforms inputs to outputs? (A)	Farmers	Farmers
What transformations exist? (T)	Produce milk, kid, compost, and goat for Iedul Qurban	Kids, and limited number of goat for Iedul Qurban
What is the reason for this transformation? (W)	Alleviating household welfare, provide education fund up to university level	Additional income, few farmers able to support schooling
Who can stop or change this transformation? (O)	Farmers, Farmers' group head	Farmers, Farmers' group head
What constraints are there in the immediate surroundings of this transformation? (E)	Nil	Limited forages, skills and capital

Gaps between expected and actual condition indicate the problematic situation which likely exist in Tunas Mukti Farmers group. The CATWOE analysis provide an indication that the first problem of goat farming in the limited benefit earned from the farming activity which remain unable to support significant additional income for the household. This was due to the limited number of lactating goat and limited farmers milking skill. Also, forage availability particularly during dry season, and limited capital constrain farmers to increase their goat population. Next step which need to be addressed was determining what intervention was considered to be the leverage points to overcome the problematic situation.

Further analysis using Causal Loop Diagram (CLD) as a qualitative modelling was required to determine the leverage points. The CLD (Figure 1) was developed based on discussion with participants.

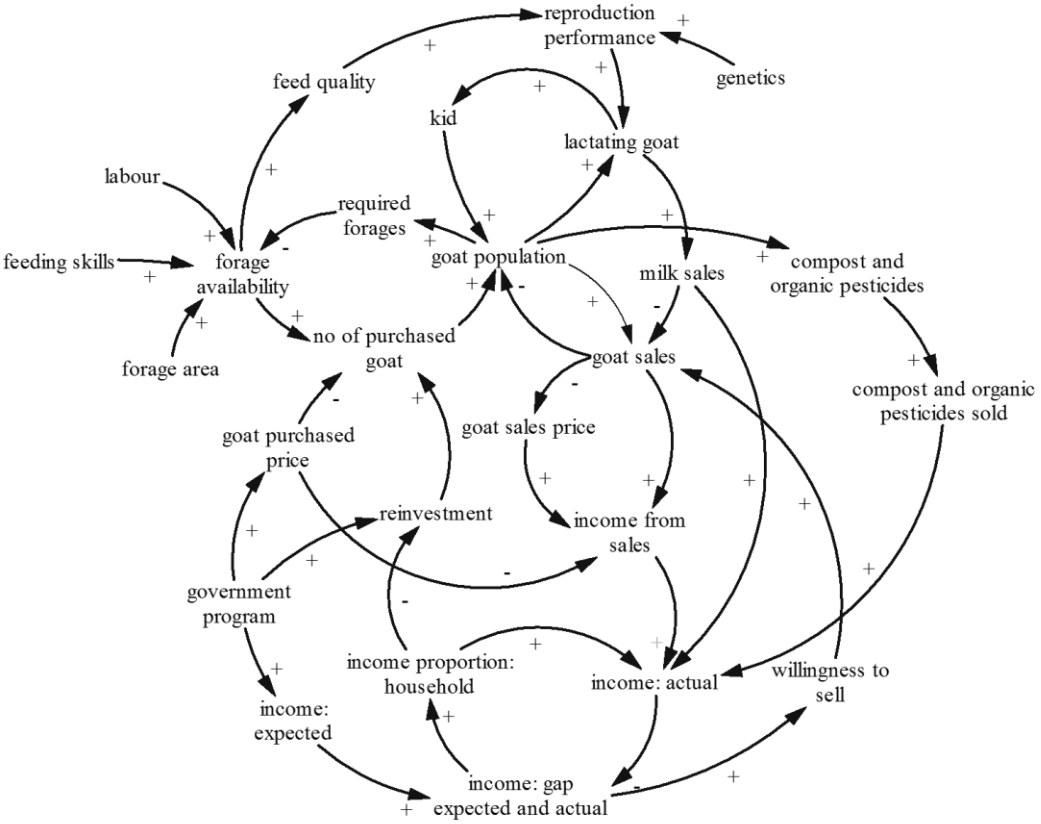

Fig 1. Causal Loop Diagram

The CLD was build based on two main variables which were the focal of the system; farmers' income and goat population. Once the CLD has been fully developed, then the loops could be identified. Figure 1 showed a total of 8 loops were identified to have linkages to farmers' income and another 11 loops to have effect on goat population. Examining each of those 19 loops would be both complicating and time consuming, therefore an identification of systems archetypes was preferable. Systems archetypes reveal common pattern of the CLD which defined the systems' behaviour.

There were three types of archetypes identified within the CLD; (1) limits to growth, (2) shifting the burden, and (3) fixes that fails. Limits to growth explains a phenomena where an accelerating growth begins to slow and might ended up to a halt. The growth is caused by the reinforcing feedback loops, whereas the slow is caused by a balancing loops which limit the growth. The leverage points of this archetype should not be focused on pushing the reinforcing loop, but on weakening the limiting factors. The shifting the burden archetype describes a situation where a short term intervention strategy seems to have an immediate positive result. As more of this instant corrective actions are implemented, more fundamental strategy became more and more neglected. In a long run, the capability of the fundamental strategy became less and less powerful and worsen the fundamental situation. Moreover, the 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).

3.1. Limits to growth

A total of two limits to growth archetypes were identified. First, the growth of goat population was reinforced with the breeding activity (Fig. 2). However, this reinforcing loop was constrained by the number of sales which triggered by the household necessity to earn income. As the key leverage points of this archetype are to remove or reduce the constraints that limit the growth (Maani & Cavana 2007), the strategy focus could be on imposing limits to the number of goat sold, or reducing the expected income, or on both. The recommended strategy for this situation was to set the sales quota so that the household income is secured, but the growth is also maintained. For this, further analysis is required to determine in which level the quota should be defined.

However, as shown by the CLD in Fig 1, reducing the number of goat sold will lead to decreased farmers' actual income, increase the desired sales rate and encourage farmer to sell more goat. The proposed strategy for this situation is to provide education about herd replacement strategies. This includes improving farmers' awareness that with the current practices their farming will not be sustainable. Within their groups farmers need to be assisted to develop processes whereby they wisely allocate the sales cash revenue so that households receive cash inflow, and while also ensuring sufficient remaining cash to purchase replacement goat. This strategy is proposed to maintain the desired sales rate in a sustainable level.

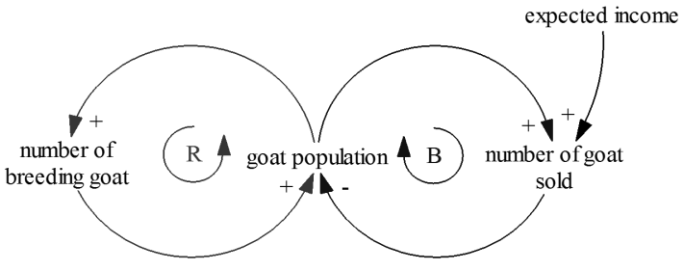

Fig. 2. limits to growth archetype: number of goat sold

Second, the growth of goat population was limited by the availability of forages (Fig 3). The key leverage point to this archetype is to find an intervention which relaxes or removes the constraint (Maani & Cavana 2007). Leverage points of this archetypes sits on effort to increase forage availability. Therefore, strategies to increase the availability of feed become one alternative issue to be discussed with the farmers.

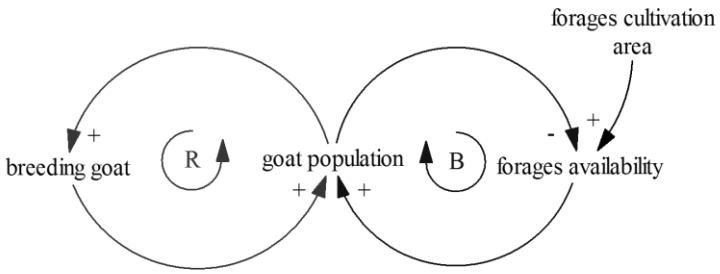

Fig. 3. limits to growth archetype: forages availability

Currently, both groups have insufficient forage area. Planting more forage is not a solution due to the limited land ownership per person. Some alternatives solutions include increasing fodder availability which could be done by growing high quality grass in the forest margins and river banks in the surrounding area, adopting feed preservation technologies particularly during the dry season to overcome the forage shortage, promoting compost processing from which additional income could be generated to buy quality feed, and ensuring farmers to allocate certain portion of their profit to buy feed rather than to private expenses.

3.2. Shifting the burden

Further, a shifting the burden archetype was identified on income loops. People tend to satisfy their basic needs using the most practical option (Giller et al., 2011). Increased farm cash inflow would be followed by increased household necessity which made farmers to disproportionately allocate profit to their household expenses. This decision was mostly determined by their household demand, rather than in proportion to the benefit or loss from the sales. Subsequently, decrease the share of income allocated back to farm inputs.

Figure 4 described the gap between expected and actual income represent the demand for income. As target income increases due to the household necessity, farmers tend to add proportion of income allocated to their household. In short term more allocation of profit that flow to household would close the gap of the target income. However, this brought a consequences of less earning was allocated to reinvestment. Reinvestment required to maintain farm productivity. If the instant solution remains, less and less reinvestment would take place. The leverage points of this archetypes should focus on how to improve farming productivity. The easy fix to address this gap was by allocating a greater share of group income for farmer members; thereby closing the gap. However, this easy fix came with the negative consequences of reduced income share retained by the group, with associated impact on reducing goat productivity.

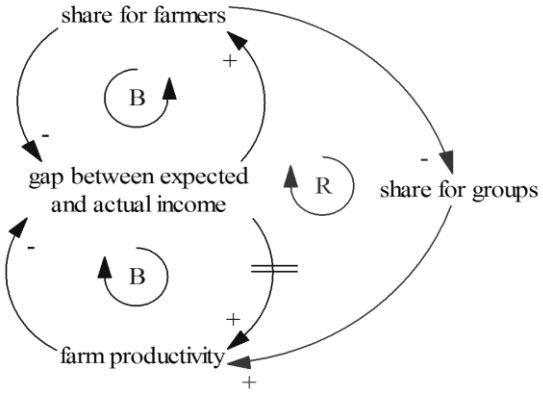

Fig. 4. shifting the burden archetype: demand for income

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.

CLD in Figure 1 showed that allocation of farmers share could be lowered by increasing farmers' income. Study revealed that there are two unfavorable common practices. First, overpriced purchasing as many farmers tend to prefer physical appearance such as coat colour or shape of horns which mostly expose to subjectivity, rather than body weight. Thus, introducing a fair trade based on body weight could be proposed as one intervention strategy. Second, farmers tend to be easily persuaded to sale their goat under the market value once they "feel" the cash in their hand. This practice could be reduced by encouraging farmers to use mobile banking which commonly available in the livestock market. Another intervention which could be proposed is helping farmers to rationally allocate their resources and set a reasonable proportion of earning both for their farming reinvestment and household expenses.

3.3. *Fixes that fails*

Figure 5 describe the fixes that fails archetype. The B loop in figure 5 showed how the government program would be able to address the need to increase goat population. The program was originally designed to purchase

more goat, thus increase goat population. Further, more population enable farmers to earn more income which should made farmers to be less dependent on aid programs (as shown Fig 1).

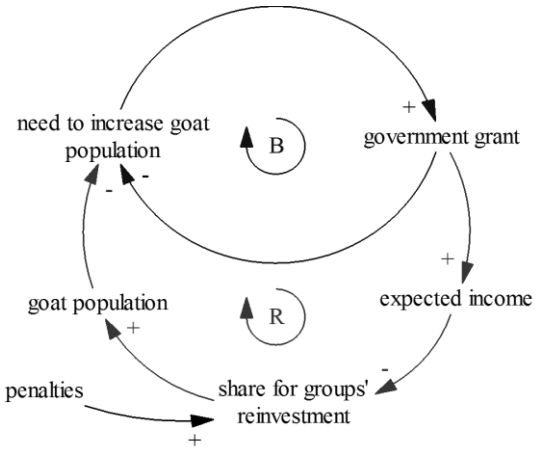

Fig. 5. fixes that fails archetype: government program

However, it had unintended consequences. Sudden increased of cash inflow provoking perceptions of higher household necessity by farmers (Nelson and Consoli, 2010). With more cash available, more ways of spending it on household needs and wants quickly emerged. Accordingly, farmers suddenly developed an expectation of meeting needs with additional income. Based on a previous study by Giller et al. (2009), there was a tendency for farmers to use the grant to their personal expenses rather than fully adopt the program that initially designed to improve their farming. This was exacerbated with the absence of penalties for poorly-performed government-sponsored groups. As a result, this practice would decrease farmers' power to buy more goat, and consequently increase their dependency on the aid program to sustain their farming activity.

Conclusions

The use of CLD as the qualitative modelling provided depth and richness to the findings through the ability of the models to find the feedback loops and describe linkages among elements within the systems. The identified archetypes helps the researchers and farmers to find reasonable strategy to overcome the problem of limited goat farming income. The strategy to improve goat farming in Tunas Mukti should not be based on increasing the population, but should be focused on allocating goat for dairy and slaughter purposes, and strengthening the waste processing to produce organic pesticide and compost, and application of feed preservation technology. The CLD showed that four potential source of farmers income were available; milk sales, goat sales, organic pesticides and compost, and product of organic farming.

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