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Article

The System Dynamics of Forest Cover in the Developing World: Researcher *Versus* Community Perspectives

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Abstract: Efforts to increase forest cover in the developing world will only succeed if the root causes of deforestation are addressed. Researchers designing reforestation initiatives tend to emphasize macro-level drivers of deforestation, about which they have extensive data and knowledge. On the other hand, local people have contextually based knowledge of forest cover dynamics in their region—about which external researchers may be largely ignorant. This type of perception gap between researchers and community members has led to many failed or insufficiently implemented projects. An emerging tool—group model-building with system dynamics—shows promise in its ability to integrate different perspectives on a complex problem such as forest cover loss. In this study, I use system dynamics modeling methodology to compare causal loop diagrams of forest cover dynamics on Negros Island, Philippines generated by researchers working for the World Wildlife Fund with causal loop diagrams generated by community members in upland Negros. The diagrams were significantly different, with very few variables in common, but both illuminate critical aspects of the deforestation problem on the island. I conclude that reforestation initiatives in the Philippines would benefit from incorporating all relevant information into a single, coherent model.

Keywords: deforestation; development; group model-building; reforestation; Philippines

1. Introduction

Global efforts to promote reforestation in the developing world are gaining prominence, due to increasing concern about the ecological and economic impacts of deforested landscapes, as well as interest in carbon sequestration as a tool to combat climate change [1,2]. The success of reforestation initiatives will require an understanding of the most appropriate scale of governance at which reforestation initiatives should be implemented—whether local, regional, national, international, or all of these. Recently, local and community-based reforestation initiatives have become popular with funding agencies and development organizations [3,4]. However, the literature also suggests a wide array of macro-level causes of deforestation, such as global trade regimes, poverty, population dynamics, and agricultural expansion [5-7]. Clearly, if these large-scale causes are not addressed, local attempts at reforestation will be overwhelmed by a broader trend towards deforestation. Deforestation and reforestation may therefore be seen as alternate states of the same variable, forest cover [8]. Some researchers have attempted to synthesize the different scales at which reforestation and deforestation operate, but few have delved into the *dynamic* interactions among scales and drivers [9,10]. Obviously, the particular driving forces that affect forest cover are highly dependent on the geographical location and scale of the study area [6].

In the Philippines, community-based reforestation projects have been attempted for several decades, with mixed success [4,11,12]. Meanwhile, deforestation in the Philippines—including inside of protected areas—remains a concern [13]. The current Macapagal-Arroyo administration (which will leave office after general elections in May 2010) has articulated a goal of re-foresting 1 million hectares of the country [14].

Fujisaka [15] posits several reasons why farmers in mountainous areas (where deforestation is the most problematic) may fail to adopt practices such as agroforestry, or leaving a portion of their land in forest. Farmer decisions about what to do on their land, and whether to plant trees, are a critical component of reforestation. However, these decisions and the reasons behind them are often explored only *after* a project has failed or been incompletely implemented. The reasons for project failure outlined by Fujisaka include: projects that address problems farmers don't actually face; introduced projects that are inferior to what farmers are already doing; projects that don't work or are too costly for farmers to continue on their own; and projects that ignore social/cultural factors. Cultural dynamics were at play in the case of a failed forest conservation initiative on Palawan, Philippines, when interventions proposed by a non-governmental organization (NGO) clashed with local traditional livelihoods [16].

These examples imply that understanding how farmers and rural communities think about land use decisions and tree planting early in the design stages of a reforestation project is critical to the goal of increasing forest cover. This is particularly the case in the Philippines, where enthusiasm for community-led forest management projects has remained high, despite these projects' mixed success [17]. However, despite widespread support for "participatory" development projects, it is still rare for NGO's, government programs, or development researchers to consult with community members and farmers around project design [18,19]. More commonly, communities are consulted about implementation and methods only after the goals and approaches have been identified by the external interveners.

In addition to local dynamics, declining Philippine forest cover is also clearly driven by macro-scale dynamics, including high rural population growth, poverty, international prices of forest products and agricultural commodities, and government policy on land tenure [6,12,17]. Researchers and development workers coming from outside the community context may have a superior knowledge of these macro-scale trends compared with local people. In fact, a common criticism of participatory approaches to community-led development projects in general is that communities may fail to perceive dynamics that occur at large scales, but which affect local conditions [20].

I am proposing that a system dynamics model which incorporates both community perspectives on local dynamics and researcher perspectives on macro-dynamics be a key part of the design phase for a project designed to increase forest cover in the tropical developing world. The complex and dynamic behavior of forest cover suggests that a modeling exercise may be ideal for revealing important and unexpected insights for decision makers [21,22]. Furthermore, the need for reforestation initiatives to take into account both local context, scientific knowledge, and economic dynamics suggest that a group model-building exercise involving both researchers and community representatives could be beneficial [21,23].

Group model-building has been used in a wide variety of resource management contexts, including water systems and wildlife management [24,25]. Although it can be costly and time-consuming, the process of building a system dynamics model with a group of participants allows for social learning among stakeholders, as they share opinions, information, and perspectives on a given problem [23]. Group model building also can provide a space for stakeholders to reach consensus on difficult or contentious issues. By bringing together participants with different types of knowledge, a group model-building process can take advantage of the maximum potential range of qualitative and quantitative information relevant to the problem being addressed [21]. Finally, comparative studies have demonstrated that problem solving teams who use group system dynamics modeling generate more structured discussions and a more complete critical analysis than groups using more traditional facilitation methods [26]. For all of these reasons, group model-building may be an appropriate tool for designing reforestation initiatives in the Philippines.

My goal for this study was to determine if an analysis of deforestation's causes and options for reforestation in the Philippines could benefit from a group system dynamics model building approach. If the researcher-generated and community-generated local models of forest cover decline are significantly different, insight into the problem of decreasing forest cover may be gained by bringing researchers and local community members together to learn from one another in a model-building exercise [21]. Identifying and modeling the causes of forest cover decrease is a critical first step in halting deforestation and promoting regrowth of deforested areas.

The study objective was therefore to compare an "expert", or researcher, view of the causes of deforestation and potential for reforestation in the Philippines with a local or community view. Specific questions to be answered include: (1) Are there significant differences between the researcher view and the community view of the causes of a decrease in forest cover? (2) Do both researchers and community participants identify causes of forest cover decrease operating at multiple spatial scales? (3) Do researchers and community members identify different "leverage points" where policies or incentives might be used to generate an increase in forest cover?

2. Methods

In this study, I compare a researcher-generated causal loop diagram of forest cover dynamics on an island in the central Philippines with a community-generated causal loop diagram of forest cover dynamics, to determine if there are significant differences between these two groups' views of the issue. For this study, I am taking the view that the variable of interest is "forest cover", which may decline (through deforestation) or increase (through reforestation) over time [8].

Negros island, located in the central Philippines, has historically been a region of high terrestrial and coastal biodiversity [27]. However, the island's landscape, which was predominantly tropical seasonal forest as recently as the 1950s, has been changed dramatically through deforestation and intensive agriculture, with adverse consequences for the island's biodiversity, water quality and forest resources. By some estimates, 95% of the island's original forest cover has been removed [28]. The Philippine government has identified reforestation of the country's mountainous regions as a development priority [14]. Local non-governmental organizations working in the uplands of Negros are also promoting reforestation projects for controlling erosion and protecting water supply.

Three prominent socio-economic patterns characterize Negros Island: a distribution of agricultural lands that disadvantages the poor; a high rural poverty rate; and a high population density [8,29,30]. Negros served as a center of Philippine sugar production beginning in the mid-1800's, during which time land-grabbing by Spanish nobility was sanctioned by the colonial government for the purpose of building the country's sugar export industry. Many large-scale landowners on Negros today are the descendents of these Spanish nobles, leaving the island's poorer residents to practice marginal subsistence farming in steep mountainous areas [31]. Negros also has a higher incidence of families living in poverty at 22%, compared with the national poverty incidence of 17% [30].

The World Wildlife Fund published a study of Negros Island's deforested condition and a causal loop diagram of the deforestation problem in 2000 [8]. I used this diagram as a benchmark to compare and contrast this researcher view with a community-based view of deforestation. The WWF research team conducted sectoral studies of Philippine biodiversity, demography, economy, and politics, and generated several causal loop diagrams specific to key points of concern for the organization (Figure 1). Accompanying text detailed the reasoning behind each diagram. The WWF's goal was to identify the root causes of biodiversity loss in the Philippines, and forest cover was used as a proxy for biodiversity, given limited data availability on indigenous species.

To generate a causal loop diagram reflecting a local community's view on the causes of deforestation on Negros, I traveled to the municipality of Canla-on, near one of the island's remaining forest reserves and its highest peak. I attended a community workshop conducted by a local NGO, the Negros Oriental Institute for Rural Development (NIRD). The goal of this workshop was to identify risks facing the community, and to analyze the community's vulnerability to and ability to mitigate these risks. Forest cover was an integral component of community risk vulnerability and was discussed extensively; multiple inter-related causes of forest cover change were agreed upon by the workshop participants. I supplemented the workshop material with follow-up interviews with NIRD staff, who have worked in the Canla-on region for over fifteen years. The causal loop diagram constructed from the workshop and interviews is included below (Figure 2). The participants in the workshop were not aware of the researcher-generated view of forest cover loss, so the second causal loop diagram was generated completely independently.

Figure 1. Causal loop diagram depicting forest cover decline on Negros Island, generated by researchers from the World Wildlife Fund [8]. Two main positive feedback loops are embedded in the model; these are discussed in the text below.

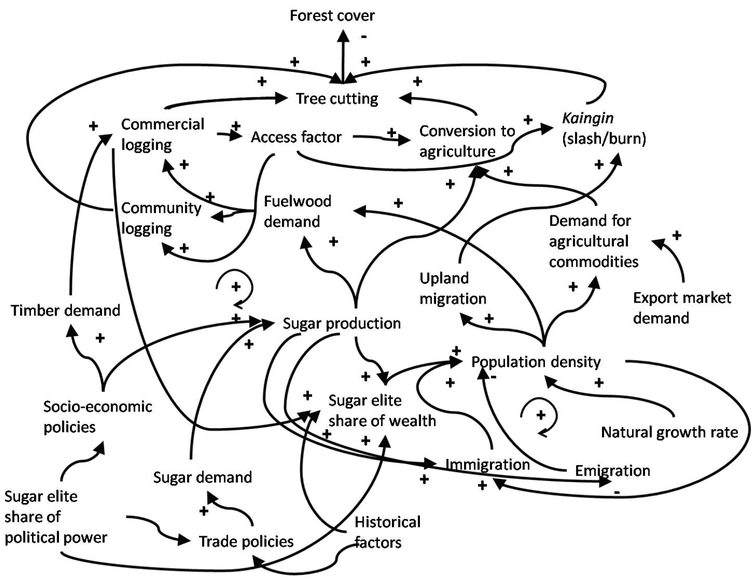
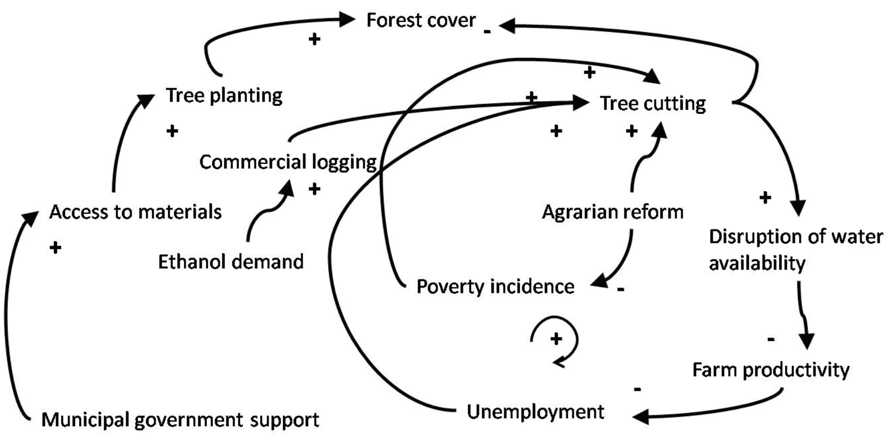


Figure 2. Causal loop diagram depicting forestcover dynamics on Negros Island, generated through workshop discussions and interviews with community members in Canla-on, Negros. The positive feedback loop in the model is labeled.



3. Results and Discussion

The researcher-generated and community-generated causal loop diagrams were substantially different, containing almost none of the same variables. One of the prominent differences was the number and nature of feedback loops in the two diagrams. The community-generated diagram contained only one positive feedback loop, in which tree cutting by farmers leads to a disruption of water availability (especially during drought), which in turn leads to lower farm productivity, which spurs farmers to cut even more trees to put more land in production. The positive feedback loops in the researcher-generated diagram pertained mainly to population and to elite capture of resources on Negros Island. According to the researchers, population density spurs immigration to Negros, as more people create more employment opportunities for those from neighboring islands (as housekeepers, farmworkers, shop owners, *etc.*). Immigration, of course, increases population density, in a classic "attractor" type of situation. Another feedback loop involves the sugar elites' share of monetary wealth, which is increased through commercial logging, which they control (according to the researchers). Sugarcane landowners' wealth increases population density, as the landowners hire more workers for the sugarcane fields. Population density increases demand for fuelwood, which sugarcane laborers must purchase from the commercial loggers/landowners, thereby increasing their wealth. All of these positive feedback loops help to explain the extreme state of deforestation that Negros Island has suffered historically.

Another difference between the researcher-generated and community-generated diagrams was the community's identification of local governments (municipality scale) as having the most leverage to promote reforestation efforts. It is logical that the community would identify the municipal government as having a large influence on forest cover, as this is the scale of government the community deals with most directly in their daily lives and with which they are most familiar. The researcher-generated diagram left out the municipal scale of government altogether, possibly overlooking a critical leverage point for affecting forest cover.

The researchers' diagram included only tree harvesting and deforestation, not reforestation, which might lead to a positive trend in tree cover. This is likely because they were concerned with the biodiversity effects of deforestation, so primary forest was seen as non-replaceable with second-growth forest. However, there is some evidence from the field that agroforestry systems consisting of a mix of planted trees such as cacao and old-growth forest can maintain high levels of insect and soil biodiversity (though rare plants tend not to thrive in these environments) [32]. It is therefore helpful to consider tree planting and agroforestry as a strategy for biodiversity maintenance.

It was not surprising that the community-generated causal loop diagram tended to emphasize on-farm or community decisions, while researchers identified macro-level drivers affecting forest cover, such as Philippine agricultural trade policy and population dynamics**.** Community participants identified poverty and unemployment in rural areas as key factors leading to tree cutting and a decrease in forest cover, while researchers mentioned poverty and unemployment only as effects of forest cover decline, not as causes of this trend. The explanation for the causal relationship given by community members was that cash-strapped farmers may resort to cutting and selling any trees that remain on their property, even if they see these trees as beneficial in providing soil stabilization, water protection, and fruit or fiber. A second mechanism related to laborers employed in paid agricultural work on neighboring farms. If facing unemployment, they are likely to find a patch of land to cultivate with subsistence crops, even if the land is inside of an ostensibly protected forest area.

The researchers' causal loop diagram had more variables than the community-generated diagram, perhaps because the researchers took a longer time to develop their diagram and performed more background research on the issues. If the community were able to re-visit their diagram over time, more variables might be added. One prominent variable mentioned in the researcher diagram as a driver was rural population density, which was absent from the community diagram. The Philippines has one of the highest population growth rates in Southeast Asia, and this may contribute to demand for farmland and deforestation in rural areas [33].

The community-generated diagram referenced the Philippines' agrarian reform program, which was intended to remove land from large plantations and put it in the hands of small-scale farmers. Reviews of the program have called it anything from a complete failure to a mixed success [29]. The community participants in this study agreed that farmers who are recipients of land under this program benefit from it financially. However, they also identified a critical unexpected consequence of agrarian reform; namely, that it can encourage deforestation. As land passes from large-scale owners to the direct control of small farmers, many of these farmers make the decision to maximize the productive capacity of the land by cutting down the trees and planting rice, corn or vegetables instead. These individual decisions have negative collective consequences for the water regime and soil erosion in the watershed.

Another difference between the community and researcher-generated diagrams had to do with the drivers of commercial logging on Negros. The community identified ethanol production, which has several private investors on the island, as driving tree harvest in the Canla-on area. Presumably, the trees are being used as a feedstock to power the ethanol production process. According to the community workshop participants, these trees are plantation-grown (not primary growth), but are not being replaced or harvested in a sustainable manner. In contrast, the WWF researchers cited lumber demand as the driver behind commercial logging on Negros. This probably has to do with the ten-year time gap between the two studies. The WWF book came out in 2000, before ethanol production had begun on Negros.

In summary, the researcher-generated diagram emphasized large scale drivers, historical trends, and political decisions made at the national and international scale as the drivers of deforestation. In the researcher model, individual farmers and rural residents are helplessly caught in a system not of their own making, which almost compels them to engage in activities that reduce, rather than increase, forest cover. In contrast, the community-generated diagram identified some trends over which residents had no control, but placed a lot of emphasis on landowners' individual decisions, and the ability of the local, municipal government to influence these decisions through regulations and incentives.

The degree of difference between the two diagrams was striking. The researcher diagram was generated using an analysis of the historical context behind current deforestation patterns, so it is logical that there would be some differences between this diagram and the community diagram, which focused on current trends and dynamics. The patterns and causes of deforestation on Negros have shifted over the past decades, and the WWF researchers did not intend all of their variables to reflect the current situation. For example, kaingin, or slash-and-burn farming, is almost non-existent on Negros currently. There is also very little migration to the upland regions—migration tends to occur in the opposite direction, from the uplands to lowland cities (or cities on other islands) for employment [34].

In spite of these out-of-date dynamics, the WWF researchers used their causal loop diagram to draw policy conclusions. The authors of the study recommended that NGOs, private entities, and local governments work together to provide family planning services. Previous studies have indicated that there is an unmet need for family planning in the rural Philippines, and that birth rates would be lower if cultural and educational barriers to contraceptive use were removed [35]. WWF researchers also recommended the swift implementation of land reform—not accounting for the positive effect of land redistribution on deforestation observed by community members (Figure 2). Other policy recommendations from the WWF study included reducing poverty and inequality, loosening the grip of elite landowners on political power, and stopping the undervaluation of timber products [8].

Community suggestions of policies to increase forest cover tended to focus on municipal government actions. Workshop participants wanted their municipal government to support tree planting efforts by distributing seedlings, materials and training. They also proposed municipal actions that would assist farmers in improving the productivity and profitability of their farms. These included providing better access to markets; providing training and materials to support the cultivation of high-value crops such as coffee and medicinal herbs; and improving irrigation systems. In the logic of the community-generated diagram, improved agricultural productivity would reduce the pressure on farmers to clear trees on their land, or to establish new plots in forested areas (Figure 2). Finally, workshop participants were critical of ethanol production activities in the region and generally thought they should be stopped. This is an activity which requires further investigation, as workshop participants did not know many details about the operation and ownership of the ethanol production company.

4. Conclusions and Policy Implications

The community-based assessment of deforestation's root causes yielded substantially different variables, feedbacks, and leverage points compared with the researcher-generated assessment. This implies a fairly serious perception gap between researchers who design reforestation initiatives and communities on the ground who implement them. The perception gap is important because it implies that the two frames of reference which are critical for designing effective initiatives to increase forest cover—community perspectives and a knowledge of macro-scale drivers—are not being integrated in the upland Philippines. For example, if researchers from prominent international NGOs (such as WWF) design forest cover initiatives to address population growth rates in upland regions, which they see as a root cause of deforestation, these initiatives could be rejected by the community, who don't view population growth as a significant driver of deforestation [15]. On the other hand, community-designed initiatives to halt deforestation could ignore the critical dynamic of rural population growth, which was found by Kummer and Turner [9] to be a significant driver of deforestation in the Philippines. One model for bridging this perception gap might be to implement a family planning program in spite of community indifference, and incentivize families' participation. Another model could be for researchers to educate the community about the importance of family planning and how it relates to forest cover. Both of these models (incentives and education) have been tried many times in development practice, and have met with only limited (and short-term) success [36].

A group model-building exercise, involving both researchers and community members, could potentially enhance systemic understanding of the deforestation issue and generate more robust reforestation initiatives. Both researcher and community perspectives undoubtedly have merit, and could generate significant learning through their interaction. In fact, the perspectives may be complementary, as they emphasize actions occurring at different scales. The promise of a group modeling project involving community members and researchers is that a unique kind of learning tends to take place during these sessions [24]. Participants in group model-building learn from one another, rather than listening to an "expert" lecture. Also, system dynamics modeling is a tool that allows participants to explicitly state their assumptions about how a system works, then test those assumptions and see for themselves the implications of changing the system [21]. More research should be conducted on these group modeling processes, but initial evidence suggests that participants internalize the learning from group modeling in a way that is not typical during a straightforward exchange of information from "expert" to "local" [37].

Some initial policy recommendations may be inferred from this study. Land redistribution programs show promise for reducing poverty rates on Negros, according to both diagrams. If these programs could be coupled with incentives and support for small-scale farmers to keep trees on their land, either through agroforestry or through leaving some land in native vegetation, forest cover in upland areas could be sustained. The question of which incentives to use (e.g., payments for ecosystem services, provision of supplies and marketing support for agroforestry) should be further examined.

Although population growth was not identified in the community diagram, the WWF study and previous studies have identified it as a major driver of rural deforestation [8,9]. Because the federal government of the Philippines has shown some hostility to widespread promotion of family planning, this is an initiative that may be more appropriately undertaken at the local government level, perhaps in collaboration with NGOs. However, if rural families do not perceive family planning programs to be in their best interests or to be relevant to their daily livelihoods, they will be unlikely to participate fully. A group model building exercise in which researchers and community members explore together the potential impacts of reduced population growth on the upland system could be a powerful tool for convincing community leaders of the need for action on this subject. Moreover, many families may already want to reduce their family size, but there may be cultural or educational barriers to doing so [9]. This is an area worthy of further study.

The Philippine government is strongly promoting biofuel production [38], but there has been relatively little investigation of the ecological impacts of biofuel production as it is currently being practiced. The details of ethanol production on Negros remain unclear, and it is possible that the community was misinformed about trees being harvested for this purpose. This is another topic that merits further investigation.

Low agricultural productivity on smallholder farms in the Philippine uplands—identified by community members as a key driver of tree cutting for extensive agriculture—has been a longstanding and complex problem [15,19,39,40]. It is beyond the scope of this article to explore this topic in great depth, but it is worth noting that low agricultural productivity and deforestation share some similarities, in that both are persistent and complex problems, and both have been the subject of many development interventions with mixed success. A group model-building exercise between community members and agricultural researchers might be useful for generating new solutions to the problem of low upland productivity, as it is important to integrate local and global perspectives on this important issue. It is also instructive to learn from communities or regions where productivity improvements have been implemented successfully [19]. Community members in this study volunteered some of their perspectives on how to improve productivity, including irrigation improvement, better marketing mechanisms, and support for growing high-value crops.

Both researchers and community participants agreed that deforestation is driven internally on Negros Island by positive feedback loops; any balancing forces are introduced exogeneously (agrarian reform is an example). This indicates that promoting reforestation on Negros will almost certainly require external intervention, as the dynamics of the system—if unchanged—will continue to escalate deforestation, due to the nature of positive feedback loops [22]. Alternatively, some of the variables involved in the positive feedback loops could be de-coupled. For example, if non-agricultural employment opportunities were available in the rural uplands, farmers could turn to these jobs during periods of low agricultural productivity (droughts, *etc.*), rather than being forced to clear forested land for additional subsistence cultivation. This would de-couple a loss of farm productivity from deforestation in the community-generated diagram (Figure 2).

Although this study generated some insights into mechanisms of reforestation in the Philippines, a purely qualitative model in this case is probably not sufficient to generate robust conclusions on policy directions. For example, in the community-generated model, agrarian reform has both a positive feedback to forest cover (through decreasing poverty), and a negative feedback to forest cover (by allowing farmers to cut trees on land they now own) (Figure 1). Without a quantitative component to the model, it is impossible to know which of these feedback loops is dominant. Parameterizing the model with quantitative data is therefore a critical next step in the model-building exercise.

This study demonstrated that a group model-building exercise to integrate researcher and community views on forest cover could yield important insights into points of leverage for policymakers. Such an exercise could improve the success rate of reforestation initiatives by designing these initiatives in a way that takes a systemic and dynamic view of forest cover in the Philippines. Previous reforestation efforts in the Philippines have had mixed success [15], so incorporating a promising new tool like group system dynamics modeling could move the policy discussion forward in a meaningful way.

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