

**The impact of institutional heterogeneity: A mixed methods approach to understanding management of the invasive mile-a-minute weed (*Mikania micrantha*) in Chitwan, Nepal**

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**Abstract:** Based on fieldwork conducted in 2014, differences in institutional arrangements and efforts to remove an invasive plant, the-mile-a-minute weed (*Mikania micrantha*), are explored in five case study community forests in Chitwan, Nepal. An institutional analysis informs an examination of heterogeneous governance relationships and norms related to Mikania management, while a content analysis provides an understanding of reoccurring themes in the interviews and their implications for social and ecological outcomes in the community forests. The complex governance relationships and regular themes of distrust of government and non-government officials help to explain collective action efforts and management decisions. In addition to distrust, other factors influencing Mikania management are explored in the case study community forests. The content analysis suggests that Mikania is impacting people's daily lives but the degree of severity and the response to the disruption varies substantially and is heavily impacted by other problems experienced in each case. Our results indicate that understanding institutional arrangements and their impacts on community issues, like trust of actors, can contribute to successful efforts to manage Mikania, and other invasive plants globally, in the future. We present data informed propositions about invasive species management and governance, and suggest that this study contributes to a better understanding of how institutions mediate invasive plant removal efforts.

**Key words:** institutions, community forestry, trust, invasive plants, Nepal

## 1. Introduction

Previous research has conveyed the important role that institutional arrangements play in mediating relationships between communities and the environment in social-ecological systems (Berkes et al., 2003). Chitwan, Nepal is a rapidly urbanizing region adjacent to the internationally important Chitwan National Park. Community forests (CFs) were formally established in the region, known as the buffer zone CFs, in the mid-1990s in order to provide residents opportunities to collect forest products and timber in forests that were largely self-governed. The community forestry program also intended to reduce people's reliance on the forest resources within the national park, often illegally harvested, while simultaneously supporting livelihoods through sustainable management of the buffer zone forests. While increasing population pressure has recently affected one of the most successful community forestry programs in the world, a new social and ecological threat looms with the invasion of the mile-a-minute weed, *Mikania micrantha* (hereafter referred to as Mikania).

Mikania is a vine-like plant native to South America that favors humid, warm (tropical) environments and it has widely invaded parts of India, China, and Nepal (Figure 1). It has proven problematic in regions it has invaded because of its rapid growth and its ability to smother and kill small trees and grasses. Due to its methods of reproduction (both sexual with seed dispersal and vegetative through rooting), Mikania is difficult to successfully remove without further dispersal. In 2010, Mikania had already covered up to 20 percent of Chitwan National Park (Singh Khadka 2010). The buffer zone community forests have been invaded to differing degrees

of severity, with some forests heavily infested and others with little Mikania (Hall et al., unpublished data). The detrimental effects of Mikania on the biodiversity of the Chitwan region have been established. These include significantly harming the vulnerable one-horned rhinoceros' food and habitat sources (Murphy et al., 2013; Ram, 2008). However, less is understood about the role that Mikania plays in affecting the everyday lives of the buffer zone CF residents, the governance in the region, and how institutions mediate the spread of Mikania. This article focuses on the following questions:

- 1) How do governance relationships operate in the buffer zone CFs?
- 2) How do the norms and rules involved in these relationships influence distinctions in Mikania management and collective action between the CFs?
- 3) How do the institutions involved in Mikania management more broadly inform the role different institutions play in mediating invasive plant management?

Institutions are defined in this research as the shared rules, norms, and values that shape human decision making and are inherently intertwined in efforts to govern common pool resources, such as community forests (Ostrom, 2005). In an effort to contribute to understanding how institutions mediate attempts to manage invasive plants as a threat to the social-ecological system, we explore the connections between the effects of Mikania in five case study community forests, their current management practices including collective action for Mikania removal, and existing institutions and governance relationships.



**Figure 1.** Mikania micrantha climbing a tree in Chitwan. (Photo by the authors)

### *Community forestry and institutional heterogeneity*

Recent research from around the globe has focused on understanding various aspects of community forestry, including common property management, power, and accountability (Arun Agrawal & Chhatre, 2006; Behera & Engel, 2006). However, despite the fact that there is work on understanding institutional aspects of community forestry in Nepal (e.g. Ojha, 2006; Ojha et al., 2009; Pokharel, 1997; Poteete & Ostrom, 2004; Varughese & Ostrom, 2001), less is understood regarding the larger role that differential institutional arrangements between community forestry groups in a specific region perform in mediating social-ecological threats like invasive species.

Community forestry often introduces more decentralized, democratic governance where people within a given community contribute to decision making processes (Lachapelle et al., 2004). However, heterogeneity exists among these arrangements; some provide specific groups with greater influence and management practices or outcome goals may differ. Different institutional arrangements within Nepal appear to have developed as the best possibility considering the regions' local circumstances (Acharya, 2002). Linear models of common pool resources, including community forests, are often inappropriate as they cannot take into account local context that is vital to moving towards institutional arrangements that promote successful resource management. Several factors have been found to influence differences in institutional arrangements in community forests including the biophysical condition of the forest (forest degradation/forest health), dominant labor occupation (community dependence on the forest resources and employment opportunities in nearby markets), and community dynamics (including whether the community has a large number of users or a smaller group)(Acharya, 2002). This article address an aspect of the gap in analyses of community forestry outcomes (Charnley & Poe, 2007; Lachapelle et al., 2004) by elucidating the impacts of different institutional arrangements between CFs in Chitwan, with a focus on Mikania management.

Institutional heterogeneity related to governance practices and management norms often exists in CFs in the same geographic region. Heterogeneity in caste, education, gender, and other factors influence which households benefit the most from community forestry and who participates in collective resource management (Adhikari, 2005). In absolute terms, richer households are more dependent on the community forest resources, contrary to previous studies; richer households with land holdings, livestock, and more monetary resources are in a better position to benefit from intermediate forest products (Adhikari, 2005; Gilmour et al., 2004).

The role of heterogeneity in collective management of common pool resources has been hotly debated in the literature (see Varughese & Ostrom, 2001). Heterogeneity here refers to differences that might impact the success of reaching a collective goal. Kant (2000) defined this heterogeneity in three levels: (1) if there are social, cultural, and economic differences between people living in the same area using the same resources, there are likely to be (2) different preferences for using the resources and (3) different preferences for management arrangements to manage the resource. Thus, heterogeneity theoretically can pose difficulties in successful collective action to manage a common pool resource (Ostrom, 2005). Ostrom (2005) argues that the focus on heterogeneity has been misplaced; instead the focus should be on the factors

affecting differences in heterogeneity such as the institutional arrangements and interactions between factors.

Using the data from our case study CFs, we employ a mixed methods approach including institutional and content analyses. The institutional analysis informs our understanding of the governance relationships and the ways participants are involved Mikania management, while the content analysis informs our understanding of and provides support to our interpretation of the reasons governance relationships and Mikania management differ. Our analysis supports that there is between-community heterogeneity in governance relationships and collective action related to Mikania and explores the specific ways these relationships differ, as well as possible factors influencing these differences. A key finding is the role that distrust among participants plays in contributing to information asymmetries related to management. We present a list of data-informed propositions related to invasive plant management and suggest how these concepts can inform other studies of invasive plants in a social-ecological context. Particularly, we argue that a more thorough understanding of institutional factors, especially the role of trust and information access, has the potential to strengthen future efforts to successfully remove invasive plants globally.

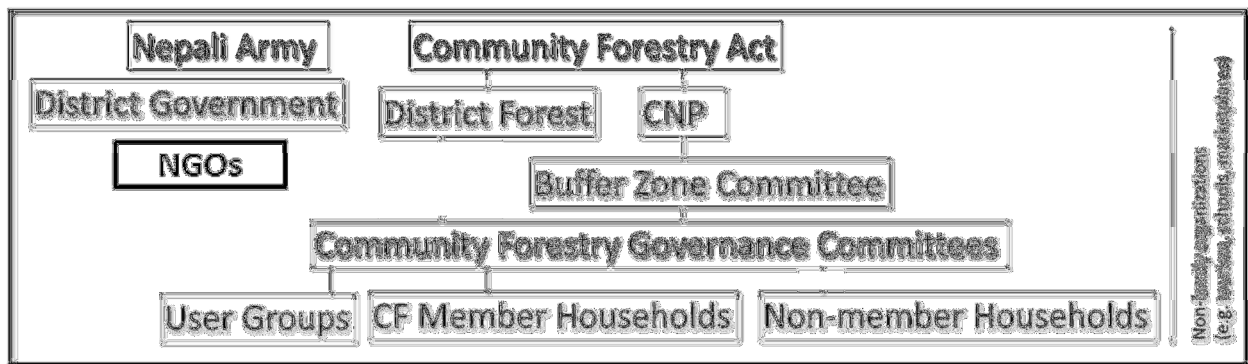
## **Methods**

### *Case study selection and fieldwork*

Twenty nine semi-structured interviews with 87 interviewees were completed between May and July 2014. These interviews included questions attempting to elucidate household interactions with a variety of individuals and organizations (see next section), Mikania management, and perceptions of Mikania. Semi-structured interviews follow a basic outline and have pre-determined topical areas to address, but they often include open ended questions that leave room for additional information to be discovered, allowing interviewees to discuss topics they feel are relevant (Bernard, 2011). Before interviewing, the protocol was translated to Nepali by a native Nepali speaker and tested with several community forestry members at the Institute for Social and Economic Research-Nepal (ISER-N) in Chitwan. Some concepts, such as “invasive species” do not directly translate or have a meaning in Nepali. As such, translations were made to best approximate the intended meaning in English. Interviewees were selected from five case study buffer zone community forests in Chitwan. These five community forests were selected from a group of 11 buffer zone community forests where ecological data, including Mikania distribution, was collected in 2013. To select case studies, first, historical data related to the income the community forest governance committees brought into the community forests and the community forest’s age were utilized to create a preliminary governance capacity measurement. Governance capacity was assessed for each community and was ranked as high, medium, or low. A random number generator was then utilized to select cases in each category, ensuring the five cases included a mixture of historically high, medium, and low governance capacities. The five forests in this research are not identified by name because some of the information discussed could be considered sensitive; as these are small communities, the information could be linked back to individuals. Fieldwork additionally consisted of participant observation (of activities such as fodder collection) in each of the case studies between and during interviews to more fully understand the contexts of the interview responses.

### *Types of interviewees and interview structure*

In order to explore governance relationships we interviewed people from multiple levels and ascertained their relationships to the CF members and the community forest governance committee (CFGC). Figure 2 is a simplified view of the participants and their relationship to CFGCs and CF members in the Chitwan region. Unlike many community forestry operations in the middle hills of Nepal, most CFs in the Terai region have an elected CFGC. Most of these committees are relatively small, often between ten and twenty members total. Each CF has a written management contract that the CFGCs are elected to uphold. The buffer zone CFs are connected to the Buffer Zone Committee, which generally acts as a mediator between the CF members, the CFGCs, and the national park. Most of the CFs in Chitwan are registered with either the District Forest or Chitwan National Park; all of our case study forests but one were registered with Chitwan National Park (the remaining CF intended to register with the park in the future). Our case studies elucidated the complexity of these relationships and in practice they are far from the simple linear structure portrayed in the diagram. The content of these interactions in each case study will be explored in the results.



**Figure 2.** Simplified diagram of participants and linkages

While interviews with CF members usually focused on one individual or household, they almost always became group events where neighbors' opinions were given. The interviewee composition was representative of the ethnic composition and educational status of each of the CFs. It is possible that higher caste Hindus were underrepresented in the interviews and that females were oversampled. We under-sampled young women (18-21 years) who were less likely to participate in an interview with males or older females present; additionally, there were fewer young men, as many were working overseas. We were able to interview both farmers and non-farmers, but it was very difficult to find people that did not farm in some capacity. Interviews were also conducted with two NGOs consisting of representatives from NGO A and NGO B (pseudonyms), both working in Chitwan and with some of the case study CFs. Each of the five CFGC presidents was interviewed, as well as national park and buffer zone committee officials.

### *Content analysis*

Content analysis, also sometimes referred to as theme analysis, is a text analysis methodology commonly utilized in anthropology, but is applicable in any case with textual data. Content analysis primarily involves deductive coding where the coder usually begins with a hypothesis or an idea from the literature that they seek to assess (Bernard, 2011). However, content analysis

can include elements of inductive thinking where codes come not from a hypothesis from the literature but a hypothesis stemming from fieldwork and intimate knowledge of the data (Bernard, 2011). Content analysis can be quantitative or qualitative in nature. In the analysis of the Chitwan community forest case study interviews, it is both. Some of the codes are quantitatively presented as percentages. In some cases, the codes are discussed qualitatively in the context of participant observation notes or an entire interview. Content analysis often lends itself to statistical analyses (for example, tests of differences in frequency of codes by gender or caste) (e.g. Vins et al., 2014), but in this case statistical analyses are not employed, as the concepts explored are expressed well with percentages of interviewees by community forest.

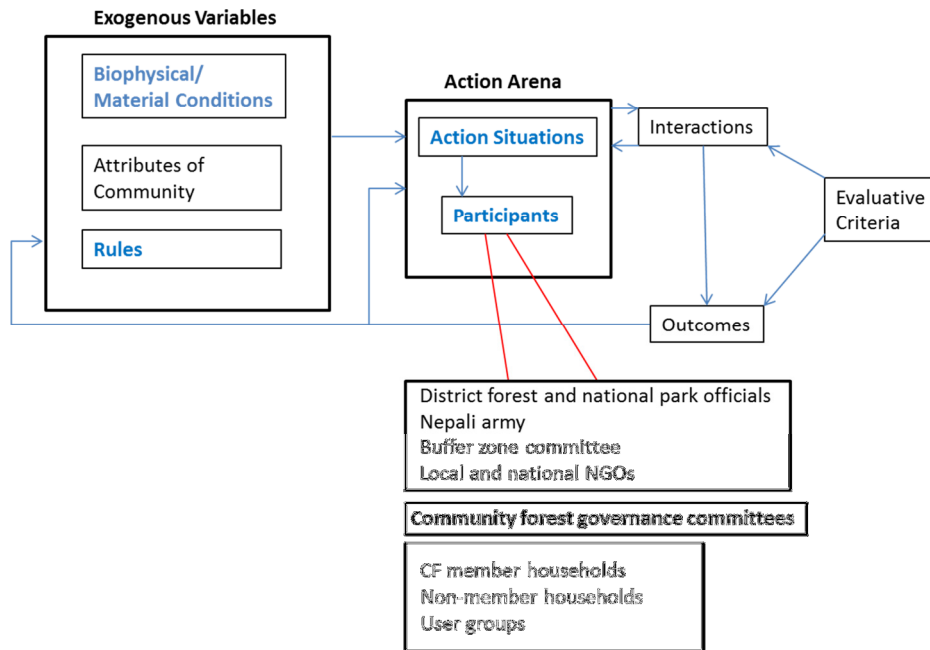
The codebook was developed according to best practices established by MacQueen, McLellan, Kay, & Milstein (1998). Two independent coders went through the codes together and calculated inter-rater reliability for each code. In order to resolve codes where we did not initially reach a Kappa of 0.7, we discussed the codes for clarification and re-coded, or an expert coder resolved the discrepancy (MacQueen et al., 1998).

### *Institutional analysis*

Content and institutional analyses are natural compliments for qualitative data exploring governance relationships, as themes can be interpreted in the context of governance arrangements. Use of the institutional analysis and development framework (IAD) (Ostrom, 2011) will inform the understanding of existing strategies, norms, and rules in Chitwan and assist in the exploration of existing governance relationships. Examining the institutional analysis and development framework (Figure 3) can make institutional analysis seem like a task that is impossible to complete well or thoroughly. However, it is key to keep in mind that most institutional analyses attempt to carefully understand a broad overview of the situation, often focusing on the action arena, and subsequently focus on details relevant to a specific research question, moving outward to exploring exogenous factors (Ostrom 2005). The complexity of considering all of the rules (not even considering norms or strategies) in a given situation can quickly spiral out of control if the analyst does not focus the analysis.

There are a wide variety of approaches to institutional analysis, but in many cases the IAD framework provides a background to the interpretation of existing strategies, norms, and rules. In this case, the participants and the action situation are focused upon within the IAD framework (Figure 3) to explore linkages between governance relationships. There are a variety of participants that interact with community forests in some manner. The linkages between these participants, including the frequency and strength of the relationships, are distinct in each of the five case study forests. Coding the interview data for the presence of these relationships aided in clarifying the relationships in each case study, but initial diagrams of governance relationships and norms of interactions were created during fieldwork in each case (see Appendix A for diagrams of the cases). The institutional analysis examines the text and participant observation notes for the existing relationships between community forest members, the governance committees, the national park, the buffer zone committee, the village development committees, NGOs, the Nepali Army, the district forest, and the district government. These relationships

impact how information about Mikania is communicated and will be discussed qualitatively in the context of the information from the content analysis.



**Figure 3.** The Institutional Analysis and Development Framework, adapted from Ostrom, Gardner, & Walker (1994)

## Results

### *CFs are heterogeneous*

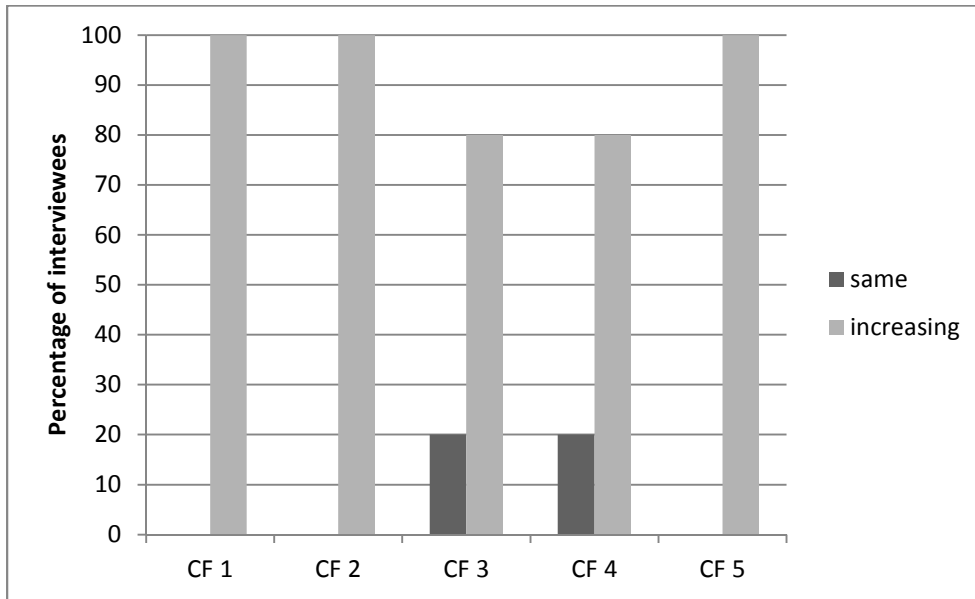
Across the five community forests, we find that heterogeneity is the norm. There is variation in the concern about Mikania, perceived extent and spread of Mikania within the forests, the methods used for Mikania removal, and the organization of community members to remove Mikania. Variation exists in the major problems identified by the community forests: invasive species, human-wildlife conflict, flooding, forest degradation, and pollution. There is additionally substantial variation in the collaboration with outside entities, specifically NGOs and the national park. Some communities regularly work with NGOs, while others have little connection. Only one case study forest collaborated with an NGO for an invasive species removal program. Some communities trust the national park, while others see it as corrupt and unresponsive to community needs. Here, we elaborate on these variations discovered through the content and institutional analyses. We then expand upon the importance and impact of this heterogeneity.

### *Perceptions of Mikania and impact on daily lives*

Content analysis identified that most interviewees in all five CFs believed that Mikania was increasing. Some interviewees thought Mikania growth was the same when compared to the previous year. Figure 4 details these percentages of interviewees by CF. Interviewees in CFs 3, 4, and 5 expressed that Mikania was impacting how they allotted their daily time, by making collection of forest resources such as grasses and fodder increasingly difficult. Interviewees in all



five CFs articulated that increasing Mikania limits food sources for wildlife, increasing the amount of large fauna (tigers, rhinos, boar) leaving the forest in search of food.



**Figure 4.** Perceptions of Mikania by CF.

*Major problems identified in the CFs*

There was substantial variation in the problems mentioned by interviewees in the different CFs. All interviewees were asked about flooding, wildlife, invasive species, and condition of community forest resources. Industrial pollution was mentioned without prompting in CF 5; in this case three interviewees discussed a Coca Cola plant that had discharged unknown liquid onto their field.

**Table 1.** Major problems identified by each case study CF.

|                                      | CF 1 | CF 2 | CF 3 | CF 4 | CF 5 |
|--------------------------------------|------|------|------|------|------|
| <b>Flooding</b>                      | ✓    | ✓    | ✓    | ✓    |      |
| <b>Wildlife: Rhinos</b>              | ✓    | ✓    | ✓    | ✓    |      |
| <b>Wildlife: Elephants</b>           | ✓    | ✓    |      |      |      |
| <b>Wildlife: Tigers</b>              |      | ✓    |      |      |      |
| <b>Wildlife: Deer and boar</b>       | ✓    | ✓    | ✓    | ✓    | ✓    |
| <b>Mikania</b>                       |      | ✓    | ✓    |      |      |
| <b>Stressed/Limited CF resources</b> |      |      |      | ✓    |      |
| <b>Industrial pollution</b>          |      |      |      |      | ✓    |

All community forests discussed a lack of forest resources in some capacity, but in CF 4 the forest had been completely shut down (except for one collection day per month) due to forest health and wildlife issues (rhino attacks). In CF 4, the Nepali army was stationed at entrances and within the forest in an attempt to prevent and protect people from rhino attacks. Mikania was mentioned in all the community forests, but only in CFs 2 and 3 was it perceived as a major

problem. In these communities Mikania was perceived as directly affecting livelihoods by increasing the time/distance to collect forest products.

### *Mikania*

All of the case study communities mentioned invasive plant species and Mikania within their forests, but there was variation in the level of concern. As noted, CFs 2 and 3 were the most concerned about Mikania. Interviewees discussed its impact on the time it took to collect grasses. There was variation in methods to remove Mikania. Interviewees in CFs 3 and 5 discussed burning for Mikania management, as well as to promote grassland growth (note in CFs 3 and 5 the CFGC presidents denied burning). Cutting and pulling (mechanical removal) was mentioned in all communities. Pesticide use was only mentioned in CFs 1 and 5. Only one interviewee (in CF 4) reported seeing Mikania on their farmland, which was very near the CF fence. Other interviewees strictly reported finding it in the forest and along the forest fence. One interviewee (the CFGC president of CF 2) reported a group he organizes to remove Mikania uproots it from within the forest and throws it all into a nearby river.

**Table 2.** Presence of Mikania and removal methods

|                           | CF 1 | CF 2 | CF 3 | CF 4 | CF 5 |
|---------------------------|------|------|------|------|------|
| <b>Mikania (presence)</b> | ✓    | ✓    | ✓    | ✓    | ✓    |
| <b>Burning</b>            |      |      | ✓    |      | ✓    |
| <b>Cutting</b>            | ✓    | ✓    | ✓    | ✓    | ✓    |
| <b>Pulling</b>            | ✓    | ✓    | ✓    | ✓    | ✓    |
| <b>Pesticides</b>         | ✓    |      |      |      | ✓    |

### *Understanding governance relationships*

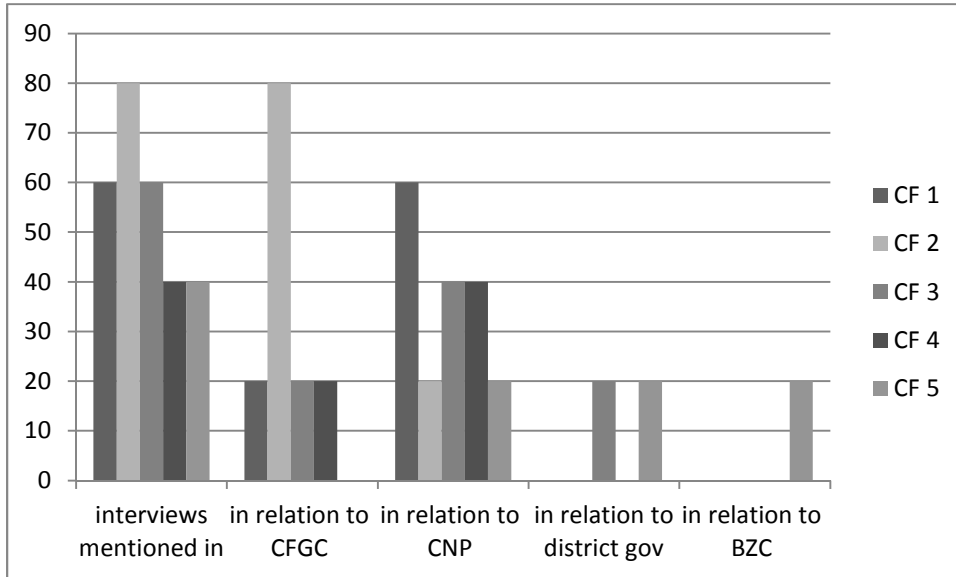
There are numerous relationships among the CF members and the CFGC in each case study. For example, all CF members interviewed reported some level of interaction with the buffer zone committee and many reported indirectly conveying concerns to the national park through the buffer zone committee members. The CFGC in each forest communicates with the national park, buffer zone committee, and village development committees about a variety of issues relevant to the CFs (a visual representation of the relationships in each case study can be found in Appendix A). We emphasize several key differences between the case studies.

### *Key differences in governance relationships*

First, collaboration and interaction with NGOs is different in each CF (NGO connections include all NGOs working with the CFs, not only ones related to Mikania). For instance, in CF 3, NGOs are very integrated, interacting with the CFGC, CF members and user groups, and village development committees. They provide resources such as toilets and wells, and in some cases provide skills based trainings. CF 5 presents the opposite case, as they have little to no integration with NGOs.

Second, the strength of the relationships between different groups and individuals within a CF is different between the cases. For example, CF members in each case have either direct or indirect connections with the national park. However, the level of trust in the national park is very different in each case (Figure 5). In particular, members of CFs 1, 3, and 4 reported low levels of

trust in the national park. CF 3 members expressed concern that park officials were corrupt and sequestering monetary resources that could be shared with the buffer zone forests. CF 2 members expressed lack of trust in their governance committee's ability to follow through with promises, as well as distrust in park officials.



**Figure 5.** Percentages of interviewees expressing distrust by CF

Finally, CF 5 is the only case study with ties to the district forest. They are not registered with the district forest, but because of their proximity to a highway and the district forest office, the district forest occasionally communicates with the CFGC members.

#### *Governance relationships affect information and management decisions*

The content analysis revealed that characteristics of these relationships impact information and management decisions. First, members in each CF are making decisions about Mikania management without consulting their governance committees or other actors, limiting the information available regarding the best ways to successfully remove Mikania and in some cases community members are engaging in removal practices (such as burning) that increase its dispersal (Murphy et al., 2013). The content analysis supported that CFs with more negative interactions with other participants are more likely to report distrust and less likely to seek information about management from outside sources. Second, in cases where Mikania is considered to be affecting time budgets and daily lives, people expressed feeling they lacked resources or relationships that could improve the management situation. Additionally, there were conflicting perspectives between participants, which the interviews revealed contributed to distrust and information availability. For example, a major local NGO expressed the opinion that Mikania was not increasing and largely failed to consider CF members' opinions in management, negatively impacting their relationship.

#### *Collective action and governance capacity*

Collective efforts to remove Mikania exist in each of the CFs, but to differing degrees. In CFs 1 and 2 there were organized efforts to cut and pull Mikania within the forest directly following

monsoon season for at least the past five years. CF 3 had “jungle cleaning” groups where specific plants were removed and the forest was cleaned of trash, but they were not centrally organized and were not necessarily only targeting Mikania. CFs 4 and 5 did not participate in collective efforts to remove Mikania in the past year. CF 4 previously had groups that attempted to cut and pull Mikania, but because forest access is currently restricted here, they are no longer able to organize. CF 5 members reported that their CFGC paid individuals to pull Mikania along the fence, but most community members did not know this. CF 5 also hired people to burn Mikania (this was also denied by the CFGC president), but this was not organized across CF members.

The relationship between governance capacity and collective action is not entirely clear from the literature. Monetary and social resources have a positive relationship with governance capacity, and as this capacity increases, people may have more access to a collectively managed resource and more incentive to organize to manage it (Coaffee & Healey, 2003). However, they may simultaneously be afforded additional access to other market opportunities a governing body with increased capacity can facilitate, decreasing their reliance on the resource and their incentive to collectively govern it. Here, governance capacity was assessed before completing the case studies based on historic data including CF income and age. We find that it has changed in some of the case study CFs. It is not always linked with collective action (Table 3).

|   | CF 1                         | CF 2                        | CF 3          | CF 4                      | CF 5        |
|---|------------------------------|-----------------------------|---------------|---------------------------|-------------|
| <b>Collective action</b>  | <b>High</b>                  | <b>High</b>                 | <b>Medium</b> | <b>Low</b>                | <b>Low</b>  |
| <b>Governance capacity (as determined from historical data)</b> | <b>Medium</b><br><b>High</b> | <b>Low</b><br><b>Medium</b> | <b>Low</b>    | <b>High</b><br><b>Low</b> | <b>High</b> |

**Table 3.** The relationship between governance capacity (GC) and collective action. GC was measured in the past; changes from recent data are in red.

## 2. Discussion

The article contributes to a better understanding of the governance relationships and management practices involving Mikania in Chitwan CFs. Understanding these governance relationships is vital to learning how Mikania is managed on the ground and efforts to remove Mikania have varied. These governance relationships represent part of the set of “rules-in-use” (Ostrom 2005). It is key to understand the heterogeneity in these relationships as without such understanding, Mikania management efforts are likely to fail as the reasons for specific management decisions and relationships between actors may be poorly understood and difficult to change. Here we present three propositions for addressing the removal of plants that have invaded common pool resources. The first two focus on the importance of access to information and how institutions impact this, while the second focuses on connection to the natural resource. These propositions are informed by our case studies, but we argue they provide insight to other communities facing invasive plants.

*Propositions: Managing invasive plants in the context of common pool resources*

- 1) Communities that have more interaction with NGOs and local government participants will have increased access to information on plant removal, which is likely to increase successful management efforts

Our study found that communities that interacted more frequently with NGOs and government participants reported greater access to information about a variety of topics, including farming, construction, and education opportunities. In particular, communities with ties to NGO B had increased access to information about best practices for Mikania removal and the removal efforts other communities had engaged in. Communities that did not interact with these external organizations, either because they were isolated or because they did not trust them, lacked this information. In essence, these differences in relationships between CF members and NGOs produce information asymmetries related to Mikania management.

Connections to NGOs and other organizations are often considered part of social capital (McCarthy, 2014); these networks often provide improved access to information (Matsaganis & Wilkin, 2015). Thus, strengthening these networks of relationships between NGOs and communities managing an invasive plant is likely to provide information benefits. While increased knowledge does not always lead to increased efforts to implement this knowledge (Finger, 1994), communities with knowledge about best practices for invasive plant removal and information about what other communities are doing begin with an advantage over communities lacking this information. Further, in communities that are already actively attempting to remove an invasive plant, new information may be put into practice sooner. For instance, CF members in Chitwan noted they welcomed and needed new information about Mikania removal because their current efforts resulted in the plant growing back.

Improving the frequency and quality of relationships between community members, NGOs, and government participants is difficult in practice and these relationships depend on the historical and cultural context of the community (Bebbington, 2004). In the context of Chitwan, overcoming distrust in some cases and isolation/distance in others, could begin with an effort from the local government to make their services and the NGOs in the area more accessible to people in the region (Arun Agrawal & Gupta, 2005).

- 2) When trust is lacking in interactions between community members and other participants, participants will lack the information to successfully remove invasive plants

Distrust characterized several of the relationships between CFs and CNP or their governance committees. Trust is important in a variety of natural resource contexts. For example, along with boundary spanning leadership (leadership that connects actors at different levels and of different types), trust has been shown to be vital in successful water management (Edelenbos & van Meerkerk, 2015). The precise definition of trust is contentious in literature from a variety of scholarly fields (Heemskerk, Duijves, & Pinas, 2015). However, for the purposes of trust in

natural resources management/use and as discussed here, trust refers to whether a partner organization or individual can be depended upon, whether they respect the interests of others, and if they are competent in acting upon their agreements (Dirks, 1999; Heemskerk et al., 2015). Trust is difficult to quantify and trust among resource users and managers with different levels of power can create situations of distrust when power is abused (Dhialhaq, De Bruyn, & Gritten, 2015).

There are numerous studies related to natural resources management and the environment that note the importance of trust among different participants and subsequently explore ways to build and foster trust. For instance, (Berkes, 2009) discussed the importance of fostering trust to implement successful co-management of natural resources and elaborated the vital role that bridging organizations play in fostering trust between resource users, government agencies, non-profit organizations, and other stakeholders. It has also been found that strong leaders can be instrumental in building trust (Folke, Hahn, Olsson, & Norberg, 2005), social learning processes can build trust in the context of natural hazards planning (Henly-Shepard, Gray, & Cox, 2015), and the participation of stakeholders can improve public trust in natural resource management (Reed, 2008). In order to strengthen the fairness and effectiveness of natural resources management, it is important both for governments to reach out to local resource users/managers to foster trust and for local resource users to reciprocate efforts to become trustworthy (Heemskerk et al., 2015).

There are fewer examples exploring what happens when trust is lacking in governance relationships and how this influences the social-ecological system. One example is Heemskerk et al. (2015), who find that distrust among actors was detrimental in the management of mineral resources in Suriname, where distrust actively impacted natural resource policies and outcomes. Distrust is not only important in shaping policy perceptions but also prohibits communication and information flow among resource users, slowing decision making. In the context of organizational literature, Wang, Tseng, & Yen (2014) study the impact of trust in mediation of the relationship between the existence of employee norms within a firm and information sharing, finding that the less interpersonal trust employees have, the less likely they are to share information.

In Chitwan, where distrust is present, information availability was impacted. When trust was lacking between the CF members and either their governance committee or the national park, the relationship suffered. CF members reported less communication with participants they did not trust, which impacted the information they had access to regarding Mikania removal. Well defined institutions in the forms of norms and cognitive structures can strengthen and engender interpersonal trust, as well as trust among different actors and organizations (Fuglsang & Jagd, 2015).

Importantly, both propositions 1 and 2 argue that institutional norms and relationships are influencing information, and that information matters for successful management/removal of

invasive species. By articulating differences in governance relationships and management norms, the reasons for differences in information access become clear and can be addressed to improve management efforts.

- 3) Specific to community forests: CFs that provide more resources to members will exhibit greater potential to collectively manage invasive plants due to greater buy-in/reliance on forests resources

The ability of the CFGC to provide resources to its members is linked to its governance capacity, which included the monetary resources of the committee. Thus, CFGCs with a higher governance capacity might be better equipped to manage the CF and provide access to forest resources to the members. Collective action has played a vital role in managing common pool resources in numerous global contexts (Agrawal, 2001, 2003; Ostrom, 2005) and our research supports that people are more likely to engage in collective action for Mikania removal when they are more reliant on the CF resources. Governance capacity and collective action for Mikania removal was closely linked in CFs 1 and 4, was moderately linked in CFs 2 and 3, and was not closely linked in CF 5. Supporting our proposition, in CF 4, the condition of the forest is very poor, the CFGC has little resources, and the members are forced to rely less on these resources. In turn, members reported being less invested in maintaining the forest and organizing collective action for Mikania removal. In CF 1, the condition of the forest is much better, the CFGC has more income (from, for instance, tourist entry fees), and the members have greater access to fodder collection and timber resources. These members reported annual instances of collective action to both clean the CF of litter and remove Mikania. CF 5 represents a caveat to part of our proposition. This CF has a high governance capacity, but a very low level of collective action for Mikania removal. This is due in part to the urban location of CF 5; it has very close proximity to a city and a highway. Thus, despite the CFGC's capacity to maintain the CF and provide members with access to these resources, the members of this CF are less dependent on them as they have a variety of job opportunities available in the nearby city.

Community forestry, and more generally commons, research has noted that poorer communities do not tend to have access to government officials that lead to stronger participation in programs like community forestry (Agrawal & Gupta, 2005) and a high level of dependence on the common pool resource is important for participation in its maintenance (Lise, 2000)

By acknowledging the institutional norms and existing relationships between participants, these propositions are a useful starting point for understanding and implementing successful invasive plant removal efforts. Understanding institutions is vital to successful common pool resource management (Becker & Ostrom, 1995; Ostrom et al., 1994; Tang, 1991) and a detailed understanding can potentially aid community members and other stakeholders in designing systems to address issues that prohibit successful removal such as lack of trust and information barriers.

## Conclusions

This study contributes knowledge relevant to our Chitwan case study participants, as well contributing more broadly to an understanding of the complexities involved in managing invasive plants, an increasingly important issue globally (Chornesky et al., 2005). It is our hope that in the context of Chitwan, this more detailed understanding of governance relationships and norms related to management will contribute towards successful efforts to remove Mikania. Based on the findings, our key recommendations from this study related to institutional design are to foster norms of trust between actors and implement well-defined management rules. The former has the potential to improve the flow of information pertinent to management decisions (Levin & Cross, 2004) while the latter has been shown to improve resource management in many cases (Anderies, Janssen, & Ostrom, 2004). One potential way to foster trust and strengthen the relationship between CF members and other participants is for government participants in particular (such as the national park officials) to address problems viewed as significant by CF members, including wildlife attacks and flooding. Addressing these problems that directly threaten people's lives may increase community trust in government participants and allow CF members to subsequently deal with Mikania removal, improving the quality of their lives in multiple ways. Future research will employ these findings to inform an agent-based model combining an understanding of governance relationships with ecological data to explore the dynamics of different sets of institutions and the spread of Mikania.

While institutional research has stressed that there are no one-size-fits-all solutions (Ostrom, 2007), this approach can be employed to understand governance relationships in any region to inform management plans that address context specific findings. The propositions presented in this article allow local stakeholders and organizations a generalizable starting point for addressing institutions and relationships that impact invasive plant management, particularly in the context of plants that have invaded common pool resources.

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## Appendix A

There are numerous relationships among the CF members and the CFGCs in each case study. Each CF interacts with actors in different capacities and frequencies and the level of trust in each relationship varies. (CFs 1 to 5 in order)

