



Women's Local Knowledge of Water Management A case study from Coatitlán, Veracruz, Mexico

Maria Lee Kernecker

Thesis submitted for the partial fulfillment of the requirements for
the academic degree of

**Master of Science in Umwelt und Bioressourcenmanagement
University of Natural Resource and
Applied Life Sciences Vienna, (BOKU), Austria**

Advisor

Prof. Dr. Christian Reinhard Vogl
Division of Organic Farming
Vienna, January 2009

Masterarbeit

*für den Master in Umwelt- und Bioressourcenmanagement
am Institut für Ökologischen Landbau
der Universität für Bodenkultur*

eingereicht von

Maria Lee Kernecker

Betreuer

Prof. Dr. Christian Reinhard Vogl
Wien, Januar 2009

Abstract

In the rural highlands of Veracruz, Mexico surface water and precipitation are abundant. There is also a high amount of humidity; nevertheless, the possibilities for access to the water resources remain limited. Development plans do not take environmental concerns into account, nor do they account for local knowledge systems and related resource management. Thereby, the exclusion of rural communities from the state is perpetuated and women, as primary resource users, are not integrated into planning and execution.

This thesis explores women's local knowledge of water resources in Coatitlán. Furthermore, it explores women's management of water resources as they relate to livelihoods for household survival and agricultural production. The way in which these management methods adapt to evolving livelihood systems and landscape patterns were also researched.

Participant observation and semi-structured interviews were used to study what women use water for, and which water sources they rely on. The ecosystem services found in the cultural landscape were also identified, in addition to the political-economic changes that impact women's everyday life. Five semi-structured and fourteen unstructured interviews were held.

Women's local knowledge of water resource management starts with the way that they use water resources. Access to water resources is shaped according to women's knowledge of their landscape and related ecosystemic processes, as well as community relationships and external economic-political circumstances. Women according to their growing economically informed needs.

The central event occurring in Coatitlán during the summer of 2007 was a state-funded road construction project. This project influenced women's perception of their environment and augmented their interest in political events, and clarified the social networks and stratification women are a part of. As women's vision of their landscape is extended to include a larger area, there are increasing varieties of livelihoods that will use natural resources in different ways than they do now, local knowledge of water resources will adapt accordingly.

Zusammenfassung

Die ländlichen Hochlandsgebiete in Veracruz, Mexiko sind durch reichhaltige Wasservorkommen und häufige Niederschläge gekennzeichnet. Die Luftfeuchtigkeit ist hoch, jedoch sind die Zugangsmöglichkeiten zu den Wasserressourcen begrenzt. Die Entwicklungspläne entsprechen nicht den Umweltbedürfnissen, und sie berücksichtigen auch nicht das lokale Wissenssystem und Ressourcenmanagement. Dadurch werden ländliche Gemeinden vom Staat weiterhin ausgeschlossen, die Frauen als primäre Ressourcennutzerinnen werden nicht in Planung und Ausführung integriert.

Diese Arbeit erforscht das lokale Wissen der Frauen in Coatitlán über Wasserressourcen und dessen Management als Existenzgrundlage im Haushalt und in der landwirtschaftlichen Produktion. Außerdem wird in Betracht genommen wie sich dieses Management an die sich ändernden Existenzgrundlagesysteme und Landschaftsmuster anpasst. Mit beteiligter Beobachtung und teilstandardisierten Interviews, hat diese Studie erforscht wofür die Frauen Wasser verwenden und welche Bezugsquellen sie nutzen. Weiterhin wurde erkundet welche ökosystematischen Prozesse in der Kulturlandschaft von Coatitlán stattfinden, und welche politisch-ökonomischen Änderungen, das alltägliche Leben der Frauen beeinflussen. Es wurden fünf teilstrukturierte und vierzehn freie Interviews durchgeführt.

Das lokale Wissen der Frauen über Wasser und dessen Management begründet sich in den Nutzungsmöglichkeiten. Der Zugang wird von ihrem Wissen über Landschaft und ökosystematische Prozesse, sowie von nachbarschaftlichen Machtverhältnissen und externen ökonomisch-politischen Umständen, beeinflusst. Die Frauen handeln nach ihren wachsenden ökonomisch-bedingten Bedürfnissen.

Das zentrale Ereignis in Coatitlán im Sommer 2007 war ein staatlich gefördertes Straßenbauprojekt, welches die Frauen in der Wahrnehmung ihrer Umwelt beeinflusst, ihr Interesse an politischen Ereignissen gesteigert und die sozialen Netzwerke und Stratifikationen verdeutlicht hat. Die veränderte Infrastruktur und die dadurch erweiterte Landschaftsvision der Frauen schafft neue Möglichkeiten der Existenzsicherung. Das lokale Wissen der Frauen wird sich zukünftig dahingehend entwickeln, dass die natürlichen Ressourcen den neu entstandenen Bedürfnissen entsprechend genutzt werden.

Acknowledgements

Caminante, no hay camino, hace camino al andar.
-Machado

This research and thesis has been not only a companion, quietly looking over my shoulder at every turn I have taken, it is the end product of a long journey, one guided by faith in curiosity, trial-and-error, and the patience of others. I want to thank everyone who was along for the ride:

To Christian Vogl for introducing me to ethnoecology, for constant support whenever I needed it, patience with my slowness, confusions, stubbornness, for proofreading, and faith, constant flexibility, instantaneous support, advice, and seemingly a lot of faith in my thesis production;

The ZIB for the Joint-Study Free-mover scholarship to become acquainted with Mexico *lindo*, Veracruz *bello*, and Xico in the first place, the lifeworld of my thesis research and then KUWI funding;

To Araceli Aguilar Melendez for her support for my research in Veracruz;

To the *Centro de Sierra Santa Marta* for introducing me to rural development research in Veracruz and inviting me along on their trips, their support for my interests and welcoming me into their circle;

To my family: Herb, Martha, Theresa, and Anna Sophie Kernecker, for their humor, encouragement and inspiration always;

To Lisi & Thomas, Magdalena, Elfie, and Gina for constant, immediate emotional support, and love during times of trial in adapting to the Austrian university system, and long grey, cold winters...without them I would not have survived the BOKU or Vienna...;

To Christina and Fritz Marthinegh for a place to live in Vienna during my first two semesters;

To the Barthofers for providing me with a welcoming second home in Austria;

To José Luis Chacón at the *UV Centro de Vinculaciones* for extra information, help, and literature;

And to the entire community of Coatitlán, the wonderful women who took me in, trusted, fed and befriended me!

Table of Contents

| | |
|---|-----------|
| INDEX OF FIGURES | VII |
| INDEX OF TABLES | VIII |
| 1. INTRODUCTION..... | 1 |
| 1.1 PERSONAL INTEREST | 1 |
| 1.2 PROBLEM STATEMENT | 2 |
| 1.3 OBJECTIVE | 4 |
| 1.4 RESEARCH QUESTIONS..... | 5 |
| 1.6 DEFINITION OF TERMS | 6 |
| 2. LITERATURE REVIEW | 8 |
| 2.1 POLITICAL ECOLOGY | 8 |
| 2.2 LOCAL KNOWLEDGE | 13 |
| 2.3.1 <i>Local Knowledge of Ecosystemic Elements</i> | 17 |
| 2.4 WOMEN AND WATER MANAGEMENT | 23 |
| 2.5 HYPOTHESIS | 28 |
| 3. METHODS..... | 29 |
| 3.1 LITERATURE SEARCH | 30 |
| 3.2 RESEARCH AREA: COATITILÁN | 32 |
| 3.2.1 <i>Access to the area</i> | 32 |
| 3.2.2 <i>Geography</i> | 34 |
| 3.2.3 <i>Climate</i> | 37 |
| 3.2.4 <i>Livelihoods</i> | 37 |
| 3.3 FIELD WORK | 38 |
| 3.4 RESEARCH DIARY | 39 |
| 3.5 DATA COLLECTION..... | 39 |
| 3.5.1 <i>Participant Observation</i> | 40 |
| 3.6 PARTICIPATORY RESEARCH METHODS..... | 40 |
| 3.6.1 <i>Informal Interviews</i> | 41 |
| 3.6.3 <i>Unstructured Interviewing</i> | 43 |
| 3.6.3 <i>Semi-Structured Interviews</i> | 43 |
| 3.6.4 <i>Sample Group,</i> | 43 |
| 3.8 DATA MANAGEMENT | 44 |
| 3.9 MATERIALS AND TOOLS..... | 44 |
| 3.10 AUTHORIZATION AND CONSENSUS..... | 44 |
| 3.11 CONSERVATION PARTNERS | 45 |
| 3.12 ANALYSIS..... | 45 |
| 3.14 WRITING | 46 |
| 4. RESULTS AND DISCUSSION | 47 |
| 4.1. LIVELIHOOD CONTEXT OF WATER USE..... | 47 |
| 4.1.1 <i>Kinds of water and their sources</i> | 47 |
| 4.1.2 <i>Water uses</i> | 53 |
| 4.1.3 <i>Water quality and treatment</i> | 54 |
| 4.1.4 <i>Coatitilán and water infrastructure: participatory mapping</i> | 55 |
| 4.2 WOMEN'S LOCAL KNOWLEDGE OF ECOSYSTEMIC ELEMENTS | 56 |
| 4.2.1 <i>Interarations between landscape elements</i> | 56 |
| 4.2.2 <i>Agrarian calendar: livelihoods and landscape</i> | 61 |
| 4.3 WOMEN'S WATER MANAGEMENT AND COMMUNITY INVOLVEMENT | 63 |
| 4.3.1 <i>Infrastructure Development</i> | 63 |
| 4.3.2 <i>Local Politics, Women, and Water</i> | 65 |

| | |
|--|-----------|
| 4.3.3 <i>Division of Labor</i> | 67 |
| 4.3.4 <i>Religion and Natural Resource Management</i> | 70 |
| 4.3.5 <i>Language: local vocabulary for climate related events</i> | 71 |
| 4.4 DISCUSSION SUMMARY | 71 |
| 5. CONCLUSION | 75 |
| 6. REFERENCES | 76 |

Index of Figures

| | |
|--|----|
| FIGURE 1 HIERARCHAL ECOSYSTEM MODEL ADAPTED FROM JUNGERIUS, 1998 | 17 |
| FIGURE 2 ALTERED ECOSYSTEM MODEL WITH ADDED ECOSYSTEMIC INTERACTIONS | 17 |
| FIGURE 3 MAP OF VERACRUZ STATE WITH THE MUNICIPALITY OF XICO HIGHLIGHTED (MARGANA CRUZ, 2006).. | 32 |
| FIGURE 4 MAP OF COATITILÁN AND ITS SURROUNDING REGION (MARGANA CRUZ, 2006) | 33 |
| FIGURE 5 MAP OF COMMUNITIES IN THE MUNICIPALITY OF XICO, VERACRUZ (MARGANA CRUZ, 2006) | 34 |
| FIGURE 6 STREAMS THAT RUN THROUGHOUT COATITILÁN AND COME DOWN FROM THE COFRE DE PEROTE | 49 |
| FIGURE 7 TWO WOMEN WALKING ALONG THE RIVER COATITILÁN GATHERING FIREWOOD | 49 |
| FIGURE 8 WOMAN WASHING CLOTHING AT A SPRING IN A CLOSE-BY PASTURE | 51 |
| FIGURE 9 WATER SPRINGS ABOVE COATITILÁN, COMING OUT OF THE HILLSIDE IN THE FIRST AND LAST PHOTO, GIRL STANDING UNDER THE EXCESS WATERSPOUT AT THE WATER RESERVOIR IN THE MIDDLE PHOTO | 52 |
| FIGURE 10 THE TORTILLA MAKING PROCESS | 53 |
| FIGURE 11 PARTICIPATORY MAPPING: COATITILÁN | 57 |
| FIGURE 12 A SMALL GORGE CAUSED BY EXCESS WATER RUNOFF FROM THE CONSTRUCTION SITE | 58 |
| FIGURE 13 FOG CLOUDS RISING AND COLLECTING DURING THE LATE MORNING | 58 |
| FIGURE 14 MORNING CLOUDS ON THE LEFT, AFTERNOON CLOUD COLLECTION ON RIGHT | 60 |
| FIGURE 15 ROAD CONSTRUCTION AND <i>LA MAQUINA</i> IN THE DISTANCE..... | 63 |
| FIGURE 16 WOMEN ATTENDING THE PRI CAMPAIGN SPEECH | 65 |
| FIGURE 17 ELECTION BOOTHS AT THE PRIMARY SCHOOL IN MATLALAPA | 66 |
| FIGURE 18 MAN GOING TO WORK IN HIS <i>MILPA</i> AND A COUPLE MEN HERDING THE GOATS | 68 |
| FIGURE 19 WOMEN WITH HER CHEESE PRODUCTION SET-UP AND A WOMAN WITH HER PLANTS THAT SHE SELLS | 69 |
| FIGURE 20 ALTER FOR SANTA JUQUILA INSIDE A FAMILY'S HOME | 70 |
| FIGURE 21 THE PROCESSES INFORMING WOMEN'S LOCAL KNOWLEDGE OF WATER RESOURCES..... | 73 |

Index of Tables

| | |
|--|----|
| TABLE 1 WOMEN'S DAILY SCHEDULE DURING RAINY SEASON BASED ON INTERVIEWS AND PARTICIPANT OBSERVATION, JULY-SEPTEMBER 2007 | 48 |
| TABLE 2 AGRARIAN CALENDAR ORGANIZED ACCORDING TO MONTH, SEASON, PRECIPITATION, WORK DONE IN THE <i>MILPA</i> , HOME AND HOMEGARDEN, FORAGING AND OTHER NOTABLE CLIMATE EVENTS. | 61 |

1. Introduction

1.1 *Personal Interest*

As a native Nevadan and dreamer of big skied geographies, the reality of water shortage has always nipped at the peripheries of my idealized perceptions of wide-open landscapes. There was a span of years during my childhood that the nearby Washoe Lake disappeared. One year the shallow lake was there, and the next, it was gone. It took a number of years for it to reappear. Maybe it was this apperception that left the indelible print of the contradictions of water availability and water use on my subconscious. I mean, what was the persistent hiss of sprinklers and hum of lawn mowers doing in a place where there was almost no water? And who, was saying that this was okay? Were other mothers timing their daughters' showers? Perhaps it was these questions that guided my curiosity towards an academic path that, in my mind, would clearly connect people and their cultures to natural resource management and use. This graduate degree would, I felt, allow me to forge together my previous academic and real-life experiences, furthering my understanding of the relationship between people and water management.

As I found out, natural resource management is a field that can range from the tedious procedures of forestry accounting and computer based modeling of rivers to preserving biocultural diversity and integrated land management. Little did I know that committing to a graduate degree in this field would demand some strenuous navigation through a barrage of courses so diverse in their subject areas. It is thus no wonder that at some point in my first year, I found myself increasingly drawn to the most primal relationship people have to natural resources and the management thereof—agriculture. While my coursework followed its required path, I did my best to glean the available university resources to steer my studies towards ethnoecology and water resource management as it related to agriculture and rural development.

I spent the third semester of my graduate studies at the Universidad Veracruzana in Xalapa, Veracruz. Lucky enough to tag along with researchers from the *Proyecto de Sierra Santa Marta* and the *Centro de Investigaciones Tropicales* working in different rural areas in the state of Veracruz, I was exposed to the local pride in tradition, the challenges confronting these communities, and the warm, open, and strong way the women managed their households and resources. In the rural areas of in the state of Veracruz, the water situation and problems facing

communities are of a different sort than those that I grew up with in Nevada. Water seems to be everywhere, from the thick humidity, to rain, rivers and springs. Availability itself is not so much the issue, as is the infrastructure and the decisions made for allocating water resources. When I arrived in Coatitlán, a small community on the slopes of the *Cofre de Perote*, it seemed the perfect place to research such a paradox: so much water everywhere, yet so little of it usable for families. To understand rural, agrarian realities, it is increasingly important to consider specific case studies of local resource management knowledge.

1.2 Problem Statement

Mexico is a country of incredible diversity and contrasts, culturally and biologically. The northern, most arid areas generate most of the country's income and are home to three quarters of the country's population. Despite having very scarce water resources, the north uses the majority of the water resources. The southern half of the country, including Veracruz, is lagging in its economic development and corresponding natural resource management scheme. While this half has the most abundant water resources and precipitation, its populations, in general, have access to and use much less. This paradoxical situation shows that water resource management is a huge national challenge (CNA website 2007). Political and legal measures are in place; however, they fail to be integrated into the reality of the water resource management situation in the rural regions. The legal framework and political measures are directed towards the state level, allowing small communities to get swallowed by the water management regime (Carabias, et al., 2005; Eling & Sanchez-Rodriguez, 2000; La Agenda Azul de las Mujeres, 2006). As in many places, labor patterns are shifting, accounting for men's absence from their communities themselves, and so women have a growing presence in the management of rural communities and are simultaneously responsible for taking charge of the local water resource management (Meinzen-Dick & Zwarteveen, 1998; Cleaver, 1998) and assuming knowledge of the resource situation.

In the rural highlands in Veracruz, water is abundant. This applies to both surface waters and climate-related events. However, the streams and river are polluted, and there is a lack of access to spring water. Both pollution and lack of access are problems for women whose livelihoods depend on these water sources. They are unable to use the polluted streams and river, and have to find spring water to use. Abundant precipitation and humidity are relied upon for crop production. Changes in precipitation patterns are problematic for planning for food production, mobility, and social participation. Engineers and planners do not take precipitation

and seasonal patterns into account when designing projects for rural development. Their uninformed planning, combined with strong climate events create problems throughout the cultural landscape. Such problems include damaging biodiversity, cultural landscape, and affiliated ecosystem services (Buechler, 2000; Durand & Lazos, 2004; Palacio-Velez, 1997).

As in many rural areas in Mexico, women have had to spend a large portion of their days retrieving water from whichever sources are available. In Coatitlán, gravity driven water-tubing infrastructure was installed in the 1990s. This so-called improvement proves provisional and unreliable, rendering a general lack of access to water sources for households. Pollution stems from women's household activities, development projects that are meant to develop Coatitlán's economic activity and infrastructure. Development planning does not respond to local environmental situations or needs, nor does it take into account the local knowledge systems and resource management. It thereby perpetuates the exclusion of rural communities from the state and the exclusion of women from these communities by neglecting to consult them on their needs and the resources they depend on (Shiva, 1989; Meinzen-Dick & Zwarteven, 1998).

Daily management of water resources reflects the changes in living and livelihood conditions. As the principle managers of water resources, women are the most affected group within rural populations and indigenous populations in Mexico. Women's management and knowledge of natural resources are ignored and not valued by the state because they belong to the private, and decentralized management sphere (Zwarteven & Meinzen-Dick, 1998). The "*Agenda Azul de las Mujeres*" was established in Mexico in order to identify the needs, problems and propositions of women and how they have to do with access, management and control of water resources (Smith & Marin, 2005). The limited access women have and their limited control of the water resources or dealing with consequences of either excess or lack of water resources due to property rights reduces the equity in access to water (Agenda Azul de las Mujeres, 2008).

The main problem I am dealing with in my thesis is the fact that women's knowledge of water resources in their livelihoods and practice of agriculture have remained largely invisible to regional, national and international environmental and development agencies. This may occur because women's local knowledge about water resources is not available to rural developers, who still do not consider women's livelihood tasks as the keystone of rural community life that

they are. When women or their knowledge is not taken seriously or considered, they themselves do not value their knowledge of natural resources. Women are not accounted for in development, because their knowledge is not deemed as valuable, because it is not “scientific.” I feel that if women’s local knowledge based on natural resources would be examined and investigated more often, it would more often be consulted in rural development planning, boosting women’s participation, and boosting the value they themselves attest to their knowledge.

1.3 Objective

My objective is to research women’s local knowledge of water resources and management thereof and find out how it is adapted to changing livelihood systems and landscape patterns. This thesis should thereby explore the relationship between local women and their rural water management system in the Veracruz highlands. This system rests on how the women in Coatitlán use water resources, and why their corresponding knowledge is the way it is, how the local cultural landscape and livelihoods inform their knowledge. The goal is to move beyond the attempt to locate the struggle over resources within this context and the corresponding resources. The practices of the women and the men, within limiting but not determining social structures, are critical to the way local knowledge is formed (Moore, 1996). Women remain acutely aware that the rules of access to and control over usable water resources are not about systematizing tradition, but instead, the result of local political resource-based negotiations and men’s migration (Carney, 1996). Discussing resource access and control have proven to be relevant in the discourse surrounding resource use, especially at the level of household management (Agrawal, 1992), which women’s knowledge is based on.

Comprehending what women know about water resources and how they manage them, is crucial to their participation and representation in decision-making processes regarding the way the natural resources in and around their community are managed. To portray what women know about water resources in Coatitlán, I will try to identify what women know about water resources and the relationships between other natural resources in their cultural landscape. Then I will explore factors that seem to influence and potentially change women’s local knowledge of the water resources that I find particularly interesting, including climate change, the regional political economy, and traditional water management methods.

The overall objective is to identify what makes up women's local knowledge of water resources and the intricate relationships between water uses and other natural resources in the immediate environment, cultural landscape, that define the way they manage water resources. This thesis should thereby also build on the existing corpus of literature on local knowledge of natural resource management, women's water management, and present a case study that fits into the political ecology realm. I would hope that my thesis would link local to scientific knowledge, as it relates to water management. The secondary objective of my thesis and research should be considered as a pilot study, testing my own ability as a researcher to apply theory to a real life situation and conduct ethnoecological fieldwork.

1.4 Research Questions

The main question guiding my research is concerned with **what women's local knowledge of water resource management is in Coatitlán and why it is the way it is**. In exploring this question, I will address the following subset of questions:

1. What is the livelihood context of water use in women's everyday life and livelihood tasks?

This question deals with how what women do is related to natural resources, their dependence on them, and how their livelihoods define their relationship to the natural resources in their immediate agroecosystem and landscape. In particular, this question will define what women define as their water resources, what they are used for specifically, and how access is defined—if property rights play an important role or not in how women use the resources they define as water. This question deals with the political ecological context that women in Coatitlán manage water within.

2. Which ecosystemic processes do women recognize as occurring between the ecosystemic elements that they also identify in their immediate cultural landscape?

I cannot understand how women understand water resources and why they manage them the way they do without finding out how women understand the agroecosystem that they are a part of.

3. What is the political-economic context that women manage their water resources in?

When we are talking about the political-economic context of a small, agrarian mountain community, we are talking about the power structures, social hierarchy, decision-making power,

and how these forces may or may not be related to income generation or simple means of survival that women depend upon. This question is related to the first question, as the political structure within the community of Coatitlán is very dependent on the level of women's empowerment. This is, in turn, dependent on what all women are in charge of, what they know about the functioning of their cultural landscape, and their role in it, as water managers for their families' survival, based on how women perceive the relationship between the *milpa* and water resources, and remaining water management for household duties, all belonging the larger picture of their livelihoods. Their knowledge may have changed as the infrastructure in Coatitlán and access to resources in Xico, Xalapa, or even further away has increased or grown easier.

1.6 Definition of terms

While some readers may demand consistency, I relinquish monotone terms for the fun of verbal dexterity. When referring to rural women, I refer to them as they belong to a community of land managers. I use the term peasant interchangeably with land manager, farmer, and agricultural producer.

All of the terms mentioned above refer to some main characteristics as defined by Ellis (1993). These include that these people should be distinguished from non-farm groups and agricultural enterprises such as plantations, estates, or commercial family farm. Terms referring to peasant and land managers indicate spatial and temporal adaptation to change, including their traditions. Furthermore, peasant and land manager families and their households should be considered a whole "unit of analysis" as it interacts with the larger economy. Peasants are not completely integrated into markets, partially because these markets are not adapted to the farmer's mode of production and survival. These families not only farm, but also are engaged in non-market livelihood activities, including gathering firewood and water retrieval (Ellis, 1993; Chayanov, 1991). I use the term "livelihood" in reference to all of the tasks that support family and household survival, specifically their means of subsistence.

Sauer (1925) has a thorough description of what a cultural landscape is, and how it is formed, and how cultural development and changes continuously created and then recreate the places and landscapes where people live. He maintained that the cultural landscape is shaped by a culture group's use of their natural landscape. Essentially, culture is the means, the natural area is the medium, and the result is the cultural landscape. The natural area is of utmost importance, since it supplies the resources that shape the cultural landscape. When I refer to

landscape, I am referring to everything that can be seen, from the ground to the clouds and the sky.

Gender refers to the power relations between women and men as they are revealed in a range of practices, ideas, and representations, including the division of labor, roles, and resources. The power relations can be attributed to different abilities, attitudes, desires, personality traits, and behavioral patterns (Agrawal, 1994; Nightengale, 2003). However, discussing or defining gender is not my goal, as this entails a study of its own (see Butler, 1990; Connell, 2002). Nevertheless, it is the in the power relations and all correlated patterns that have a lasting effect on the way natural resources are used and managed.

2. Literature Review

In my research of women's local knowledge of water resources, I thought, at first, that this was a fairly specific subject. It turns out I was wrong. Yes, it does fit under the rubric of political ecological, ethnoecological, and feminist geography studies. But drawing the lines between these fields became harder and harder for me. The more and more I got drawn into my literature review, the more integrated everything seemed to be.

When investigating women's local knowledge of water resources, I first had to identify all the separate concepts that are part of this subject area. Water management in general, is a political process. Because it is a political process directly affiliated with natural resources, water resources, I reviewed political ecology literature, dealing with access and control over resources. To better understand rural, agrarian management structures, it is important to first find out what local knowledge is, as it is strongly related to control and access. I would have to get a strong base in the general discourse of local knowledge, including what farmers, land managers in general and women know about the processes occurring between elements in the ecosystem. And, because what people know is based on what they need resources for and the corresponding tasks, many divisions of labor and corresponding knowledge is gendered. I also reviewed literature falling into gendered political ecology or feminist environmentalism.

First I will review political ecology literature, which is important for a base of political-economic contexts that natural resources are managed in. Second, I will review a body of literature dealing with local people's knowledge of ecosystem components and how these people systematize natural resources in relation to each other. This deals with local knowledge. Lastly, I will review literature that is relevant to women's livelihoods and their water use and management.

2.1 Political Ecology

Political ecology encompasses conservation, use and control of natural resources by social groups in the face of complex relations between politics, economic pressures and societal regulations (Blaikie, 1985; Peet & Watts, 1996; Haenn, 1999; Watts, 2000, Robbins, 2005). Political ecological studies are rooted in their critique of the quest for economic growth leading to a shortage and misuse of natural resources (Peet & Watts, 1996). Doing a literature review of these corresponding studies served to become informed about the basis of discussions dealing with the people—natural resources relationship and the ways in which it is typically considered.

The historical development of political ecology as a discipline of its own is embedded in the history of economics. This means that economic theorists from the 17th century, including Adam Smith, Malthus, Ricardo, and Marx all contributed to the fundamentals of how people relate to natural resources. Namely, during this period, natural resources were implicitly linked to economic activity, since these resources provided the materials for productive activities. Thus, the political economy¹ is transformed by and transforms individuals and nature. By simply studying the political economy everything gets reduced to social constructions, thereby disregarding all things non-human. And so, ecology is expanded by political ecology to better include cultural and political activity within the analysis of ecosystems that are considerably but not wholly socially constructed, thereby expanding formerly narrow interpretations of either field (Greenburg & Park, 1994).

Throughout the 20th century, social scientists further explored the place of humans in ecosystems. The link between access to ecosystem services and power played a crucial role in how natural resources were managed. The concept of the hydraulic empire referred to a social or political structure that maintained power by having exclusive control over access to water (Wittfogel, 1957). Peasant studies (Chayanov, 1986) combined questions of how communities were being integrated into and simultaneously transformed by a global economy with local resource management and environmental regulation and stability, dealing with the transition of the global economic forces of capitalism (Peet & Watts, 1996). Chayanov (1986) studied how a farm family could adapt to or manage its livelihood during periods of resource scarcity and market fluctuations (Chayanov, 1986; Robbins, 2001). Scientists from this time period working under the banner cultural ecology and geography could now, retrospectively, fit also into the political ecology category.

An important facet of political ecology is its exploration of the adaptive relationship that land managers² have to their livelihoods and corresponding natural resources (Walter, 2005). Blaikie & Brookfield (1987) considered the land manager, who is also in charge of food production, as a central actor in exploring people's relationship to nature. This is reflected by the fact that historically, peasant societies worldwide were adaptive systems, and followed cycles parallel to

¹ Understood as the study of the condition under which production is organized by regions and nation-states; the ways that communities with common economic interests used politics to effect beneficial changes (Robbins, 2005).

² I use the term land manager, farmer and peasant interchangeably, all in reference to rural persons who live predominantly off of the land. See my definitions section.

the ecosystem and ecosystem services (Rappaport, 1967). Rappaport's studies of wild pig populations and the peasants in New Guinea are one example of how anthropologists were using theories applied to systems from ecology for explaining social phenomena. Critiques of this method of studying people and their ecosystems most often focused on the lack of clear boundaries in such studies (Park & Greenburg, 1994).

Land managers' organization according to the natural resources in question often means considering power roles within a user group and the access granted to individuals within the group, or the group as a whole. Many political ecological studies deal with environmental degradation, seeking to expose flaws in dominant approaches to environmental resources, exposing the unwanted impacts of policies and market conditions, especially as they affect local people. It contests the way ecosystem services, i.e. natural resource management occurs, whether through regulatory institutions or local knowledge systems, and if resource user groups are allowed to occupy an important or relevant space in civil society, as resource users (Blaikie & Brookfield, 1987; Robbins, 2005).

Throughout the decades, as political ecology has continued to evolve, the discourse about power relations, namely the interplay between peasants and the state, centered on natural resources that are in the rural landscapes, has shifted to focus largely on questions of access to natural resources and how that access differs between different social groups. Thus, access to and adaptation to changing availability of natural resources, specifically by land managers, who have historically had a central role in this relationship, is, for me, the central message and goal of political ecology. Thereby the relevant position of land managers in the interplay is acknowledged and reinforced.

The social relations of agricultural production in rural communities that are entrenched in local land-use practices play a central role in regional and global political economies. Landscapes cannot be understood without taking the associated livelihoods into consideration. This is based on the assumption that ecological processes cannot be understood without first understanding the contexts of local productive relations and wider economic systems, reinforcing the relevance of social relations of production influencing land use (Watts, 1983; Zimmerer, 1994; Moore, 1996). These social relations span from gender relations, to local history, and to culture, and are simultaneously defined by the regional results of global economic forces (Moore, 1996).

The mode of livelihoods production is a combination of key social and material elements; these elements are constant. In political ecology, systems of knowledge come into play, specifically in terms of investigating social systems that have different ways of going about things: different values and beliefs, priorities and decision-making systems. The field expands the exploration of ecosystems in their social construction, including cultural and political activity (Greenberg and Park 1994; Robbins, 2001; Rochelau, 1996). Researchers continue to study local ecological knowledge and management, with increasing recognition of the role of regional economic cycles in setting the terms of subsistence (Barham & Coomes 1996, Berkes 1999). In *Beyond Land and Water* (Nietschmann, 1979), the predicament in local natural resource management systems is explained by describing the changes and conflicts that occur in the peasants' production system, while reconsidering the social context of decisions, the economic context of those social systems, and the political context of that economy. This shows the many layers that make up the livelihoods context of people's landscape.

Cockburn and Ridgeway (1979) claimed that political ecology is based on the fact [rural] of environmental degradation stemming from corporate and state mismanagement needs to be carefully followed, so that grassroots activity can be documented in response. Thus, their goal is to explain natural resource change in terms of constrained local and regional production choices within global political economic forces, largely within a rural context. This means they strive to get a better understanding of both the regulatory systems that occur in the management practices and disappearing knowledge, and ultimately, integrating these knowledge and practice systems into alternative development approaches (Peet & Watts, 1996). Hempel (1996) claims that by exploring and explain community-level and regional political action in the global sphere, in response to local and regional degradation and scarcity, the interdependence among political units and their natural environment and the resulting political consequences of environmental change can be studied. Watts (2000) recommends a careful analysis of the forms of control over resources and their implications for environmental health and sustainable livelihoods, since an absence of possibilities to do so can encourage environmentally damaging activities (Scott and Sullivan, 2000). Political circumstances can foster those kinds of activities—obvious examples being the Green Revolution of the 1970s that manifested itself in agricultural production all over Latin America.

The process of adapting management of natural resources can result in a range of consequences in the natural resources that make up the cultural landscape in question. As

many studies of shared natural resources have made clear, open-access schemes lead to individuals divesting costs to the rest of the community or society while pursuing private benefits. This leads to catastrophic consequences for the resource itself in the long run (Ostrom, 1990). Common property resources are defined resources for which it is difficult to exclude users. There are a couple basic requirements for making commons work. The first is to establish some kind of property rights, which may be private or communal; the important point is to remove the open access condition. The second requirement involves creating and then enforcing resource use rules among the users themselves. Once property rights and resource use rules have been established, both the costs and benefits of any management action stay with the same group of shared users. Commons property resource users then become a management system, because they can mutually monitor management results, and ultimately adapt their decisions, as they need to for their specific context. Failure of collective management is a failure in the specific structure of rules that govern collective property, influencing the value of the resource in question (Ostrom, 1990; Dietz, et al, 2003).

A local, communal property-rights system is characterized by certain prerequisites to allow it to work. These include that there be accurate and shared information about the condition of the resource. Also, it means that those participating in the natural resource management system share a common understanding about the potential benefits and risks associated with the continuance of the existing condition as contrasted with changes in norms and rules that they could feasibly adopt. Trust is a key ingredient in the system and the respective “norms of reciprocity.” Based on this trust, participants follow certain agreed-upon rules that are based neither solely on unanimity nor on explicit control by few. This most likely can only work if participants plan to live and work in the same area for a long time, also allowing the participants to balance their interests (Berkes, 1992; Dietz, et al, 2003). Balancing their interests is a part of adapting to changes and remaining flexible for new local developments, changes that encroach upon small, rural mountain communities through the political economy.

This body of literature has integrated the insights of political economy with those from environmental science and moved beyond narrow area-studies and development studies focus. The multiple contributions of political ecology literature have produced a body of work that has inspired scholars across theoretical, empirical and disciplinary boundaries, thereby ensuring that the way ecological processes as they are interlinked with social processes will be interpreted and re-interpreted for many years to come. What I have drawn from reading about political

ecology and political ecological case studies is that it is the perfect complement to local knowledge and ethnoecological studies, since it provides a global base for a local study of people and natural resources, whether it be in terms of conservation, power or access—and how these three aspects may all overlap.

The political ecological discipline of study has emerged from a long history, with roots in the political economy. When scientists from other fields, particularly geography and anthropology saw the limitations in previous studies, they started applying ecosystem sciences and the methods used to study them to cultures and people's ways of life in an increasingly globalized political economy. Case studies that fall into this category make it hard to distinguish disciplinary boundaries, but accommodate the interwoven nature that characterized environmental and social problems. Many times they deal with environmental problems that coincide with economic-political opportunities and lack thereof. Specially, how marginalized communities and individuals deal with these problems. Solutions suggest a need for participatory decision-making, or describe case studies where self-organization for improved decision-making improved both landscape and ecosystem services, natural resources, and access to them—both in terms of improved quality or quantity.

2.2 Local Knowledge

Political ecology can and must acknowledge the interested and contextual character of local knowledge, they must also explain the structured biases built into official knowledge systems, which are used by experts to secure employment, control resources, and justify extraction and enclosure (Bebbington, 1996). Local knowledge of managing natural resources has become increasingly relevant in the last century, as is reflected in political ecology and ethnoecological literature that specifically investigates local resource users' knowledge. Literature on local knowledge includes local knowledge of natural resources, and their management, often adaptive. Gender specific studies of natural resource management are also prolific. Existing ethnoecological literature reflects land managers', farmers' identification of ecosystem elements and the processes that occur between them. The emphasis in my research is on the farmer as the "knower" and on the "knower's" capacity to invent and create knowledge and apply it (Bebbington 1996 quotes Giddens 1979 and Long 1990). With the term "farmer" I am addressing the rural population dependent on agricultural production at large that is relatively marginalized in representation by political/economical decision-makers at all levels.

Rural people dependent on agricultural production are engaged in livelihoods requiring regular contact with their immediate natural resources (Valbo-Jørgensen, 2004; Mackinson & Noettestad 1998). As a result they have a profound awareness of their local ecosystems allowing them to adapt their use of natural resources to changing climate patterns and demands in [global] markets (Berman & Kofinas, 2004; Berman et al., 2004; Snowshoe, 2001; Valbo-Jørgensen, 2004). This means that farmers, specifically, are able to adapt their natural resource management practices because of their deep understanding of the connection between ecosystemic elements, from the ground to the sky, from soil to climate. Although it is the farmers around the world are invariably connected to their immediate natural surroundings, it is governments and other responsible institutions that end up defining how natural resources are used, rendering the actual individual resources users and groups invisible to the decision making process. Many individual users and groups are sometimes invisible to decision makers, planners. To avoid misinformed decision making, it would be beneficial to consult with farmers and other local resource users before setting resource management norms (Chambers, 1994), getting an insight to their knowledge of the local ecosystem, natural resources and their relationship to those who constantly use them.

Local ecological knowledge is often an integral part of the corresponding local culture, and management is adapted to the local area. Resource users themselves are the “managers.” They identify themselves as members of local community and not as individual scientists or resource managers answerable to their peers or an anonymous government agency (Berkes, 1999). According to Lewis (1993), knowledge begins at the level of shared systems of classifying natural resources or phenomena, leading to the understanding of processes or functional relationships. This approach considers societies’ modes of production as adaptations to their local environment (Berkes, 1999).

Also referred to as traditional, folk, indigenous, or farmers’ knowledge systems, local knowledge is based on the context it occurs in, reflecting the world view and ideas that are shared by people living in a specific region (Barrera-Bassols & Zinck, 2002). Local knowledge is an active and living paradigm, shared between generations, evolving to and adapting with the influx of new ideas, external pressures, and interactions between individuals and social groups. Local knowledge is not static or isolated, but built upon and spread by social interactions between resource users. While it is specific to certain locations, it can vary from individual to individual or from community to community, according to age, gender, socio-economic status, ethnicity or

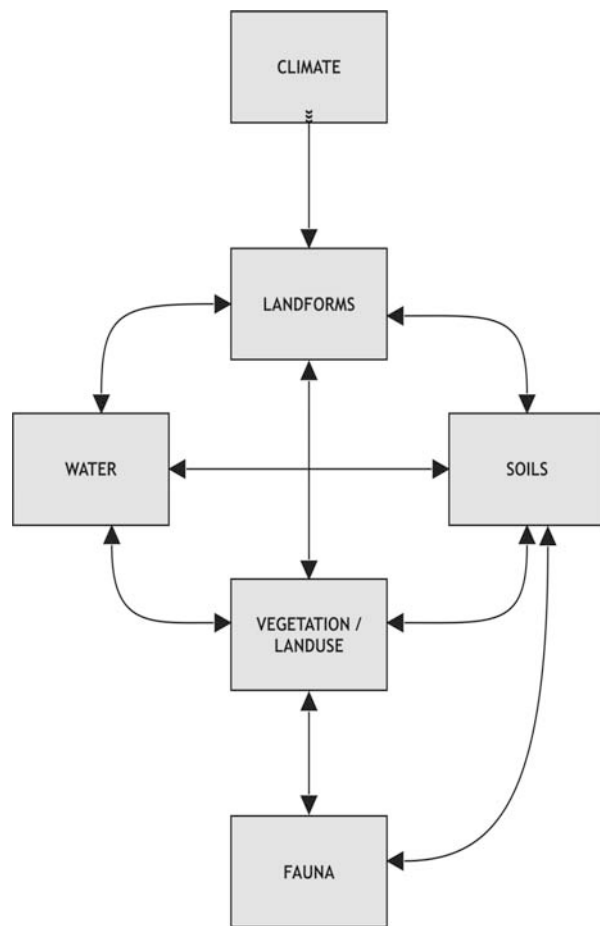
occupation (Berkes, 2003; Berman & Kofinas, 2004; Sumberg & Okali, 2002; Ryder, 2003). Local knowledge is the sum of understanding and observations that farmers reveal regarding their livelihoods and landscape (Ericksen & Ardon, 2003). Farmers' local knowledge is revealed through their agricultural practices, and how they define elements within their immediate agroecosystems (Oudwater & Martin, 2003; Barrera-Brassols & Zinck, 2000). Their local knowledge of the processes occurring between ecosystemic elements is crucial for understanding the way they classify, name, and categorize each element, each resource within the landscape and agroecosystem. To move beyond classification systems (Niemeijer & Mazzucato, 2003), it is necessary to understand how farmers translate their knowledge of the various ecosystemic elements and natural resources to the way they farm (Barrera-Brassols & Zinck, 2000; Oudwater & Martin, 2003). Farmers' observation and adaptation according to local and changing conditions form a crucial part of maintaining the dynamic nature of their local knowledge (Corbeels, et.al, 2000; Sumberg & Okali, 2002). Farmers respond to instability, variability and transition with an impetus to identify site-specific solutions to sustain, retain, or restore soil fertility, crop health (Hihorst, et.al, 2000), and water quality. This process of adapting knowledge demonstrates that farmers understand at which points of the ecosystem they might need to intervene to produce better results in their production, which reflects their deep understanding of their surrounding natural environment.

People's knowledge, whether from those who are considered "experts" or not, are embedded in cultural norms, social relationships, and value-laden judgments, even and especially in large-scale scientific investigations like climate change (Demeritt 2001). Ethnoecology focuses on the conceptions of ecological relationships held by a people or a culture. It is a subset of folk science defined by Hardesty (1977, 291) as "the study of systems of knowledge developed by a given culture to classify the objects, activities, and events of its universe". The application of traditional ecological knowledge to contemporary resource management problems in various parts of the world has become recognized in the international development paradigm (Berkes, 1996). Local knowledge is a preferred term because it conveys neither the ecological aspect of the concept, nor a sense of the temporal dimension and cumulative cultural transmission. Local knowledge refers to recent knowledge (Berkes, 1999).

Local knowledge can also rely on critical studies of science as a way of the politics of why regulatory structures are the way they are, why they may be privileged or institutionalized, and how facts are challenged. The discourse of local knowledge as it pertains to competing,

conflicting and cultural, racial, gender, class, or regional interests may coexist. Knowledge about the world is synthesized into generalizations and principles independent of context, space and time (Capra, 1996). Stevenson (1996) defines specific “interrelated components” of traditional ecological knowledge including specific environmental knowledge; knowledge of ecosystem relationships; and a code of ethics—agreements for common property management—governing appropriate human-environmental relationships. In a resource management system local environmental knowledge also includes an appropriate set of practices, tools and techniques. Those ecological practices require an understanding of ecological processes, such as the functional relationships among key species and ecosystem elements. A management system could be compromised of the appropriate social institutions, sets of rules-in-use, and codes of social relationships. Local knowledge may grow; both management systems and institutions can adapt, change, fall apart and then be renewed (Berkes, 1999). Klooster (2002) states that there is a differential value of local and scientific knowledge in varying contexts. In rural Mexico, for example, local knowledge has been shown to be somewhat less effective at evaluating the medium-term impact of human actions than scientific knowledge; even though it is more flexible and adaptive in its implementation (Grossman, 2003). While the local knowledge of these processes were reported by researchers, and their findings are considered as local knowledge, I, myself, would claim that the processes identified were structured, systematized by researchers themselves.

This literature review relates to the second part of my research question since it reviews the literature of how land managers perceive their landscape, the elements that are a part of it. Without knowing how the different elements of the ecosystem that the farmers themselves are a part of, interact, they would not be able to be engaged in their livelihoods. Failures of many imposed environmental management solutions including forestry and selling timber, around the world, the results range from failed crop introductions to detrimental changes in property rights, highlight the necessity of environmental knowledge developed locally (Brokensha 1980). Decision-makers neglect local knowledge and corresponding management systems because their fundamental characteristics do not fit the new development paradigm: this refers to the embeddedness of knowledge in the local culture; boundedness of local knowledge in space and time; the importance of community; lack of separation between nature and culture, and between subject and object; attachment to the local environment; and a non-instrumental approach to nature (Berkes, 1999).



2.2.1 Local Knowledge of Ecosystemic Elements

To gain insight to how land managers, subsistence farmers, or peasants, understand the natural resources in their immediate environment, and plan their livelihood accordingly, I read through an onslaught of literature on local knowledge. This literature insinuated that farmers make connections between natural resources and other ecosystem elements, including climate, and the processes occurring between them (Fig.1). This is to say that farmers use a system of rules and causes and effect for planning the way they schedule their agricultural and other livelihood activities and also organize their natural resources. The local knowledge literature I reviewed consisted predominantly of case studies of farmers in different regions and their natural resources management methods for their immediate landscape.

Figure 1 Hierarchal ecosystem model adapted from Jungerius (1998).

After finishing the literature review for ethnoecological case studies, I realized that I needed to adjust the model to better fit the many additional interactions that occur between ecosystemic elements. The final model that I made shows how water and climate are part of a very interconnected system of processes that make up the cultural landscape or agroecosystem. Ecosystemic processes occur through the reciprocal influence that elements have on each other. A theoretical model made it easier to follow the way local knowledge is mapped out or understood by the researchers. After reviewing numerous ethnoecological case studies done on farmers in different regions, I adapted the model of understanding how farmers understand their immediate landscapes to better reflect the interconnectedness of the natural resources.

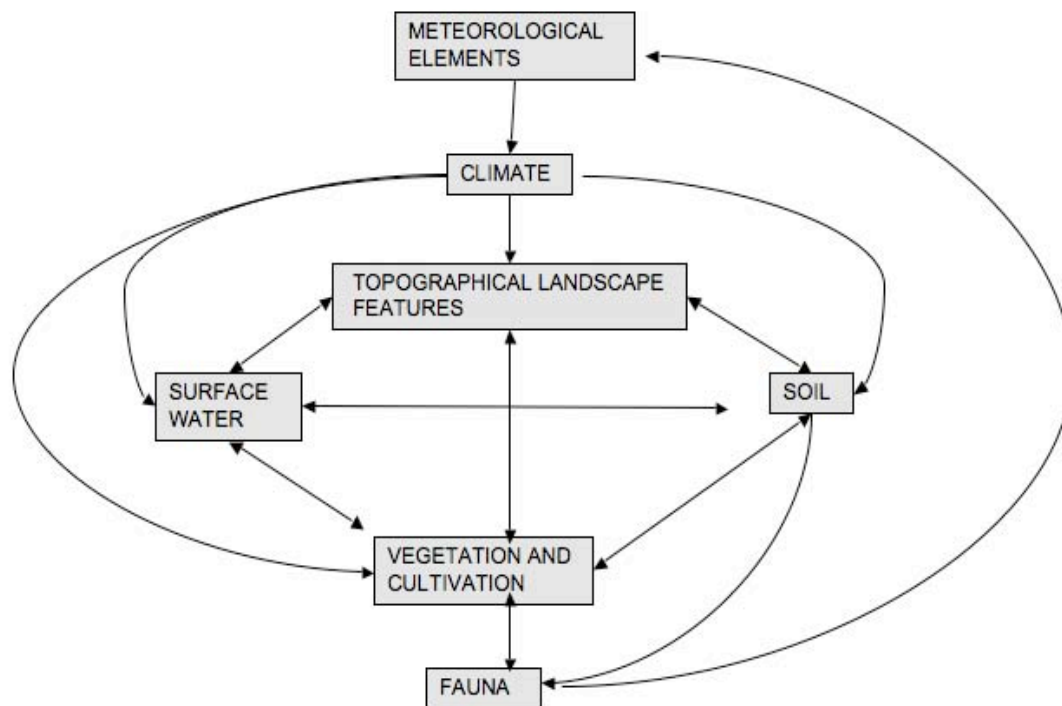


Figure 2 Altered ecosystem model with added ecosystemic interactions.

In my literature review, I read for processes between local knowledge of ecosystemic elements and natural resources, organizing them in relation to each other in the hierarchal model (Figure 2). This model reflects the ethno and agroecological studies from around the world. The process that connects climate to landforms includes anything that has to do with atmospheric pressures on landforms. These come in the form of wind, precipitation, and temperature. For example, the process between climate, to landforms, and soil can represent erosion through rainfall. Climate can directly influence landforms through wind, by moving sediments, altering the landscape. Landforms influence water resources and their distribution. Higher elevations and steep slopes provide lower elevations with water. Water resources include all bodies of surface and ground water, counting soil moisture. In the model, vegetation and land use is an element denoting crops and human land use planning. Fauna includes animals, most often connected to the agroecosystems and landscape through their manure, used for soil. Fauna also refers to the microorganisms in the soil. Animals are dependent on vegetation and are affected accordingly. Climate also has an impact on animal behavior. Vegetation/land use is related to soil through nutrient addition or reduction occurring through compost or other region-specific practices. The

relationship between water and soil can be identified through the process of water drainage, erosion, and absorption (Jungerius, 1998).

In the following sections, I will go through selected processes in greater detail occurring between ecosystem elements that land managers, farmers, recognize according to the literature reviewed. By assigning farmers' observations about their immediate landscape to an agroecosystem model, it becomes evident that dividing soil into "good" and "poor" could denote a difference in the way farmers recognize all the natural resources and elements influencing each other. This demonstrates, that farmers' local knowledge of ecosystems goes beyond a simple hierarchal understanding, and informs them about events and ecosystemic interactions should be avoided or sought after. In the following sections, I will highlight the most relevant processes that include climate and water resources. Because my research deals specifically with water resources, I am presenting solely a review of the processes I interpreted, that include water resources, either in the form of precipitation or surface water.

2.2.1.1 Vegetation and Atmospheric Pressure

Ethnoclimatological³ and ethnometeorological⁴ literature makes up a large bulk of literature I reviewed to find out what other researchers reveal farmers' knowledge of ecosystems. There are three categories within the interaction occurring between the landscape and climate that farmers take into consideration when planning their cropping: 1. How farmers tell forecasts, how they are used, and what they mean, 2. The link between precipitation and crop or vegetation health, and 3. Land use activity planning with seasonal weather trends.

In certain regions, farmers use plants to forecast climate or weather patterns. Using plants in this way reflects farmers' knowledge about their local vegetation and how it responds to climate and other atmospheric pressures. For example, In India, the variation of the blooming of the golden-shower tree has been used to predict the onset of the monsoon, since the flowering peak occurs a month and a half before the rains do (Orlove, et al., 2002). Forecasts are important for farmers because that they link atmospheric pressures with their cultivation practices and planning. Farmers who rely on rain to water their crops are particularly motivated to understand precipitation patterns.

³ Local knowledge about climate processes (Orlove, 2003).

⁴ Local knowledge of weather processes and forecasting (Orlove, 2003).

Humidity and wind information is especially relevant during specific seasons, such as harvest and pesticide application. Climate and weather variability have a great impact on crop yields and livestock weight gains, and consequently agricultural production (McNew, et al., 1991; Orlove & Tosteson, 1999). Orlove and Tosteson use the term “forecast” as it guides generation, diffusion, modification and application of scientific information in terms of historical, scientific and culturally dependent human-environment relationships (1999).

Some may rely on governmental institutions for weather information, while others make their own predictions based on traditional knowledge. There are several examples. Farmers in the Andes read the Pleiades constellation, using it to interpret the coming weather; farmers are able to accurately coordinate planting with rainfall by reading the stars (Peru, Bolivia: Orlove, et al., 2002).

They connect rain and temperature with conditions that facilitate plant growth. In this specific example, farmers cultivate understand weather patterns in conjunction with potato needs and characteristics. On Lombok Island, Indonesia, farmers rely on rainfall as their sole source of water in their crop production. They use traditional weather forecasting methods that are also based on the stars, moon position, and crop condition (Indonesia: Suyuti, et al., 2004).

Information regarding immediate weather events, including precipitation, wind shifts and dew points, or drying conditions current weather conditions, when available, are most heavily relied on (United States: McNew, et al., 1991). Farmers in Australia base their weather predictions on long-term averages they keep track of, but increasingly work from weather forecasts made by government institutions. The lack of forecasts of future weather patterns instigates the most insecurity in the region (Hoffmann, 2002). Huda, et al. (2004) address the use of forecasting for land use decision-making, specifically in the case of the El Nino and seasonal events for managing rangelands in Zimbabwe, cropping in Indonesia, and southern India. The timing of weather events defines the sequence and timing of agricultural activity and land management. Crop selection, sowing time and area, fertilizer, harvesting, yield estimation, crop quality, marketing and consumption are related to understanding forecasts (Huda, et al., 2004).

Farmers plant their crops according to the seasons to recognize coming seasons and plant their crops accordingly. They adjust their planting season to fit rainfall patterns throughout the year (Ethiopia: Corbeels, 2000; Mexico: Pulido & Bocco, 2003). For example, in the Ethiopian case,

the time with little rain is the *Belg* season, where farmers plant corn and sorghum that do not necessarily need as much moisture. In their rainy season, the *Kiremti*, they do most of their planting (Mexico: Pulido & Bocco, 2003). The strong correlation between precipitation and cultivation shows that farmers understand that crops need high amounts of water during the initial cultivation phase of waiting for plants to grow. Andean farmers connect the distinct growing season with the rainy months of the year, usually from October through March, which are the warmest months and longest days for planting. Farmers rely on the right level of soil moisture and air temperature, and so aim to plant their potatoes right at the start of the rainy season (Orlove, et.al., 2002). Harvesting and subsequent storage is set aside for the dry season, when it is not only easier to work, but keeps crops from rotting due to moisture. In Michoacán, Mexico, farmers focus on forest management, logging and extracting resin in the dry season (Pulido & Bocco, 2003) to avoid rotting.

Farmers relate strong rainy season with successful harvests. This is apparent through farmers' adaptation to drought years, when farmers lower their number of livestock, use various methods to conserve soil and water and change the fertilizers they use (Zimbabwe: Chuma, et al., 2000). Farmers in Mali blame the reduction in crop growth on reduced precipitation (Dembelé, et al, 1999). In Mexico, the same correlation was observed, the reduction of precipitation resulting in the reduction of wild plant species availability. The changed climate has turned the rain into "being uncaring or envious," forcing agricultural practices to adapt (Mexico: Hersch-Martinez, 2003).

2.2.1.2 Landforms and Water Resources

For many farmers, landforms define whether or not water resources are available and how they are managed. Slope is the main factor in the interaction between these two elements. The connection between landforms and their influence on water resources defines how abundant the corresponding harvest will be (Honduras: Erickson & Ardon, 2003). This is because topographical attributes of the cultivation landscape influence drainage and moisture availability in the soil. Steep slopes will cause water resource, whether surface water and irrigated water, to potentially drain away (Niemeijer & Mazzucato, 2003; Kenya: Jungerius, 1998) and take soil with it (Mali: Onduru, et. al., 2002).

2.2.1.3 Atmospheric Pressures and Landforms

Furthermore, farmers also use techniques according to elevation and its relationship to precipitation and other atmospheric pressures. Atmospheric pressures are linked to landforms typically based on erosion that alter the landscape. Different precipitation patterns form gorges by eroding hills and leaving them rocky. Farmers note that excessive precipitation creates “scraping water,” making hills smaller and forming valleys (Niemeijer & Mazzucato, 2003). This process of erosion reflects atmospheric pressures’ influence on landforms (Zimbabwe: Chuma, 2000). In the Mackenzie Delta in Canada, for example, people relate the erosion and sometimes disappearance of whole riverbanks and landslides with a warmer climate (Snowshoe, 2001). On the other hand, herbalists in Kenya explain that altitude of land influences climate (Jungerius, 1998).

2.2.1.4 Atmospheric Pressures and Poor Soil

The link between atmospheric pressures and poor soil is connected to the previous interaction described. The effects of atmospheric pressures and lack thereof best characterize this, causing soil erosion (Burkina Faso: Lompo, et al., 2000; Ethiopia: Data, 1998). The process occurring between atmospheric pressures and the soil results in nutrients being washed away, which is detrimental to cultivation (Ethiopia: Eyasu, 2002). Farmers consider wind erosion a problem for soil, as wind dries soil out, depleting it of its fertile particles (Ethiopia: Eyasu, 2002; Data, 1998).

2.2.1.5 Atmospheric Pressures and Good Soil

As with the other processes, the knowledge that farmers have of the process linking atmospheric pressures and poor soil at the same time reveals knowledge of the link between atmospheric pressures and good soil. One of the most specific examples of farmers’ knowledge of the influence of atmospheric pressures on good soil is in Burkina Faso, where farmers maintain and conserve the quality of soil by using agro-forestry techniques and constructing planting pits. These pits essentially are a system of integrating organic materials back into the soil. The key is that their technique relies on the wind to transport organic material into the pits they construct (Lompo, et al., 2000).

2.2.1.6 Atmospheric Pressures and Fauna

Farmers demonstrate that there is also a relationship between these two elements, via the effect that climate change has on vegetation. It influences the amount and kinds of fauna and animal species arrive to their region (Canada: Snowshoe, 2001). Farmers’ land use-planning

reveals that they connect atmospheric pressures and livestock. The manure coming from their livestock is allowed to decompose in separate quantities according to season and precipitation. Farmers distinguish between the fertility of the manure according to the season in that it decomposed.

2.2.1.7 Water Resources and its Ecosystemic Interactions

Farmers know that increased precipitation will result in an increase of surface water resources (Niemeijer & Mazzucato, 2003). This connection thus automatically links water resources to atmospheric pressures. Similar to many other interactions between natural resources and water resources and good soil together are related to the soil's potential to produce a bountiful harvest. The process of decomposition corresponds to the moisture content in the soil. Farmers relate soil moisture and the availability of water resources to fertile and good soil (Mexico: Grossman, 2003; Ethiopia: Corbeels, et.al, 2000).

The relationship between water resources and vegetation/landuse can clearly be understood through soil. In decomposition, farmers consistently relate the necessity of water resources and moisture to speed decomposition processes. For example, farmers have developed several variations of a technique in which they use infiltration pits for decomposition, combining the practices of water harvesting and soil fertility at once. They harvest water, and fill the water pits with crop residues after harvesting to facilitate the decomposition of the crop residues. To maintain a steady rate of decomposition also during the dry season, the pits are watered (Zimbabwe: Chuma et al, 2000; Kenya, Mali: Hihorst, et. al., 2000; Kenya: Jungerius, 1998). Farmers strongly relate the existence and growth of vegetation and forest with rain, because forests attract rain (Jungerius, 1998). On the other hand, the interaction between water resources and soil can also be negative. Surface water flow is, like rain, associated with erosion and washing out of soil nutrients, diminishing the fertility in the soil (Pulido & Bocco, 2003).

2.3 Women and Water Management

The livelihood approach can be used to understanding how people use natural resources in their day-to-day livelihood activities. In the case that these activities are completed in one local place, where the individuals in question are rooted, means that the way they use natural resources is dependent on their local knowledge of the resources in question. It is in this framework that it makes sense to examine the relationship of women and natural resources, and specifically, water. In my investigation of literature on women and natural resources, I

stumbled into a few different disciplines: ecofeminism, feminist geography, and feminist political ecology. Case studies dealing with the basic relationship are found in any of the corresponding journals and book chapters.

In this section I will highlight the main themes and issues that connect the sources. In navigating the literature published and studies done on the way women manage their local resources, most often based on rural and somewhat marginalized regions, I found that the discourse is somewhat polarized. One side focuses on ecofeminism, an essentialist theory spearheaded by Vandana Shiva, claiming that women have an innate connection to nature through their spirituality, allowing them to tend to naturally conserve and protect natural resources. This view is countered by geographers and political ecologists, who instead, emphasize the material, practical knowledge of ecosystems and landscapes that rural, agrarian women have (Agrawal, 1992). Gender is one social relation through which the access to and distribution of natural resources—and therefore local knowledge—can be considered (Carney, 1996; Rochelau, 2005; Shroeder & Suryanata, 1996).

Ecofeminism describes the gendered nature of resource use and agriculture—and therefore the accompanying local knowledge. It also describes the way this gets affected by development. Furthermore, it examines the gendered construction of nature, how women interact with nature and the environment and how those relationships are structured by patriarchy and how women choose to resist oppressive practices. Female involvement reflects a hope that political mobilizations can lead to a deeper feminist consciousness and directly challenge decisions specifically out for private and limited production and increased livelihoods opportunity (Nightengale, 2003).

When discussing women's resource use, the concept of place is crucial, as the relevant literature contests the more static notion equated with community as described in the social sciences. Place, in the rural, cultural landscape is constructed by the livelihood systems that individuals are a part of. Livelihood systems are gendered in multifaceted ways. They are made up of specific spaces for men and women whose work roles and responsibilities are shaped by distinct social factors. These factors include and control over assets, land quality, opportunities to earn an income, access to shared resources, external social support systems, and access to support from the state or organizations (Wickramasinghe, 2005).

Around the world, women's limited access to resources remains constant. Women engage in village-based, ecosystem based, and family-based resource management to secure their own, their family's and their community's livelihoods. Consequently, it is increasingly recognized that women are dealing with land, farming for food and subsistence, and sustaining family farms (Zwarteveen, 2006). This livelihood approach allows for combined research on the many kinds of aspects used to study interrelated gender issues. Livelihoods provide a broader framework for analyzing gender as it related to local contexts. Considering livelihood in conjunction to gender and geography allows for a global perspective to be accommodated (Wickramasinghe, 2005).

Many studies linking gender to environment divulge into material practices that bring women closer to nature and gives them practical knowledge of ecosystems (Agrawal, 1992; Nightengale, 2003; Cleaver, 1998b). This is contrary to the argument coined largely in part by Shiva (1989) that women have an inherent connection to nature, automatically granting them an understanding of ecosystems and their services. Vandana Shiva (1988) asserts that the management environmental goods must be restructured and reevaluated in terms of gendered considerations. Women's local knowledge of water resources is a part of their knowledge of ecosystemic processes.

Rural women are in charge of their families' survival and so are both land and household managers. Thus, their knowledge of water resources encompasses processes occurring outdoors, in the agrarian landscape, and based on family needs indoors, in the household cycle (Zwarteveen, 1998). I am not examining the position of women in the local social structures or system. Rather, I am focusing on the production-based relationship between gender and environmental action studies. I do not explore women's roles or position in terms of power. I focus on them, because in many rural areas, they are the ones that are around. In these areas, women are in charge of their families' survival. And in heading the household management and livelihoods required to ensure family survival, women's survival skills are based on a different knowledge of environmental processes and systems than that of men. State-imposed development schemes for production improvement take men's environmental knowledge while ignoring those of women altogether, leading, in some cases hypothetically, to collapse of ecosystemic elements and their processes environmental systems that are tended to and managed by women (Cashman 1991).

Women are motivated to social and political action differently than men. Efforts by men to expand collective agricultural production in Mexico, for example, making heavy demands on female labor, have resulted in women's defiance (Mutersbaugh 1999). Robbins (2002) claims that increased cropping and extension of agricultural land actually results in an increased labor burden for women, who then travel farther and work harder to produce the same necessary goods that support the household. These goods include food, fuel, and water. He asserts that differential power of men and women and their uneven access to income resulting from development may also lead to an expansion of cropping at the expense of lands for fuel wood, fodder and medicinal plants (Robbins, 2001). Because these conflicts take place within rural households rather than between them, resistance and adaptation to changes in ecological processes would thus be expected specifically from women, and reflected in their knowledge and the necessity to involve them in decision-making regarding all natural resources in their landscape.

During the past decade water resource management policies have increasingly emphasized the participation of women in the planning and management in the interests of efficiency and empowerment (Zwarteveen, 2006). Women are often motivated to improve their domestic water supplies as to save time, which can then be used for income generating activities and rural, local development. This view recognizes the multiple roles of women in reproductive, productive, and community management activities and also acknowledges the limits on women's lives primarily in terms of time available for productive tasks (Buchler, 2001; Nightengale, 2003). Poverty concerns are dealt with by suggesting that by spending less time retrieving water for their household needs, poor women will have other opportunities to secure an extra income. This claim rests on the assumptions that women primarily use a single or distant water source and that they are strongly interested in bringing this source closer to their home. Thus, the women collecting water are also the managers of water supplies and will participate in water management and planning (Cleaver 1998). Decisions over land-use remain with community households. The decision-making process facilitates women's efforts to reassert their rights as they relate to the natural resources in their immediate landscape (Carney, 1996). The affiliated relationship is the active interaction between practice and idealization of land use. Ideas of land use are continuously restructured, accumulated and changed. Unequal access rights can affect the way people use nature, and how human nature then comes about (Watts & Peet, 1996). So, women's access to water resources is an important component in shaping the way infrastructure for water is shaped and landscape is developed.

The lines between property and land use, forest and farm, wild and domestic, farming and gathering, in addition to the boundaries between household, community and political organization results in a dearth of systems to consider (Rochelau, 2005; Wickramasinghe, 2005). A lot of managing these systems comes down to access women have to resources. Rights to access of environmental resources are commonly differentiated by gender, as are responsibilities for the management of various ecological systems and functions. Development efforts seeking to alter local production systems may inadvertently reduce the resources that can be claimed by women.

Shiva argues that in rural development, women need to participate to the extent that they are represented not only by costs but also by the benefits. Women and their livelihoods that are embedded in nature are unproductive, because they are mediated by technologies specifically for production, even when these technologies destroy life. She gives the example of a clean river that is not considered productive, as it needs to be developed with [dams] in order to become so. The women, who use the river to satisfy their families' water needs, are not "officially" involved in productive labor. It is only with the engineer, that water management and water use become productive activities. Women rely on facets of nature's produce in order to produce sustenance and ensure survival. Scarcity of water and food among other resources and needs, affect poor, rural women most severely, because their work cooperates with nature's processes, because, work that satisfies needs and ensures sustenance is devalued in general. Not recognizing nature's processes as factors in the process of economic development support for increased control over natural resources in the conventional understanding of productivity (Shiva, 1989).

Local knowledge of natural resource is and can be further used for sustaining women and their families and thus improve life and diversity. "Legitimizing" women's local knowledge, it becomes both an ecological and feminist political project, celebrates local women's culture in terms of their livelihoods. This process of changing the perspective can be considered part of the feminine principle, which endorses a non-violent way of perceiving the world, thereby sustaining the diversity of nature. Only the profit-generating properties of a resource system are given value and exploited. The properties that stabilize ecological processes but cannot be used for profit-making possibilities are ignored. The value of nature depends on the economic interest for nature's resources (Shiva, 1989). Women's work is often deemed invisible while being linked to

nature and needs. This conserves nature by maintaining ecological cycles and communities by satisfying the basic needs of food, nutrition and water. Survival is apparently enough. Ways of considering the relation women have with natural resources (Wells and Gradwell, 2001).

2.4 Hypothesis

Political ecologists, geographers, and anthropologists including relevant researchers such as Rocheleau (1996), Carney (1994, 1996) and Berkes et al. (1998, 2003) document the way rural women adapt their methods of managing natural resources according to different external factors. In my research, I observed a group of women in the community of Coatitlán to find out how they manage local water resources and deal with climate events. The components and elements of the cultural landscape, affiliated livelihood activities, development implicated changes in women's local knowledge. Rural women's knowledge of water resource management may be dependent on their livelihoods. If women's local knowledge of water management is dependent on their livelihoods, then their livelihoods are dependent on women's knowledge of ecosystemic processes occurring in their landscape. Changes in the landscape may cause women to adapt the way they use the natural resources, including water. Changes in the landscape occur if development policies are put into action, bringing new services, such as education and health services to the community, and infrastructure, such as new roads and a water system.

I hypothesized that women's knowledge of water resources and management is formed by the livelihoods they are engaged in. Their knowledge of water resources and how to manage them corresponds to the cultivation of the *milpa* and household tasks, including grinding corn, making tortillas, cooking in general, and cleaning. I also hypothesized that, as in many rural, rather impoverished areas in Mexico, men migrated to other cities and the United States in search of more promising employment opportunities. Therefore, women would have increasingly important roles, in terms of decision making for their families. This would, in turn, influence their knowledge of water resource management in that it would be informed by greater self-confidence and be based on a perception of a greater landscape, as women's tasks included more and more those of what men were previously solely in charge of.

3. Methods

As Davis and Wagner (2003) point out, the methodology in ethnoecological research publications is too often unclear, many details left out of the process description. When starting to write about my methods, I initially forgot to mention how I even ended up in Veracruz. My semester abroad in Xalapa, Veracruz, Mexico, was crucial for informing my research. My semester abroad in Xalapa, Mexico. This time does not officially count towards my research time schedule, but was important for improving my Spanish and getting insider views to Mexico, simply by being there, my daily routine, going to the market, and taking an ethnoecology and a natural resource management class. Without the semester there, I would not have gotten to Coatitlán.

My research process can be separated into several steps. The first involves a review of ethnoecological and political ecological literature I covered while in Austria. These provided me with an introduction to the major themes comprising the studies of the relationship between people and their natural environment. This literature focused on the local knowledge of farmers and the way they managed immediate and necessary natural resources for crop production. I then reviewed political ecological literature, which deals largely with power over and access to natural resources by their users and managers. This literature discusses the way globalization and liberalization of markets impact natural resources and their users.

The second step in my research process was the literature search in Mexico I conducted during my fieldwork stay. I went to several libraries to get Mexico and Latin America-specific literature, dealing with women, water, and climate, in various combinations. This literature was important for creating a contextual base in which I would be doing my own research, specifically the natural water resources and affiliated rural communities.

The third part of my research was the fieldwork and all of its necessary preparations. This part involved finding a community and contacts, working my way into the community, building up trust, and applying ethnoecological research methodology to real life research practice. This part of the research process was the real test, asking questions rooted in the bulk of literature I had read, applying the many things I had read to my live surroundings and environment. While this part was the shortest of the entire thesis research process, it was the most intense and the

most difficult. It reflected exactly how prepared I was and was not. It also made it made clear to me what precise and clear fieldwork required.

3.1 Literature Search

My literature search corresponds to each part of my thesis research process. During the first phase of my research, I explored existing articles, book chapters, and books on local knowledge, ethnoecology, of ecosystems and elements thereof. I used an existing collection of related and relevant literature made available by Dr. Christian Vogl, and other colleagues, and went to libraries to complement this collection. This part was necessary to get introduced to ethnoecology and corresponding case studies and research. I was specifically looking for the local knowledge that farmers, rural agrarian people, have of the processes occurring between elements in their agroecosystems

The libraries I went to in Vienna include:

- The main library of the University of Natural Resources and Applied Life Sciences, Vienna
- The University of Vienna main library and Institute of Geography library
- The Vienna University of Economics and Business Administration.

The second phase of my literature search in Vienna covered the category of political ecology. The literature I sought out included, on one hand, classic theories on the relationship between people and the way they shape their landscape through natural resource use, texts concerned with the way natural resources are used and managed. On the other hand, it included case studies of specific groups of people managing specific kinds of resources and often, how economic development and global migration patterns shape people's natural resource use. A predominant theme is access to certain natural resources by different groups, and power roles based on the very access to the resource in question. Labor based migration, changing market structures influencing local demographics of the places where case studies are based. This literature ended up mostly being book chapters and articles on case studies of communities of varying sizes and their natural resource use patterns, written by feminist geographers and political ecologists.

The last part of my literature search was focused on specific studies in Mexico, which I conducted while I was in Mexico City and in Xalapa. The libraries I went to during my field stay in Mexico included:

- Miguel Lerdo de Tejada Library, Mexico City
- The Central University Library of the National Autonomous University of Mexico (UNAM), Mexico City
- Vasconcelos Library
- Library of the National Institute of Ecology in Veracruz, Mexico
- Central Library of the University of Veracruz, Xalapa, Mexico
- Municipal Library in Xico, Veracruz, Mexico

Search phrases I used in all libraries I went to in Austria and Mexico included the following phrases, their translations, and variations thereof:

- | | |
|---------------------------------------|---|
| • “Mexico AND water” | • “Political ecology AND water AND women” |
| • “Mexico AND women AND water” | |
| • “Veracruz AND water” | • “Political ecology AND women” |
| • “Veracruz AND women AND water” | • “Political ecology AND water” |
| • “Veracruz AND climate” | • “Women AND water” |
| • “Sierra Madre Oriental AND water” | • “Climate AND water” |
| • “Sierra Madre Oriental AND climate” | • “Land use AND water AND Mexico” |
| | • “Seasonal variability AND gender” |

Doing a local search in Spanish, my goal was to find Mexican examples and case studies that had possibly been done on water resources management in rural communities. In the course of my literature search, I met and talked to informants and researchers who were key for relevant but unpublished information. Dr. José Luis Chacón Perez of the *Universidad Veracruzana* gave me three theses that were based on research and development projects in Coatitlán and neighboring communities. A number of workers in the *Palacio Municipal*, the city hall, in Xico, also gave me information and short reports important for forming a background understanding of Coatitlán and the rural municipality of Xico. The municipal chronicler, the owner of *Café Teocelo*, and the worker at the local library all gave me their interpretations, of the local history and on different issues in the rural areas in the municipality of Xico.

3.2 Research Area: **Coatitilán**

Coatitilán is in the municipality of Xico, which is in the state of Veracruz. I chose to do my research in Veracruz, because the contrast between water availability and usable water supply is so pronounced. Coatitilán could be representative of many other rural, small communities in Mesoamerica that have similar agrarian histories centered around the *milpa* and are looking to be part of the global market. Tucked into the verdant folds of the Cofre del Perote, and poorly connected to neighboring towns, it remains, in 2007, a somewhat isolated regions, making for an interesting research location.

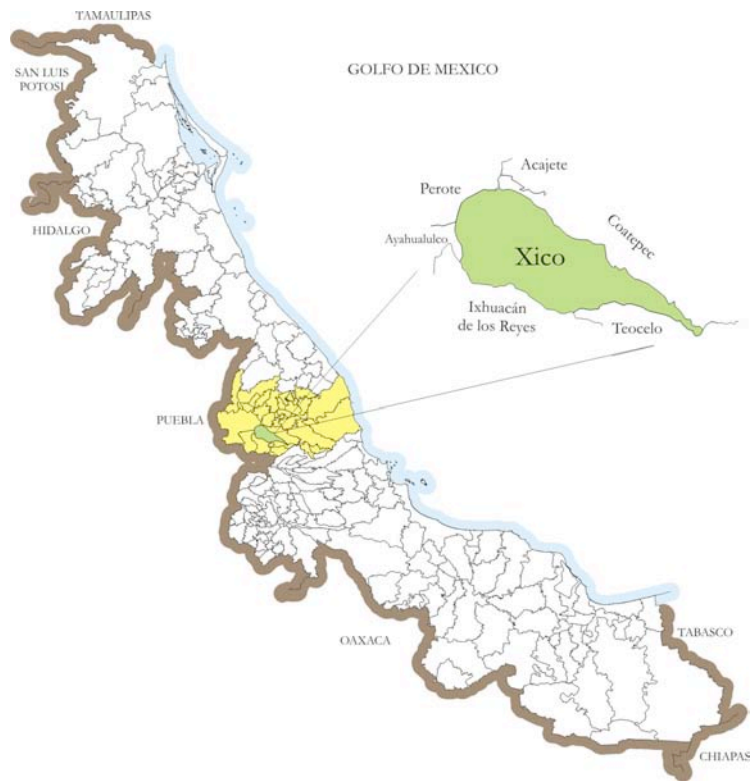


Figure 3 Map of Veracruz state with the municipality of Xico highlighted (Margana Cruz, 2006).

3.2.1 Access to the area

My decision to do my research in Coatitilán was less an intentional choice, but rather a case of the community finding me. On the first Saturday of my field visit in Veracruz, I went to the weekly market, *tianguis*, in Xico, and met two women who invited me to their home in the community of Coatitilán. I accepted their invitation, went the next day to visit them, and to see if their community could fit an exploration of my research question. I decided to use this community because it is small and rather isolated. Furthermore, it was interesting because of a development project in progress, it was the rainy season, and there were local elections and the preceding campaigns. I could, based on the dependence on agriculture, the strong climate fluctuations, and changing infrastructure development, explore women's knowledge of water resources.

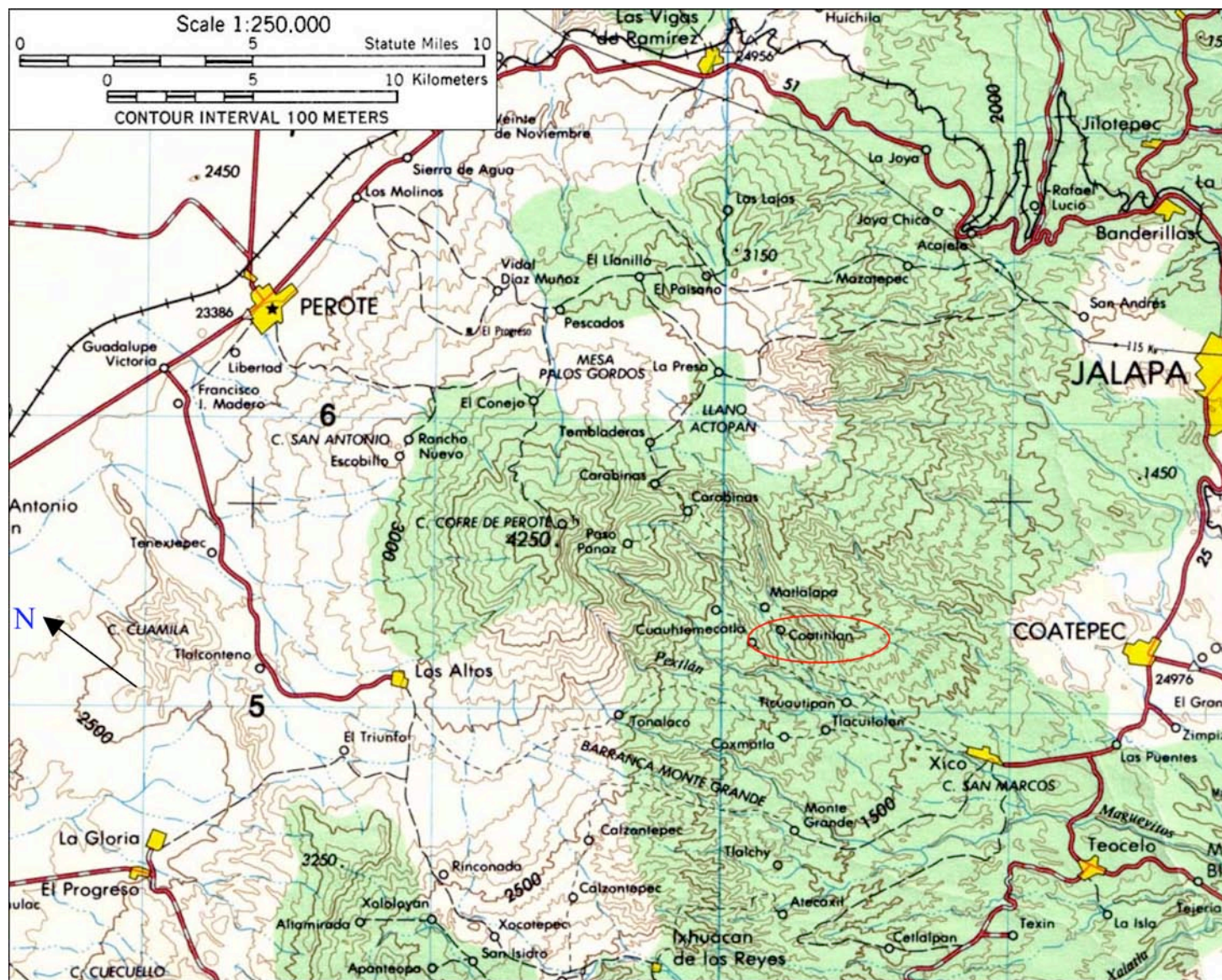


Figure 4 Map of Coatlilán and its surrounding region (Margana Cruz, 2006)

3.2.2 Geography

Coatitlán is one of eight small communities in the municipality of Xico, located in the state of Veracruz. The community is located at 2,080 meters above sea level, at 09°70'39" and 19°27'38". According to the census of the year 2005 there were 255 people, 137 males and 118 females, living in a total of 44 houses (INEGI, 2005).

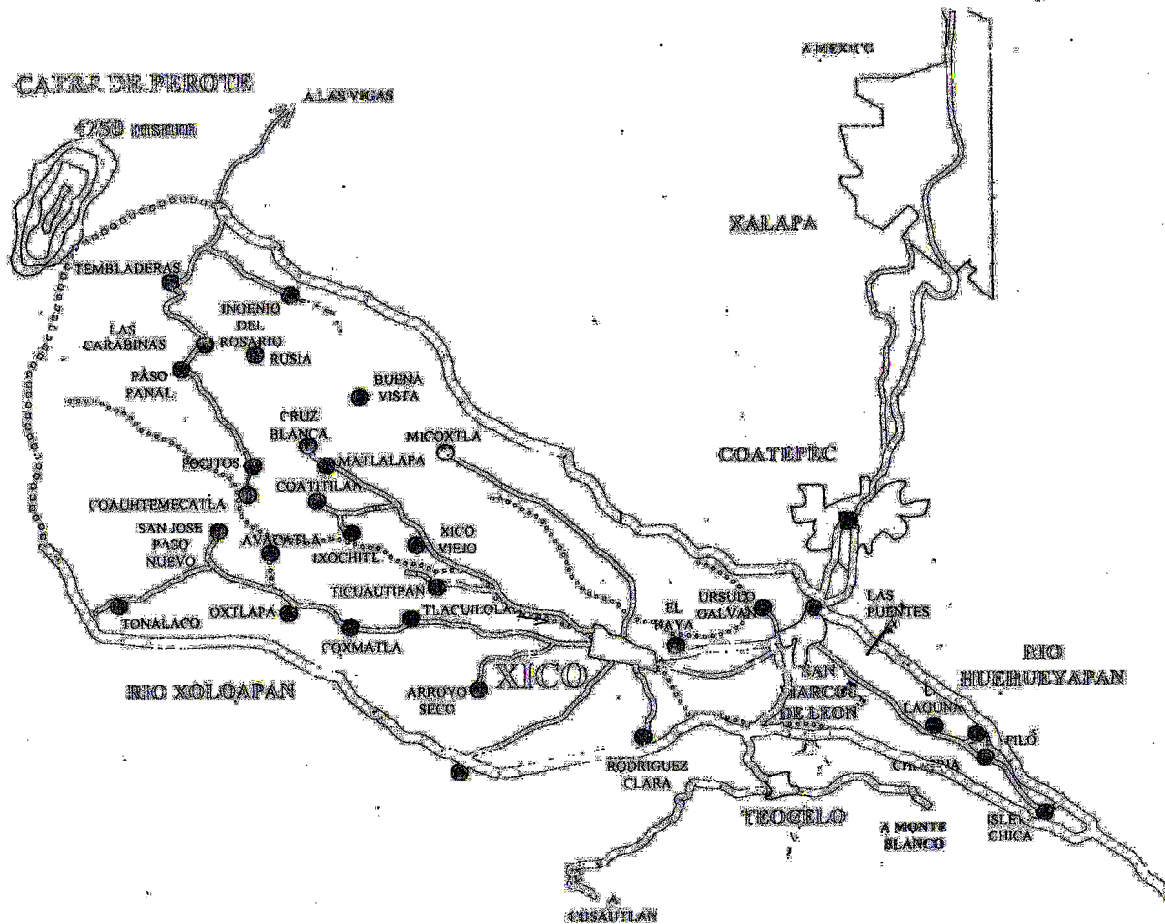


Figure 5 Map of communities in the municipality of Xico, Veracruz (Margana Cruz, 2006)

The municipality Xico is in the *Sierra Madre Oriental*, covering approximately 2,400 km². The area is located in a west to east strip beginning at the Cofre del Perote, approximately twenty-five

kilometers away from Xalapa (Hoffmann, 1993). While it is fairly close to the larger city of Xalapa, the topography makes it hard to reach and rather remote, only eleven kilometers away, it takes close to an hour by car to reach Coatitlán. It is on the route linking Xalapa to the many communities on the Cofre de Perote. Communities are connected by a system of dirt roads that were built thirteen years ago (City Hall of Xico informants, 8/2007).

Coatitlán is a significant cultural and historical unity, clearly perceived as such by its inhabitants. It has most of its claim to fame due to the historical route that the Spanish explorer *Hernan Cortes* took on his first trip from the Gulf coast to Mexico City in 1519. The boundaries were put into place in 1542 under the viceroy *Antonio de Mendoza*, and since then have shifted only in the lower elevations. Ditches and rows of trees mark community boundaries, which have been present for several centuries, put into place to clearly demarcate property parcels (Hoffmann, 1993).

The region has long been occupied, its resources long been used. Historically, forest resource use and hunting were the two predominant uses, depending on the current economic situation. The landscape is thus a result of the land use practices (Marchal, 1983) coinciding with the cultural history. The region, as it is today, is a biotic community shaped by the relationships between different groups of people with each other and with animals and with natural resources making up the features in the landscape (Rochelau, 2005).

Altitude is one of the most often referred to landscape characteristics in the region. Coatitlán is a part of the “intermediate” zone of the municipality, which lies between 1,400 and 2,500 meters. The altitude rises to over 4,000m within 60km, creating impressive climatic differences within the region reflected in crop choice and cultivation. Xico is a region extending from the folds of the *Cofre de Perote* at 1,200 meters above sea level to 4,000 meters above sea level all within a span of 20 kilometers (Hoffmann, 1993).

Because Xico has a tropical climate and is positioned on a steep incline, with altitudes ranging from low to high, it has rich crop diversity (del Angel-Perez, 2004). Conversions in land use and infrastructure development in the past couple decades have had significant outcomes for food production, female labor patterns and access to environmental resources (Carney, 1996; King 2006). Access to water resources is problematic in terms of unequal access and poor infrastructure planning both influencing access, water quality or misinformed in terms of seasons, neglecting climate patterns (Agenda Azul de las Mujeres, 2008).

Humid winds come up from the gulf, hitting the mountainous barrier and then releasing copious amounts of water towards this outside slope, making for fast and heavy rivers and a number of waterfalls. The region is also marked by porous black rocks, basalt columns and soil whose colors range from grey to rust, resulting from millions of years of volcanic eruptions. Perote, a mountain and semiarid landscape have cold winds and extreme temperatures that sometimes sinks to below freezing (Hoffmann, 1993).

The area is characterized by relatively widely dispersed ranches and communities, located between rivers and separated by gullies, ravines, and steep hillsides. Communities are surrounded by extensive pastures and are typically characterized by sparsely scattered houses, each surrounded by a corn and bean field and gardens with fruit and flowers (Hoffmann, 1993).

The municipality retrieves water from the *Teocelo* River, which is a tributary to the river La Antigua. It has a number of streams. The *Matlalapa* River is a tributary of the *Teocelo* River. *Matlalapa* river has a flow of about 1,554.9 l/s, with a temperature that fluctuates between 8 and 15 degrees Celsius.

Coatitlán is part of an *ejido*⁵, shared with several communities from Xico, including Matlalapa, Micoxtla, Aquilitla, Pocitos, Cuauhtemecatla. The *ejido* was founded in 1939 and spans 866 hectares. The *ejido* is made up of around 250 families, 1,450 people, most of who are engaged in agricultural activities. The social structure is guided by those highest up, namely the representatives to the *ejido* and the municipality. The *ejido* authorities are elected directly in an assembly and are granted the title "*Presidente del comisariado ejidal*". The *ejido* members, community elders, and municipal agent, all elect the municipal authorities in an assembly. There are several federal committees and programs that have been implemented in Coatitlán. These include *CONASUPO RURAL*, *Becas Progresas*, *CONAFE*, *Procampo*, *Credito a la palabra*, *Parroquial*, committees from the PRI and from the PRD, and also the *Sociedades de Padres de familia* of first and secondary schools, and a group of alcoholics anonymous. Coatitlan has two primary schools, a community store and a chapel. Officially, there is running water, but the infrastructure is not especially stable. It is common for the communities to use the river as an open and shared washbasin (INEGI, 2007; City Hall of Xico informants, 8/2007).

⁵ *Ejido* is the term used for shared land managed communally in Mexico.

3.2.3 Climate

Climate is the defining force in the daily and yearly schedule for the inhabitants of Coatitlán. It is characterized by the high amounts of humid air that are pushed up from the ocean towards the peak of the Cofre del Perote by gulf breezes (Hoffmann, 1993). The lighter summer breezes that accompany the season's heavy rains characterize the "time of the water" from June through September. The "*nortes*" mark the winter months, arriving at the Gulf coast with polar winds, bringing with them the cold season from November to February. Lighter rains are also characteristic for this time. They are locally referred to as both "*llovisna*" and "*chipichipi*." The rainy and cold season are separated by a dry period during April and May. During the cold months the temperatures can drop to freezing, "burning" the fields. This can also occur between October and November, damaging corn. A lack of sufficient precipitation in the hottest months, April and May, can also damage the corn, especially if the seeds are sown early. Excessive rain during the beginning of the rainy season can also hurt the fields that are in bloom. For the most part, there has been a reduction in precipitation in the past years. The variations in the hydrological cycle are largely explicable due to the intense deforestation that occurred in the region of the *Cofre de Perote* during the twentieth century (Hoffmann, 1993). The climate is temperate-humid, with an annual average temperature of about 19°C, abundant rain in July and at the beginning of September, and lesser intensity in February. The annual amount of precipitation is around 1,769 mm (Servicio Meteorológico Nacional Database, 2007).

3.2.4 Livelihoods

Sugarcane, citrus and corn production make up the main cash crops in Veracruz. The state is the sixth highest producer of corn, while there are few farmers who produce on the scale found in the northern states where most of the competitive commercial corn growers are located. Corn production is mostly for household consumption; small quantities are sometimes sold in local or regional markets to contribute to household income. Land holdings are usually less than 5 hectares and are prepared manually. Fertilizers are predominantly organic. Pesticides are used only when the household income allows it (King, 2006).

Due to the altitude, one of the main economic activities in Xico is the sowing, maintenance, harvesting, and industrial processing of coffee. In the lower elevations, the region cultivates sugar cane. The cultivation of corn beans and squash are for self-consumption more than for commercial ends. The soil is fertile and allows for production also of oranges, limes, bananas, peaches and other fruit trees. At higher elevations, the main economic activity is cattle farming, although families

also raise sheep and goats, and have, in the past years, started trout cultivation. Coatitlán is too high for coffee cultivation. The sustenance economy of Coatitlán is based on a creative and organic nature, on local knowledge, on locally recycled inputs that maintain the reliability of nature, on local consumption for local needs (Hoffman, 1993; Shiva, 1989).

Land is divided into small parcels, reflecting a system of production specific to the steep inclines of the Cofre del Perote. Aside from corn production—the *milpa*—the other staple food includes potatoes. Home gardens allow for cultivation of a range of vegetables, from radishes to peas. Women and men also collect wild spinach “*quelite*” (*Amaranthus hybridus*), and cala lily (*Zantedeschia aethiopica*), capulin (*Prunus salicifolia*). Livestock is held and pigs, chickens, and goats are kept for family consumption and extra income (Hoffmann, 1993).

The so-called crisis of traditional agriculture in Mexico is especially relevant for the production of corn and beans. There are several factors for the agricultural crisis, particularly the loss of self-sufficiency for basic grains. On one hand, the competence or success of cattle raising and the increase in population have led to a reduction in the fallow time of the *milpa* from 5-7 years to 2-3 years (Paré, 1996). The impoverished of the soils and restrictions that climate factors place on the region have made it more difficult to cultivate. The crisis is the sum of the nineties that occurred in Veracruz resulted in an increase of inputs into agricultural processes. These implications have not reached Coatitlán.

3.3 Field Work

I stayed in Mexico from July 2007 until September 2007. Before I left, I had my time schedule, a question list, activities, and time set aside for library research. I left, knowing that I would have to just throw myself into being in a small community for the short amount of time that I had. First, I spent almost a week in Mexico City, going from library to library, but spending most of my time at the *Universidad Nacional Autonoma de Mexico* library. I spent time in the history section, the geography section, and in the natural resource, political and ecological section. After this time, I left for Xalapa, Veracruz, where I met my advisor from the *Centro de Investigaciones Tropicales*. As other researchers know, there are always unexpected situations. Shortly upon arrival to Xalapa, I found out that I would have to change my research location from another village in Veracruz to a different community that I had to find during my allotted fieldwork phase.

Within my first week after arrival in Xalapa, I met two women at the weekly market in the largest central town and municipal headquarters, Xico. The two women, mother and daughter, invited me to their village to talk to women after I briefly described my research about women and water. The next day I went to their village, Coatitlán, and spent the day in their household. That first day I followed one of the women around to collect firewood and “helped,” or rather tried to learn, to make tortillas. After that day I decided to base my research on that village.

Once being accepted into the community by the first two women, I spent the first ten days to two weeks to become acquainted with their family. I accompanied the women on daily tasks and errands, meeting other women in the community through them. I used the snowballing method to meet other women. This means that one woman would refer me, and often introduce me, to another woman—often a sister, a neighbor, cousin, or in-law (Vogl, et al, 2004; Bernard, 2002). I was dependent on the women I already knew as to gain the trust more quickly of new women I met. From women not directly related and friends with the women who had already had more contact with researchers and their projects, skepticism was high—I realized it was better to stick to my original research plan, and to use the methods I had planned for to better avoid unwanted situations. In the following sections I will specifically address the steps and methods, and tools and considerations I took into account during my remaining time during fieldwork.

3.4 Research Diary

My research diary was for taking notes of researchers, authors, book titles and articles, and notes on relevant research. Before I left for the field, I also brainstormed for questions, narrowing them down in order to be better geared for my field-stay in Mexico. Once in Mexico, I used the diary for jotting down observations and quick notes. I also took descriptive notes that were more lengthy and helped me record and keep track of the observations I made, what I watched and what I heard. All of these observations I used to augment question answers from interviews and to shape my research results.

3.5 Data Collection

Working alone and with one month’s time, I was somewhat limited in the methods I was able to use. As Bernard (2002) writes, with limited time, it is important to go into the field situation “armed with a list of questions you want answered” (331). The three methods I used most deliberately included participant observation, informal interviewing, and semi-structured interviews.

3.5.1 Participant Observation

Bernard (2002) calls participant observation the foundation of cultural anthropology. This means that as an outsider, the researcher participates in some facet of the life around them in a given place. Over the course of a month, I “got close” to a group of women in Coatitlán. I felt that they too were enough comfortable with my presence to allow me to observe and record information about their lives. My month there coincided with several events that heightened the discussion pertaining to water/climate, local infrastructure development, municipal elections, and the [very rainy] rainy season.

Participant observation formed the basis for my field research. This meant I was actively engaged in the life around me. I joined women and their families in everyday activities. I ate with them, helped women to cook and collect firewood. They taught me how to make tortillas, and so I spent mornings and afternoons trying to achieve a perfect tortilla that they were able to make so easily. I joined one woman in her rounds to collect health data on children and mothers, using this opportunity to meet a wide range of women. It was important for these other women to see that I was with someone from their community that they trusted. I was then able to ask them questions in the form of informal interviews. When candidates for the upcoming election came to speak to the community members, I listened and watched concerns expressed by women. After the hurricane I perused the damaged fields with different families and family members to see and hear commentary on the damage.

3.6 Participatory Research Methods

I planned to do two group exercises, mapping and seasonal calendars. Because it did not work to get a group of women together for the specific task of completing these activities, I incorporated questions regarding seasons and how they related to their work, to cultivation, and to market-related issues into interviews and conversations. The rainy season negatively influenced the willingness of women to leave their houses in the afternoons, which was when they had free time.

The mapping activities did not result in the way I had planned or envisioned according to my research proposal and preparation either. One rainy afternoon, there were three families (or the majority of the family members) present in one house. I used this opportunity to ask those present if they could draw me a map of the community, and specifically note the water resources, trees, cultivation areas, roads, and houses. I wanted to see how they considered the physical/spatial relationships between homes (i.e. people for my research) and the most important resources, the things they used. All present adults informally, spontaneously “nominated” a young man to do the

drawing, during which time the rest pointed and advised. I stood in the background, and when someone would ask me about what exactly I wanted, I simply repeated what I had already said and asked them to decide what they considered right, specifically in relation to the size or location of water, streams, etc. They wanted to know if they should draw the stream, because it was only present in the rainy season, and I told them that if they thought it was important, if they used it, or needed it, they should draw it in.

3.6.1 Informal Interviews

Informal interviews are more like conversations than interviews. Keeping track requires persistent note taking during and after conversations. This is the preferred method during the beginning of the field stay, since it helps strengthen the bond to the community and come across other interesting topics (Bernard, 2002).

I used this method during my entire field stay. It filled time when I was waiting for the bus with young mothers, or when I crossed paths with a woman on the road, on the way to get her corn ground. This method allowed me to have access to and spend time with the women in Coatitlán. When I would “slip” into an interview, I considered this an “informal interview,” which was almost accidental or unplanned, but a situation where I would end up talking about the topics relevant to what they knew about water. This spanned a wide range from what they knew about climate, to what they cultivated throughout, and how their days were organized. I categorized my questions and conversational base according to an adapted Berkes (1998) “local knowledge onion.” I used the following list of questions as a guide:

Practice

- What is water?
- What do you use water for?
- Which rules guide who, how, when water is used?
- How do water resources change throughout the day, throughout the year?
- What relationships to rain do season, daily schedule have?
- Which jobs are dependent on water?

Knowledge

- What problems are there with water?
- What is the seasonal influence on water resources for the household?

| | |
|-----------------------------------|---|
| | How do you know when the weather will change? |
| | How do you know what the weather will be? |
| | How do you know it will start raining? |
| | Are there rules for using water? |
| | Who do you ask for information about rain? |
| | Where do you get water? |
| | Which projects are there for improving water resources? |
| | How are projects impacted by water? |
| | Why is water necessary? |
| | When is there too much water? |
| Social organization | How do you pay for water? |
| | Who is in charge of water? |
| | Who owns water? |
| | Who controls water? |
| | Who has access to water in the community? |
| | Who in the family has access to water? |
| Worldview | Which God or Saint is in charge of water? |
| | When do you pray for water? |
| Language/Local Expressions | What kinds of water are there? |
| | What kinds of rain? |
| | Which seasons are there? |
| | Which language is spoken? |
| | Which crops do you grow? |
| Economy | How do you earn money? |
| | Which jobs do people here have or look for? |
| | Who leaves the community for work? |
| | Where do they go? |
| | What do they do? |
| | Who does their work when they are gone? |
| | What do plants need in order to grow well? |
| | What jobs does the household require? |
| Season/Climate | How has climate changed in the past years? |
| | Where do you get your information regarding |

weather and seasons?
What do you eat, when?

3.6.3 Unstructured Interviewing

Unstructured interviewing is more “official” than informal interviewing, since both parties involved know that it is an interview. Such an interview follows a loose plan at the same time that it has minimum control over people’s responses. This is important to get people to express themselves at a pace they feel most comfortable with (Bernard, 2002). I used this method a few times when there was not enough time for a full-length semi-structured interview, but I still wanted to touch upon relevant topics and get input. I used the same list of questions and topics as listed above for the informal interviewing.

3.6.3 Semi-Structured Interviews

Semi-structured interviewing is the best option when there is only one chance to interview someone. While it shares the “freewheeling” qualities with the unstructured interviews, it is based on an interview guide. I used an interview guide for more accurate comparison of information between women. My guide was a list of topics and corresponding broad questions and helped keep conversations on track, keeping both my informants and me from following new leads (Bernard, 2002).

To test the questions I planned to use in my semi-structured interviews, I did a “pretest” first with the mother of an acquaintance who lived in a close-by small community. By doing another test of the questions with my “host” family in Coatitlán. I was further able to gauge the appropriateness of the questions. I quickly changed all “yes or no” questions to questions demanding descriptive answers, since my informants were eager to please me and simply agree with my questions. For example: the question “Has the climate changed in the past years? If yes, how?” simply became “How has the climate changed in the past years?” The informants either described the changes to me, or simply negated the fact that the climate had changed.

3.6.4 Sample Group,

According to the census of the year 2005, there are 53 females in Coatitlán that are aged 18 and older (INEGI, 2005). These women are more likely to be actively involved in household management and decision-making. Of these women, I held semi-structured interviews with five, and fourteen unstructured interviews. I held informal interviews with many other women and several

men during the course of each day, on the street, or in other people's homes. The women I sought out were women who had significant experience in leading a household.

3.8 Data Management

My data storage comprised mostly of writing notes in my notebook, and later typing it and storing the file both on my computer and external hard drive. In the many cases that I was not able to record the interview, but asked questions and observed certain behavior or conversations, I noted the results in the evening, or in a quiet moment. I photographed the people, the landscape, and infrastructure relevant to the water system. The map that came out of the mapping activity is photographed and also backed up. All photographs are backed up both on a DVD and external hard drive.

3.9 Materials and Tools

Although Bernard (2002) suggests paying informants, I chose not to pay with money, but rather buy food and grocery item including coffee, sugar, bread, rice, and candies. I gave the children markers, papers, and paper world maps.

My materials included quite simply my notebook, an Olympus digital recorder, and a Canon camera with a video function, my laptop computer, and a USB memory drive to back everything up. I had full rain gear, good shoes, pens, and paper, and a first aid kit.

3.10 Authorization and Consensus

In my first visit to Coatitlán I talked to several women about the possibility of my doing research there. I was told that there had been several people from the universities and municipalities there for research. They seemed to have had good experiences working with people from "outside," so I felt that my presence would be more quickly accepted. I verbally confirmed with a group of community-active women that my field research would occur in their community. Then I went to the municipal palace/city hall in Xico to describe my project and let the officials know that I was in the community.

For my field research with mostly women in Coatitlán, I did not use consensus forms. Rather, I felt that by asking their permission and talking with them, I entered into a mutual and clear understanding and agreement.

3.11 Conservation Partners

Women are linked to life and nature through their role as providers of sustenance, food and water. The privileged access of women to providing sustenance has a historical and cultural, and not merely biological, basis. Women's production of sustenance is also the production of life, because they not only collect and consume what grows in nature but make things grow (Shiva, 1989). Vegetable and flower gardening and foraging for wild foods are attractive to women whose alternative income-earning prospects are limited. Women are producers of livelihood, responsible for the survival of the family, producers of functioning house and crops (Peet & Watts, 1996). As is the case in many rural communities in Mexico, men leave to go either to the "norte," the United States, or to industrial towns or areas within Mexico to supplement their families' incomes. This forces women to augment their own work with work left by men. Rochelau (1987) claims that women mobilize their water resource management strategies to ultimately make the best use of the access allotted to them. Water resources enhance the value and quality of land resources, but vary the scope and seasonality of income streams and thus the viability of the economic units engaged in livelihood production (Rochelau, 1987; Schroeder & Suryanata, 1996).

3.12 Analysis

In the context of contradictions, between abundance of water and lack of official water infrastructure, between visions for development and holding onto tradition, and within the framework of the local cultural landscape, women's local knowledge of water management has a wide range of ingredients. The aim of this study was to learn what women's local knowledge of water resources in Coatitlán, Veracruz, Mexico was. This involved understanding what women use water for, where they get their water from, what they consider water resources, how they understand water in terms of other elements in the ecosystem, where they learn about water resources, how they learn about water in relation to their livelihoods, and finally, I wanted to find out if the economy, the market, men's migration, education, local politics and climate change or changing weather patterns have crept their way into how women perceive and understand water.

My data analysis is qualitative. I consolidated all of the information into answers that correspond to the many aspects of my research questions and sorted them into thematic groups. My observations build on the answers I received from the informant women. The results are organized into aggregated groups according to my research questions. Women's livelihoods, what they are engaged in day to day and how these activities involve water—and the corresponding access to water or water information. I link these results to the basis of the political ecological discourse. I

then systematize the ecological processes in their landscape that they see and relate to me follow these results. Finally, I discuss women's involvement in local politics and the relationship their involvement has to the division of labor and related changes.

Before delving into the results of my stay in Coatitlán, I want to make a disclaimer of caution and careful treading in interpretation. Studies of local knowledge overwhelmingly seem to be based on the assumption that the local knowledge presented is insider knowledge, emic knowledge (Vogl & Puri, 2006). I have a particular problem with this assumption. While I do agree that the results of research in local knowledge are the closest possible scientific representations of what people do actually know, based on their experiences, I do believe that connections and conclusions are drawn by the researcher and reflect the researcher's perspective. The results that I present need to be understood according to my perspective, my organizational logic. I, as the researcher, filter my perceptions and observations through a lens based on my own life experiences. My lens through which I see the world, my research, is pre-informed with literature I have read and the combination of all my life experiences. So, as a researcher of women's local knowledge, the results should still be understood as etic, from an outsider perspective (Vogl & Puri, 2006).

3.14 Writing

Because the analysis and writing of this thesis was a part-time endeavor, parallel to working and taking exams, it took longer than I originally anticipated. During this time, my writing style and perspective might have changed. I was constantly reading additional literature, having meaningful conversations with other students, researchers and professors, or attending presentations—all changing the way I perceived the way I analyzed, interpreted and then wrote about my research.

4. Results and Discussion

4.1. Livelihood context of water use

First I will describe what women consider “*agua*,” their sources, and then how these sources are used in women’s livelihoods—either directly or as a framework guiding their livelihood work. The way women use these water resources is dependent on access: to the sources themselves, to methods for improving quality, to information on forecasts. Ultimately, the interwoven relationship between these aspects supports the role women have in decision-making for their families and the community of Coatitlán as a whole, connecting their case to the political ecological discourse.

4.1.1 Kinds of water and their sources

An often-heard phrase by women is “*por el agua*.” “*Agua*” is a catchall term for all moisture in the form ranging from precipitation to surface water. For women in Coatitlán, water is rainwater, spring water, river water and grey water. Women say that they are “*ricos de agua*” in Coatitlán. There are plenty of springs, streams, a river, and plenty of rain. Water sources, their quality, and what they are used for are directly related to access, which is a different question: how useable and accessible are the water resources in question.

4.1.1.1 Rain

Rainwater is collected, only sometimes for watering or washing. Rain is a source not for water, but for women to schedule their daily and yearly activities on. Prior to installing the water tubing, women’s schedules were filled in large part by water collection. Since that has not played such a central role in the past years, women shape their daily schedule according to rain patterns—mostly to avoid getting wet. This changes their time management. Rainwater can be a source for problems in the women’s immediate landscape, is a source for ensuring vegetation and crop growth.

Women follow a schedule according to the weather patterns during the rainy season (Table 1). Women’s activities include grinding corn and making *masa* for the families’ tortillas, preparing snacks and lunch for the family, sometimes bringing the smallest children to school, helping men in the *milpa*, and doing housework: washing clothes, cleaning the house, fixing clothing. There are some women who also make cheese. If women go to Xico to do their *mandados*, or sell items they collect in Coatitlán, they go in the morning with the bus between 7 and 9.

Table 1 Women's daily schedule during rainy season based on interviews and participant observation, July-September 2007

| Time | Activity/Task | Weather patterns |
|------|---|---|
| 6 | Get up, drink coffee and eat sweet bread, start grinding corn, 5 kg every 3 days (for a family of 4) | If cloudy, then it rains for a couple hours. If dry and clear-skied, it stays dry and clear-skied until the afternoon |
| 7 | Wash clothes so that they dry, prepare food for kids, men go to the milpa | |
| 8 | Kids go to school | |
| 9 | Start cooking breakfast and making tortillas | In the case of morning rain: can stop for a couple hours |
| 10 | Men return from the milpa and everyone eats breakfast | |
| 11 | Men go to work (reforestation project, trout, milpa, faena), women work in the homegarden or go help in the milpa | |
| 12 | | |
| 13 | | Rain starts and usually lasts through the afternoon |
| 14 | Start cooking lunch | |
| 15 | Eat lunch, go to the school for meetings, bring men their food | |
| 16 | | |
| 17 | Wash dishes and clean house, do whatever else needs to be done | |
| 18 | | |
| 19 | | |
| 20 | Go to bed | |

The abundant nature of water resources certainly changes the concerns of women. Rainwater resources are not considered valuable resources for household uses, but are relied upon for watering the *milpa*. I found that rain seems to serve as a framework within which women complete their activities and plan their schedule accordingly. While the attitude to women have towards rain seems neutral, it still is a reason why not to do certain things. For example, when a meeting was supposed to take place for mothers and their children's health, one Saturday, it was scheduled at two in the afternoon. Since it rained, the meeting did not occur. Overabundance of rain is considered a problem as it causes problems for both plants and soil. Nevertheless, women depend on rain for vegetation and would not know how to deal with an absence of it, since their perception and management of their agroecosystems depends on it. Precipitation fits into a different category of water resources than surface water resources including spring water and streams and rivers. Rainwater is not a common water resource and therefore is not contested in the same way. Therefore, the way it influences women's livelihood management is through the way it influences the structure of women's schedule and participation, and their collaboration in community activities.

Rainwater is the pillar for their day-to-life and year-to-year planning. It is the guide for women's activities. They are accustomed to it and are dependent on it for the way they cultivate their main source of food. At the same time, it can be a source for destruction of the landscape and plants. In this light, rainwater, as is both valued and unvalued as a water resource.

4.1.1.2 River and streams

Rivers and streams stem from the *Cofre de Perote* mountaintop. In describing these surface water resources, women clearly give the *Cofre de Perote* an additional, important role in their understanding of their landscape. It looms above them, seeming to emanate special energy or take over some specific role that allows it to be a source for the streams and rivers.

Water from the river and streams is used primarily for washing clothing. However, in the past years women considered river water decreasingly clean, pollution stemming from cleaning, dams, and trout cultivation.

Women who don't do their families' wash in the rivers do their wash in their homes from the water that comes to the house from the spring via the tubing. The river's water level doesn't change so significantly during the dry season, it is nevertheless visible.

Figure 6 Streams that run throughout Coatitlán and come down from the Cofre de Perote



Figure 7 Two women walking along the river Coatitlán gathering firewood.



The way women in Coatitlán talk about the river fits into the upstream—downstream user kinds of discussions typical of river water use in common property discourses. In the past years, the *Universidad Veracruzana* was involved in a development project there that would give men an extra income through trout cultivation (Margana Cruz, 2002). This project has, however, polluted river water downstream, so that women can no longer use river water for washing their clothes, as they did before. Furthermore, there is a subtle competition for women to wash their clothes

earliest. If the downstream users are too late for doing the clothing washing, the water in the streams and rivers is already contaminated with the grey water from upstream women doing their wash. I did not perceive this conflict to be a huge source of contention, whereas when the upstream families were emptying their human waste directly into the stream, downstream women went to the municipal head to have the problem solved.

The river water source is interesting since it is the source that, while being a resource developed for economic income for Coatitlán, the same development is detrimental to water quality for the women who are downstream river users from the aquiculture station. Another downstream/upstream water problem is contamination occurring from laundry washing. This issue is considered a problem by families according to class and access to information and opportunities from outside of the community. It so happens that some of the participant families whose male members are involved in the trout cultivation project also have their own property with their own spring and own tubing, channeling the water directly to their house. This means that they benefit from trout project for extra income and also don't have to worry about their household water sources. Women who might not live close enough to the families' homes to get water from their private springs while the tubing was cut off might not have any choice but to use the river water. It is not the men who have to retrieve water, and so women are left to deal with contaminated water and social networks that allowing them to have access to clean water. So, in this simple case of a very small-scale project, the class and gender differentiations are magnified. Again, a well-meant, well-prepared, and successful rural development project "stirs up" a portion of women's livelihoods, neglecting their knowledge or concerns. However, women adapt to the new circumstances and disinfect water accordingly, using chlorine supplied by the health department. So, in a way, the development project, intended to benefit families, did so only to a limited extent. Women's knowledge and their needs are ignored, and while they adapt their knowledge also using new informational resources, it drives them to dependence on those resources. In this particular case, they rely on health center for chlorine drops. The pattern of independence—development—dependence falls into the aggressive argument Shiva (1988) dominates in the feminist geography. And while I would like to steer away from aggressive declarations, this situation is so clearly painted by this small example in Coatitlán as it relates to river water resources.

4.1.1.3 Spring water

If they can, women in Coatitlán prefer to use the water that comes from springs because it is cleaner than river water. They use this water for the majority of the household requirements.

Women are wealthy in terms of spring water. through the rocks and is clean. There are springs where water simply surfaces from under the ground and also other water that emerges from the rocks up further on the mountainside. Spring water reproduces itself with rain. A central issue in the water management infrastructure during the summer of 2007 was the road construction project. The construction required the tubing to be turned off for the duration of the project so that the machinery used for the road construction would not damage the tubes.

Figure 8 Woman washing clothing at a spring in a close-by pasture.



Thus, the “normal” run of things shifted to a provisional situation, requiring women to regress to water retrieval patterns from before the water reservoir and tubing were installed. Women retrieved water from springs by walking and manual transferal, and also went to one family’s property that had their own private tubing installed, conducting water from their own spring to their house.

There are three principle springs that Coatitlán uses. Since the reservoir was installed, women no longer have had to spend the additional time to retrieve water for their livelihoods use. Now, in the past nine years the spring water reaches families through tubing that runs through a large part of the community. Because it traverses properties, and goes by houses and roads, it requires disinfection. Women know about the location of the springs because there is a lot of clean water that comes out of the rocks or the ground. By looking around and following water or moisture, they find the spring. They consider themselves lucky because in Coatitlán water will never lessen dramatically, dry up or run out, even if the water coming from the spring and in the river changes according to the season. Direct connection is essentially basic tubing taking the water collected at the spring to individual houses. Because Coatitlan is on an incline, the water moves through the tubing purely by gravity. The water cannot be turned on and off. It keeps running, constantly. There is one larger spring water collection box, which supplies the majority of the downstream families. The families living uphill/upstream from this large spring have another smaller spring that they rely on. The main and largest spring box though, was not able to deliver water to families during the road construction, as it was disconnected. The women called it “*tapado*.” Because of this, women had to go to the two families who had independent spring and water systems directly on their

property. The compromise and extra work that resulted for women did not seem to be a problem. Often, children would go and fill up large buckets.

Figure 9 Water springs above Coatitlán, coming out of the hillside in the first and last photo, girl standing under the excess waterspout at the water reservoir in the middle photo



Spring water is perhaps the most interesting water source for considering the water management social structure among women, specifically in relation to access and property right issues. This was particularly interesting due to changes in water availability through the tubing due to the construction project. This event highlighted the entire water distribution system and women's knowledge of the springs, soil and landforms, as I will discuss at greater length in the following chapter.

When the construction project was not under way, the majority of the women got their water as from the large water reservoir box to their homes via gravity. The families living above the large, main reservoir have their own springs. The springs and the water that comes out of them belongs to the families whose property it is on. While the construction project was under way, women would get water from the closest neighbors who had spring water directly channeled to their homes from the corresponding private springs.

I did not perceive any conflicts or negative attitudes in either women who had to go somewhere else to get water or from the families who had the springs at their homes. However, I did sense a sort of superiority or wealth in the families who were self-sufficient in their water supply. And, families who seemed better off seemed more likely to have better access to spring water, either because they had their own spring, or because they had better relations to the families who had their own spring, and so could come get water without any problems from the family with the spring. Had I had more time to research, I would have liked to further investigate the networks between families (represented by women and their contact or relationships to each other) and spring water. Different levels of access to water sources can cause the perception that women have as it relates to the

credibility attached to what women know. It can also influence the power positions within social relations between women, fundamental to their knowledge of water resource management (Warburton & Martin, 1999). Access to information about the water resources and the water resources themselves Local development decisions effect women's access to and their use of water resources. While these decisions are based on economic development goals, they neglect the degree to which women are affected by the projects themselves (Walker, 2006).

According to women, water resources have always been communal, while private property and land ownership have been a part of Coatitlán for several generations. Water resources, on the other hand, in terms of springs, have been common property, except in the case that a spring is directly located on a family's property. When such situations arise that affect all women—some because they are cut off from spring water and some then have to share their own personal access to their springs—suggests that women can consolidate and thus increase the possibility of taking on extra collective water management tasks, as Scott & Silva-Ochoa (2001) describe in the case of the Lerma Chapala Basin in Mexico.

4.1.2 Water uses

Women's livelihoods, ranging from the in the *milpa* to in their households, guide the way they use water. Since the installment of the water tubing, women predominantly use this water for their needs. Water is used for drinking, for washing and cleaning, cooking, cleaning the clothes and the floor. Because there is already enough vegetation due to the abundance of humidity, water is not used for irrigation. The *milpa* is never watered or irrigated. The tubed, potable water reaches each house, and comes directly from the springs up on the higher hillsides. Certain houseplants, flowers are watered, except in the rainy season, when the plants are no longer watered. Furthermore, spring water is used in tortilla production. Spring water is needed for the *masa*, to add moisture to the mixture of corn and lime. The water is added to soak the corn in, before all being ground and

Figure 10 The tortilla making process.



then turned into tortillas. Spring water is used in all food production in families' households, but the tortilla is the most important.

In describing women's local knowledge of water resources management in Coatitlán, it is important to define what the sources of their knowledge about water are, and how they have access to certain elements of that knowledge. The source of women's knowledge is their livelihoods. Their livelihoods define how women use water resources. How women use water resources is also dependent on how their access to water resources is.

In development that does not consider local people's knowledge and how they might contribute to development plans, nature's ecological cycles are disrupted. Thereby, women are displaced from maintaining those cycles, sees this process of fragmentation as one of increasing efficiency. Market efficiency and profits do increase through fragmentation, but at the cost of nature's capital in fertile and living soils and the destruction of women's work in keeping the inherent fertility of soils alive. Movements by rural women to protect forests or rivers have always been rooted in protecting their agricultural base. If considered through the production of a tortilla: each increase in "productivity" in this system is a decrease in the productivity of women as food producers and processors (Shiva, 1989).

4.1.3 Water quality and treatment

While the water stemming directly from the springs appears to be clean, it must be disinfected to rid it of parasites. The water is either boiled or drops of chlorine are used. The chlorine drops are distributed by the health clinics. After using the chlorine drops, the water is still raw but disinfected. The women used to think that the water that came from the spring was clean, not contaminated in anyway. But the health clinic told them otherwise. Grey water is water that has been used to wash clothing, dishes, or the floor. It can no longer be used and it is thrown out. Women have their husbands or another male family member make of canal or hole in the ground that is used for disposing of grey water. They reason that the ground consumes the grey water. They don't have any other system for disposing of their used water. Water does not surface in these areas. Water resources can become abused if women do their wash and it contaminates all the water. Each person has the right to go to the municipal "president" to complain and tell him that something doesn't work. Grey water is dirty because of the whole village. In Coatitlán there is not such a problem with grey water because the houses are far apart and there is no collection of trash. Now,

due to the tractors working on the road construction the water coming down from that mountainside, the water is dirty, full of dirt, and cannot be used for drinking.

Women's knowledge of water quality reflects their generation and education. This in turn is reflected by the access they seem to have to the world outside of Coatitlán. This, furthermore, is related to their children, if they leave Coatitlán for work or for school, and what news and information they then bring back to the community and home with them. The older women I talked to maintained that their water was very clean, and, in their attempt to please me, as the outsider, praised the high quality of their rural, subsistence based life, relying on the resources they had in their immediate landscape. Younger women, who have children ranging from young to young adults, when speaking about water quality, mentioned two different factors. One was the sterilizing of the spring water and one was the treatment of grey water. Women consistently mentioned that they were lacking the availability of drainage systems. For temporary measures, some women said that they dug holes where they emptied their grey water. Women in Coatitlán know that if other families and their use of the rivers for their sewage contaminate water, families can get sick. Like environmental hazards, it would falter on the same conceptual and practical problem: accounting for and understanding change in a complex modern political economy.

4.1.4 Coatitlán and water infrastructure: participatory mapping

As a beginner in coordinating participatory research methods, my planned mapping activity (planned according to Bernhard, 2002) took its own route, adapted to the families participating. It became a simply sketched map of Coatitlán, as described by those involved. According to my plans, I had hoped to engage a group of women in a participatory research activity, namely having them draw a map of Coatitlán, the water sources and infrastructure, and any other important features in their landscape. Of course, the commentary coming from the women was the most interesting, as they told the drawer to draw a water spring "there!" pointing to a spot in the mountains.

The map shows the largest spring in Coatitlán, and corresponding reservoir that supplies the majority of the village. It is located above the highest area of the village and is on the land that belongs to one certain family. There are several families who have their own private, smaller spring in case their home is not close to the water tubing line, or uphill from the reservoir or too far downhill. The school connected their water supply to a private spring connection, shown in the map

as *Teodora Galves*' property and spring. Prior to their connection, the school children went along with the teacher to the river to fill water containers for use in the school.

When I asked the participants to draw where the water resources are located. The main water resources, including the river, the stream, the largest springs, and the water reservoir tank and tubing were drawn in. I feel that with an experienced researcher I would have gained more from this activity.

4.2 Women's local knowledge of ecosystemic elements

Because of their work both in the cultural landscape—the *milpa*, their home gardens, and collecting wild vegetables—women make many connections between the natural resources and ecosystemic elements that make up their agroecosystem. Women in Coatitlán, as rural women engaged in agrarian livelihoods, should have local knowledge of ecosystemic elements representative of land managers worldwide. With ecosystemic elements, I refer to the resources that are available to women in their landscape that they use for their livelihoods.

4.2.1 Interactions between landscape elements

In this section I organize the results of my interviews and participant observation and organize them according to the principle interactions occurring between them, as in the literature review. They are organized following a hierarchical ecosystem model, similar to the way interactions related in literature are organized.

4.2.1.1 Water resources and vegetation

At the springs, the water comes out of the ground because of all the trees. Trees moisten the soil; with a large number of trees, springs come into being and that is where the water comes out. If the trees are cut, if the mountainside is deforested, then the community will suffer for a lack of water. Furthermore, having larger forests will attract more rain. More rain will allow spring water to be reproduced. Women used to say it should rain because the seedlings in the *milpa* still needed more time before they would come out of the ground.

4.2.1.2 Vegetation and soil

If the mountainsides could be successfully reforested, then the mountainside could be saved. The water is a problem for where they opened the mountainside for the construction.

.

Figure 11 Participatory mapping: Coatitilán



Trees and forest strengthen the soil, preventing it from sliding and thereby damaging the pastures and *milpas*. The soil in turn, in such cases of mudslides, suffocates the corresponding vegetation. Soil thus has the effect of suffocating the vegetation.

4.2.1.3 Landforms and water resources

Excess rain in the rainy season can cause plants to rot. It can also instigate mudslides since the soil becomes too heavy with moisture, explained with the phrase “*por el agua*” reflects the role that water can take on.

Construction and development of the landscape around Coatitlán make the soil weaker, opening it up to the rain, and causing whole chunks of earth to slide. This occurs because excess rain is no longer absorbed by the soil, then creating rivers and streams on its own.

Figure 12 A small gorge caused by excess water runoff from the construction site.



4.2.1.4 Atmospheric pressures and landforms

Atmospheric pressures include anything from rain, to clouds, fog, wind, and other weather related events. Landforms include anything related to topography, elevation or steepness. The

Figure 13 Fog clouds rising and collecting during the late morning.



relationship goes in the other way with the high elevation attracting the fog. Women say that the air pressure pushes the humidity up from the ocean. Excessive rain causes loosened soil to slide. The clouds come from the ocean by Veracruz. And then the clouds rise up towards the Cofre de Perote. There are times when the water comes even if the weather is nice. There are times when the weather is nice, in Coatitlán, but in the lower elevations it rains. The Cofre de Perote is what sustains the community, because it informs women of what is coming, warning and forecasting. When it is clearly visible, but the air moves downward, it is because there is no bad weather. Even though women in Coatitlán rarely go to the ocean, they can see it. And, it plays a large part in the way they explain weather patterns and weather behavior.

4.2.1.5 Water and soil

Excessive water in the rainy season loosens the soil. Less rain means there is more sun. Less trees result in less rain and increasingly strong sun. In the case of the road construction project, and combined with the excessive water, the rocks and dirt that were moved around for the road construction and there was a mud slide, covering the grazing fields with mud and rocks, destroying part of the *milpa*. Lack of moisture hinders the plant from the normal climate patterns.

4.2.1.6 Atmospheric pressures and fauna

Weather events such as thunderstorms kill animals. The remaining relationships between these two ecosystem players were related to me through the way that women forecast weather events. When the rooster crows, or “sings,” during the night, it means that the weather will change. The rooster knows in advance when the weather is changing. If the weather is dry and nice, the goats are let out. The goats also warn the community if it will rain, because they start to shake and move around.

4.2.1.7 Atmospheric pressures

Women use weather signals to predict precipitation. Based on the time of year, they are prepared for different kinds of related precipitation. It generally rains in the afternoon, but the encroaching rain can be predicted more appropriately through different signals. Most often, fog settled into the landscape at one or two in the afternoon. As the fog lowers, a light wind starts blowing and temperatures lower. Otherwise, women gage how coming weather will be according to different signals: the darker the clouds, the heavier the rain, when the sky is cloudy, and when it arrives. When the clouds are closer to the ground, they rise up and it starts to rain. Clouds only rise, they don't sink. The ocean influences “sends” clouds up to Coatitlán.

Figure 14 Morning clouds on the left, afternoon cloud collection on right.



If, upon awakening in the morning, it is dark and cloudy, it doesn't take long before it starts to rain, unless in the case of a cyclone. The main daily weather shifts are at 8am, at noon, and at two in the afternoon. Fog also signals seasonal changes. When fog covers the Cofre de Perote, a season change is anticipated. Fog is humidity present in the air. When humidity is no longer in the air, it means that the dry season is approaching.

4.2.1.8 Meteorological Signals

The moon is important part of the forecasting system. It is not considered a part of the immediate ecosystem, but is nevertheless a deciding factor in climate, weather, and seasons. The moon "*manda*," or sends, the rain. Women use the moon to know when it is time to start sowing their seeds. It is normal that the stages of the moon come with increments of increasing water, and so sometimes the moon becomes full of water.

My results demonstrated how extremely important and inseparable from the context of place, the place inseparable from affiliated livelihoods, together forming the cultural landscape, the quilted result of land use that women are a part of. Ecological ways of knowing nature are participatory. They require involvement with the landscape, with the natural resources, with the ecosystem. Nature is the experiment and women, as agriculturalists and water resource managers, have the role of natural scientists. Their knowledge is ecological and plural, reflecting both the diversity of natural ecosystems and the dynamic occurring in cultures that are part of the cultural landscape (Shiva, 1989; Sauer, 1925), which in turn is evolving as economic demands change livelihood practices.

4.2.2 Agrarian calendar: livelihoods and landscape

I have organized the agrarian calendar, put together according to information I recorded from women, according to precisely the agrarian activities that inform women's knowledge about climate, weather and seasons.

The dry season is the season for cutting down the crops. The seeds are sown in February. Knocking down the plants because the corn has to be sown and cultivated does this. A normal rainy season is needed so that things can grow and a normal dry season is needed to work the fields. Thunderstorms are in April and May, incurring strong winds that knock things over. There is almost always wind, although the patterns are different than they used to be. These thunderstorms are more windy than rainy, which can be detrimental for the young plants that are sprouting up during this time. May is the hottest month, followed by June, which is the month that is both hottest and with the rainiest. July also belongs to the also a rainy month with thunderstorms. The most flowers grow in October. December is the coldest month, with freezing rains, called *heladas*. It is so cold that when it rains, everything freezes, and nothing grows.

Table 2 Agrarian calendar organized according to month, season, precipitation, work done in the milpa, home and homegarden, foraging and other notable climate events.

| Month | January | February | March | April | May | June | July | August | September | October | November | December |
|------------------------|---|--------------------------------|--|---|---|---|--|--|------------------------|---|--------------------------|----------|
| Season | Cold season | | Dry Season | | Transition season | | Rainy season | | | | Cold season | |
| Precipitation | Hailstorms | | Transition | | Bochorno | | Thunderstorms | Heavy rains, cyclones, aguaceros | | Transition | Chipi-chipi, nortes, fog | |
| Milpa | Harvesting last corn, Preparing fields for corn and bean planting | | Planting corn, beans, fertilizing fields | | Weeding, Pest management, and fertilizing | | | Harvest corn | | | | |
| Home and home garden | | Plant broad bean, squash, peas | Plant callalilies | Harvest vegetables, fruits, and flowers making cheese | | | | Harvest callalilies and sell them in Xico. | | Planting seeds for plants in home garden. | | |
| Foraging and other | No special activities. | | | Collect quelites (| | Collect capulín and wild spinach and sell in Xico | | | No special activities. | | | |
| Climate related events | Transition, mild and stable. | | | | | | Erosion due to the heavy rains, no work, men migrate to towns for work, “tiempo de guayaba.” | | | | Frost burns crops. | |

The ice burns the plans, burns the bean, and burns every kind of fruit. The ice dries out the chilies. People who know how to take care of their plants and fruits and everything, they are successful, and those who don't know how to take care of things, their plants dry.

Climate patterns do not change; there are rainy days and dry days. The normal climate pattern is being changed so that months formerly characterized by specific seasons are now divided into a half-month of rain and half of a month of dryness. Every year it changes, and things are no longer the same.

Women's knowledge of ecosystem processes is necessary because it reflects the local environment, the local cultural landscape context that is the frame for understanding water resources and their connection to each part of the cultural landscape, which their livelihood are a very alive part of. Forecasts are dependent on women's knowledge of the processes occurring between ecosystemic elements.

When the people in Coatitlán noticed that there was less rain, and there was a project from *CONAFOR* to reforest the mountainsides, they developed a conservation ethic, stemming from the awareness of their ability to damage an important element in their landscape, natural resources (Berkes, 1999). Marsh (1898) referred to the local knowledge of processes occurring between natural resources and elements of the agroecosystem as "invisible" bonds of ecology. Women and elements in the ecosystem reflect knowledge that forests influence amounts of water. Constructions of the environment are reflected most clearly by the categories in which nature is described and ordered. Local people, scientists, and other observers all have taxonomies for soils, species, and land covers, reflecting their constructions of the environment. This stems from the fact that land managers have an intimate knowledge of their local environment, conditions, problems, priorities and criteria for which they manage their natural resources (Berkes 1999; Sumber, et al, 2003).

The problem with development plans that go unquestioned lies in the centralized authorities' belief that they create water and have the power to augment it. These plans do not succeed in recognizing that women and other rural producers are participants in the hydrological cycle and can survive sustainability only through that participation. That is why in water management, it is imperative to think and act ecologically, to "think like a river," and to flow with the nature of water (Zwarteveen, 2006). The women recognize that water circulates from seas to clouds, to land and rivers, to lakes and to underground streams, and ultimately returns to the oceans, generating life wherever it goes. It is a renewable resource by virtue of this endless cyclical flow between sea, air and land. Damaging the water cycle is probably the worst but most invisible

form of violence because it simultaneously threatens the survival of all. They direct and commoditize thinking about water as a resource and create an illusion of producing abundance while manufacturing scarcity (Shiva, 1989; Singh, et al, 2004) even if the scarcity is spread to other resources in the landscape, including the people who are part of it.

4.3 Women's water management and community involvement

The dimension of migration of increased in the past decades, as have the corresponding changes in agriculture and rural landscapes (Jokisch, 2002), spreading to the way income is earned, how they earn it, and how this translates to who makes what decisions. In this section I will not only address migration and the way it ultimately influences women's local knowledge of water resources, but also the way measures to economically develop the community and related added income to the community change the social structures between women, and thus also their knowledge sources.

4.3.1 Infrastructure Development

Increased mobility, made possible by the roads and bus installed in the early 1990s, has reduced hunger in the community. There is always enough corn and enough beans. And the rest is dried or bought in the town for income. Before the village occasionally suffered from a lack of food, but now there is always enough to eat. It all came to be because there was a municipal president who wanted to build a road, thirteen or fourteen years ago. Before this road, the community was private and closed, with footpaths leading to Xico. With the new road the community will have access to Perote and increased services.

Figure 15 Road construction and *la maquina* in the distance.



The road construction project was a great source of excitement. Every day, women asked me if I have already seen where "*la maquina*" was that day. They pointed it out, and one woman asked me if I wanted to go look at the road and its progress. "*La maquina*" is spoken of in a manner suggesting pride and admiration. The road will connect the small villages of the "*ejido*," to Perote, a larger town on the highway between

Xalapa and Puebla. Perote is special because “Well,” explains Juana, “We can buy more cheap things there.” Other women explain that they can sell things in Perote and make extra more money. The road promises more traffic through Coatlilán, which can lead to potential extra income. “Fidel,” the governor of Veracruz, funds the road construction, according to the women I speak to. Through the joy of being more connected to Perote, the women feel an opportunity to join the modern world that many of their husbands, sons, and brothers have access to when they migrate to the city for work during the week.

The entire community is involved in the development. Several men that work on the road construction project are directly from Coatlilán. The women take turns among themselves to prepare large lunches for the men. The attitude toward the road construction is mixed. During the rainy season, as the women I spoke to explain, the abundance of rain loosens the dirt, making everything muddy and loose. The area under construction is at risk for mud slides. When the dirt becomes excessively loosened and slides, it covers the communities’ fields, making everything “*enlodado*.” With mud, rocks, and dirt covering the fields, the young corn crop is at risk for being ruined. The grazing pasture for the few cows is also destroyed. The rainy season of 2007 was particularly strong. This meant that there were many days that were so rainy, that further construction and work on the road was impossible. The prolonging of the project left it unfinished, increasing the risk for mudslides, and making the relationship to the project increasingly rocky.

The theme of development stability-crisis-adaptation appears over and over in many types of agroecosystem landscapes. Resource crisis are important for the renewal of management systems, just as dynamic ecosystem processes are important for the renewal of ecosystems, in the case of Coatlilán, the hurricane and the corn crop (Berkes, 1999). There is a central importance of community based resource management in traditional systems, and thus also the needs to incorporate participatory processes into contemporary resource management, even if these are simply reciprocal sharing of relevant environmental, political information. Local needs are addressed in local decision-making (Peet & Watts, 1996). It is precisely the lack of participation women have in local decision-making that results in results that are detrimental to the cultural landscape, disabling full completion or progression of women’s livelihoods the way it “otherwise” would. In this sense, Shiva’s argument that development is a direct assault on women’s local knowledge of environmental services is understandable. It is precisely this lack of

representation that women then get in these kinds of political discussion of ecosystem services that is reflected in the feminist political ecology discipline.

The principles of local control, democratization, and community-based sustainable development are apparent in Coatitlán, which is a local community with a strong heritage. It is important to consider that these rural social communities are situated in a cultural, economic, agro-ecological and socio-political context, influencing how, and why, the women manage resources in particular ways (Bebbington 1996). Whether this can be translated to women's gender identity as it is constructed by their use and nature of the local context is hard to say. I feel that women identify with their work because they have little choice. And their work is inevitably connected to the way they use their local natural context and the way they understand the nature of the their local context. Nevertheless, I do not feel confident that I witnessed a strong identity as such.

4.3.2 Local Politics, Women, and Water

In the summer of 2007 the municipal elections for Xico were going on. Candidates from each party came to the community and held speeches, talked to the people gathered around, and distributed gifts. Women were vociferous about their discontent with the infrastructure services, several agreeing that the government often made promises for but did not fulfill them. Before the election, women told me that the PRI⁶ party had gone from house to house and talked to the women about buying their vote, offering 200 pesos per vote. They spoke to the women, since women are at home during the day. This was not a worthwhile sum, and didn't have enough sway. Women were active in the dialogue about the municipal elections

Figure 16 Women attending the PRI campaign speech.



⁶ *Partido Revolucionario Institucional*

When speaking to women about the government's role in the community, many referred to "Fidel," the current governor of Veracruz state, who funded the road, the school, and health services. They spoke with approval of Fidel, saying that he had brought them many good things. The municipal president did not make out so strongly with praise from women, who said he was not good at bringing them things that they needed. He supplied money for building materials, in exchange, the local men contributed with *faena* to complete construction.

Figure 17 Election booths at the primary school in Matlalapa.



During the campaign season, women were always present when a candidate came to give a speech. If one woman offered her opinion or advice of what the community needed from the local government, specifically concerning a better water supply system, women backed each other up, agreed with each other. They spoke about what they and their families needed more than the present men. A children's health initiative was being built up while I was there. One of my informants was in charge of the initiative, which included going to each home in the community where there were young children and weighing them, measuring them, and getting a

general assessment of their health. Most young mothers were receptive to the initiative and interested in the access to better health services. Women meet regularly for school related issues. They meet with the teacher to discuss what their children are doing, and what the school needs. Mothers were interested in opportunities to improve children's health and education. Women were also organized and loosely connected through an informal network that existed was between the upstream and the downstream women of the main community water line. Downstream users talked to each other about the misuse of the upstream families of the river and small tributary with their sewage. The downstream women complain to the municipal politicians.

Women are connected through issues that, in feminist geography are contested in the way in which they are and have been attributed to belonging to the women's realm—the household. However, when health and household survival is brought “outdoors,” through water quality, women enter a different realm. I would say that their involvement in water distribution, infrastructure, and quality brings women to a new level. Their children's education, health and therefore, also water quality, because it directly affects the household. Water brings women “out” and is one of the central binding forces in Coatitlán.

4.3.3 Division of Labor

Men do the work in the fields; they do all the work for cultivation. If a woman does not have a husband or male family member, the woman looks after the animals and the field, and goes to collect the wood. Women's work is in the home and kitchen; but, they also have to do men's work outside. For example, men collect wood, and women help them, care for and work with the wood. If men say that there is a lot of sowing that needs to be done, women go to the fields and weed. Women also help them fertilize the soil. Women are very clear in relating their heavy workload and emphasizing that they have more work than most men.

Working is the only way the food, the money, is brought into the family. Work ensures and food and income. Sons and husbands work so that the rest of the family won't suffer. They take things with them down to town to sell during the „time of the guayaba.“ Thankfully our family doesn't have to experience the „guayaba“ because we have not been without anything to eat. The time of the guayaba is when there is nothing to eat and nothing to sell. If there is no food to sell, they women sell the calla lilies, cheese. Milk and cheese earn money.

Figure 18 Man going to work in his *milpa* and a couple men herding the goats.



The clearest distinction between women and men's work is that men are engaged in *faena*, work that is communal, and for maintaining the community. Men don't have to work in the fields except for every moon. Men never mill the corn. Men's work is confined to the machete. Men do the electrical work. Water infrastructure is installed and maintained by the men in the community. The municipal government supplies the funding and the men do the work. The men decide among themselves who is responsible for which jobs. While there is no pay, it is done for the benefit of the community. Nine years ago the community members that did not have water access directly at their house got together and got funding from the municipal government for materials to install a water line and reservoir from the largest spring above the village to the houses.

Men are in "officially" in charge of the *milpa*, but the women also assist in the work done on the there, and otherwise bring food to the men working in the *milpa*. During the rainy season, men go and work in the cities and elsewhere to earn extra money. They typically work in construction.

To supplement the available income of their husbands, sons, and some daughters, women in Coatitlán go to Xico to sell calla lilies, fruits, and some vegetables both harvested and foraged. Several women told me that this was not possible until their houses were connected to a water line, since they had extra time to find and produce items to sell. One of the women I talked to had completed midwife training and used to supplement family income through her midwife service to Coatitlán and other communities in the *ejido* until medical services arrived. Several

women also make and sell cow, sheep, and goat cheese. Milk is sold to dairies. Several women asked me to show them how to knit so that they could make bags and sell them in addition to the food products.

Figure 19 Woman with her cheese production set-up and a woman with her plants that she sells.



Education is directly related to income. Children attend one of two primary schools in Coatitlán, and then go to the secondary school in Matlalapa. Many young women get pregnant during their secondary education, where they meet the young men. When they get pregnant, the young women generally move into the home of the young man, and the young men leave school to work in Xico, Xalapa, or other surrounding larger areas to earn money for the additional family members. Young men and women who reach the level of the high school have to go to school in Xico, requiring their families to pay for housing and food. I did not meet any families where a family member had completed high school, due to financial constraints.

While women have the self-confidence and give themselves the credit for their work, they also relinquish some of that exuded independence when describing that men work to support their families. However, with men migrating to the other towns to work, women use their ability to take over men's work to also take over their involvement in their participation in local political decisions, by attending campaign talks and voting.

As Jokisch (2003) describes, the removal of labor can threaten the capacity of households to respond to labor demands, eventually maybe leading to a reduction of cultivation or agricultural production. He asks whether migration undermines agricultural systems or if it changes the rural

cultural landscape. In Coatitlán, migration doesn't necessarily change these elements. Instead, women take on an increased load of tasks that were formerly done by men. However, as more and more of the younger people migrate also, including young women, the local labor force will decline and the cultural landscape could very well be changed. Furthermore, with the increased access to larger towns and mobility offered to the community, earning an income outside of Coatitlán will become increasingly easy and the norm, and perhaps the *milpa* will lose cultural value. On the other hand, as women recognized with the implications of deforestation, giving up on one of the key livelihoods from the local cultural landscape was detrimental. So, I would assume that the cultural value of the *milpa* would hopefully be retained as not to lose either self-sufficiency or a part of the cultural landscape. Meanwhile, additional income from migration labor would at first be used for luxury goods and not for the household or education, as suggested by Durrand and Masey (1992). This trend would perhaps not last long before being reversed and the community became accustomed to additional income.

4.3.4 Religion and Natural Resource Management

People pray to San Isidro, the saint of the crops. When there are strong storms, the community prays to the saint: "San Isidro, blessed, San Isidro, farm worker, take away the water (rain) and bring the sun, because we want the sun for our harvest"⁷. If the wind becomes strong and

destroys the crops, they also pray to San Isidro for a harvest. Santa Juquila has been

Figure 21 Alter for Santa Juquila inside a family's home.



vigilant in Coatitlán for six years. Only God knows where a hurricane or storm comes from. San Isidro is the saint of the earth, the protector of soil. The Virgin de Guadalupe is also important in Coatitlán as she is everywhere in Mexico. This is because she is Mexican, "*indigena*," and represents the whole region. The two, and God, are important for the harvest and the planting. In Coatitlán there is one chapel designated to the Santa Juquila. One

⁷ "San Isidro, Bendito, San Isidro labrador, quitanos el agua y pon el sol, porque la verdad es que nosotros queremos el sol de la siembra."

family has a small Saint in their home; others adorn the rooms where they sleep with small pictures of the saints.

The mexicanized Catholicism of the women in Coatitlán varies in the way it manifests itself into their speech, or habits as they walk by the church, look at their pictures of the saints they have on their wall. The older women, integrated religious rhetoric into their speech more often, with phrases such as “*solo Dios sabe*.” Younger women were not particularly feverous in the belief they exuded. When one woman told me that I could pray to Santa Juquila and ask for money, or a car, the saint would help me get it, I started to feel somewhat skeptical of the depth to which they believed in her.

4.3.5 Language: local vocabulary for climate related events

Women refer to the original language as “*Mexicano*.” No one speaks it anymore, except I was told, one old lady in Ixochil, the neighboring village. I was told that even the oldest informant’s parents did not speak it. Nevertheless, I noticed that a number of plants had “*Mexicano*” names. Local names for different kinds of rains include “*chipi-chipi*,” referring to a light, constant rain, most often affiliated with late fall and early December. “*Aguaceros*” are the heavy rainstorms that predominate in the rainy season. “*Nortes*” are strong rains in combination with strong winds that are characteristic for the later winter months. The dry months are called the “*tiempo de guayaba*,” meaning that there is no food and little income.

As other studies demonstrate, traditional knowledge and classification systems are kept alive through the local language. When speaking between themselves, women in Coatitlán did speak more quickly and with a different intonation than they did when speaking with me. And they wanted me to meet the woman who spoke *Mexicano*, wanting to impress me.

4.4 Discussion Summary

The central event occurring in Coatitlan during the summer of 2007 was a state-funded road construction project. This project influenced women’s perception of their environment and augmented their interest in political events, and clarified the social networks and stratification women are a part of.

During this time, women’s livelihoods temporarily shifted back to older patterns of water retrieval, and washing laundry in the streams. Concern for water infrastructure saturated the way women spoke to local politicians, and bolstered their enthusiasm for travel to other towns in the future. In a way they, as women, were empowered through the road construction project and

may be increasingly so in the future. Migration and men's work in other places leads to a greater shift in the roles women have in their households and the community as their livelihoods may change. Women will be granted more space for input and they will take it and use it to their individual and community benefit.

In community decision-making, especially that concerning water resources, both precipitation and surface, women need to be consulted. Had the institutions of governance and affiliated engineers consulted with the women, they would have found out that the rainy season was the wrong time to conduct such road construction and that the construction was problematic for the families' water resources. Also, the damage on the cultural landscape as a whole affected the whole community: the grazing pastures and cultivated fields were filled with rocks. Without effective governance institutions at the appropriate scale, natural resources and the environment are in increasing risk stemming from increasing consumption and new technologies for resource use. The knowledge base of resource use and management is strongest in small-scale ecologies and between people's networks in communities that are based on a series of successes and failures that have existed for many generations.

The road construction project also reinforced the sense of community in the way women dealt with the changes in water retrieval. Women with their own springs on their property allowed other women access. If the relationship between the women who got water from another woman's property was not on good terms, the retriever sent her children. In this sense, communities uphold face-to-face communication, increasing potential for building trust between resource users. The characteristics of resources and social interaction in many subsistence societies have the right conditions for the evolution of effective self-governing resource institutions.

The question of access to water for several women then resulted in a power play, which I did not get to explore further. Different levels of power within user groups allow some to ignore common use agreements. Local knowledge becomes a control resource. In this same line, women who had increased control because of their higher social position—based largely on access to more fertile landscape, natural resources, and water springs—used the increased knowledge they may have had to control their resources and the way other women could access resources.

Human-environmental interactions and processes are often gendered. The differing access men and women have to different aspects of agroecosystems is based on their different social and cultural roles. Changing gender roles or power can drive environmental transformation (Carney, 1996; Rochelau, 1996). This can be related to water, who uses it and who is in charge. In Coatitilán, these shifts occur predominantly as a result of men's migration to cities and other places for work. The opposing systems of men and women are the products of socially and culturally created structural positions relative to labor and nature. "Normal" women's work and "normal" men's work, and the expectations assigned to gender explains much about what women and men know about their environment, how much access they get to elements of agroecosystems, and their ability to adapt to environmental risks and burdens. Hidden implications of agricultural change might now be seen simultaneously as costs in women's power. Women's prominent role in environmental management might be understood in terms of a simultaneously occurring decline in gender-specific expertise that is critical for community survival (Brodth, 2001). Scott & Silva-Ochoa's suggestion is applicable to the women in Coatitilán, namely, that the consolidation of water users seem to increase the likelihood of them taking on extra collective water management tasks. Sharing water among women means ensuring solidarity and improving chances for community survival.

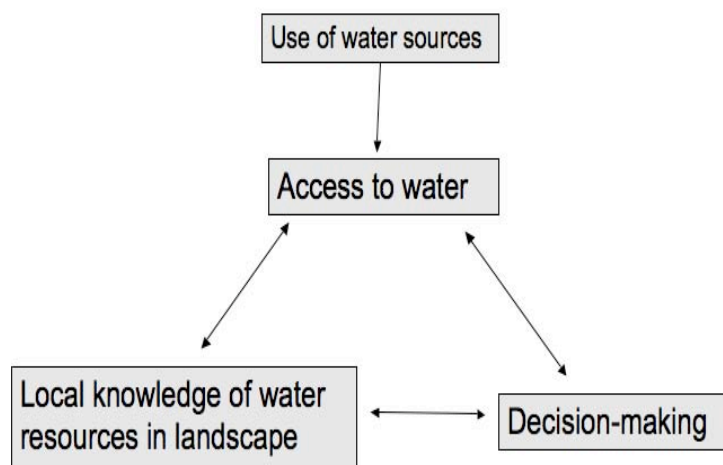


Figure 21 The processes informing women's local knowledge of water resources.

Rural social systems are structured around divisions of labor and power that differ in their access and responsibility for natural goods and systems. Who controls what, who is allowed to decide about what, and who is expected to do what tasks are the issues at hand in this discourse. Any development effort geared at a specific group has notable

implications for the environmental

systems governed by that group, gender or community. By explaining how environmental conditions change and why, people not only articulate their notions of how ecosystems work, but also the patterns of cause and effect they perceive. Such explanations further reveal their

perceptions of how landscapes looked and functioned in the past (Davis and Wagner 2003; Schroeder & Suryanata, 1996).

Women's local knowledge of water resource management starts with the way that they use water resources—either through weather or surface. This is translated to the access they have to it, or how they deal with the access to it. Access is informed, in part by their local knowledge of water resources IN their landscape. This goes to include rainwater in the sense that their knowledge of weather and its impact on other ecosystemic elements defines how they can access rain or avoid rain to perform their livelihood tasks. Decision-making refers to household decisions, when to go to the municipal capital, Xico, to go to the market, how to schedule their day, how to use water, and how to treat it. Decision-making defines if they use certain sources. The decisions women make reflects their needs. Women's local knowledge is thus the product of interrelated factors, but not to be separated from their cultural landscape and the affiliated livelihoods.

5. Conclusion

Women have had more presence in local decision-making processes since the road connecting Coatitlan and Xico was built, resulting in a greater number of men migrating frequently for job opportunities in larger towns and cities. Thus, women have to take on the men's roles and maintain that *machismo* is less present than it was before—the women allow less than they did before. The more blatantly gendered constructions have changed mostly in the last ten years, coinciding with the time when mobility to Xico and other villages in the *ejido* increased due to improved transportation infrastructure. I believe that as women's vision of their landscape is extended to include a larger area, there are increasing livelihoods that will use natural resources in different ways than they do now. This means that women's needs will change, their cultural landscape will change, and thus so will their local knowledge of managing water resources—either with a varied rain schedule or no need to regard the precipitation, climate, or with changing infrastructure that does not force women to collaborate for systematized community water management system.

Signals from the environment have to be received and properly interpreted by women in question if they are to be successful in adapting their water management to new circumstances in their community. Different water users relate in different ways to the different water resources that are available. Adaptive management assumes that nature cannot be controlled and yields predicted; uncertainty and unpredictability are characteristics of all ecosystems, including cultural landscapes, and the people that are a part of them.

Women's local knowledge has to do with their position in the power relations not only with the male community counterparts, but the male dominated political, decision-making regime that governs how landscapes are changed in the name of development, thereby disregarding resources that women depend on for their livelihoods. Furthermore, women's local knowledge of water resources will increasingly be affiliated with empowerment—giving women's own work and span of energy the recognition it deserves, trusting *their* knowledge of *their* landscape that their management depends on.

6. References

- Agrawal, B (1992). The Gender and Environment Debate: Lessons from India. In: *Feminist Studies* 18(1): 119-158.
- Agrawal, B (1994). Gender and Command over Property: A Critical Gap in Economic Analysis and Policy in South Asia. In: *World Development* 22(10): 1455-1478.
- Agrawal, B (2000). Conceptualising environmental collective action: why gender matters. In: *Cambridge Journal of Economics* 24: 283-310.
- Agrawal, B (2003). Gender inequality, cooperation and environmental sustainability. In: *Inequality, Collective Action, and Environmental Sustainability*. Eds: Jean-Marie Baland, Samuel Bowles, and Pranab Bardhan. New York: Russel-Sage.
- Arredondo Salas, S.M. & Wilson, P.N. (2004). A farmer-centered analysis of irrigation management transfer in Mexico. *Irrigation & Drainage Systems*, 18: 89-107.
- Baland, J.-M., Platteau, J.-P. (1996). Halting degradation of natural resources: Is there a role for rural communities? Oxford: Clarendon Press.
- Barham, B.L., O.T. Coomes & Y. Takasaki (1999). Rain Forest Livelihoods: income generation, household wealth and forest use. *Unasylva* 50(198): 34-42.
- Barrera-Brassols, N. and Zinck, J.A. (2002). Ethnopedology: The soil knowledge of local people: 11-42.
- Barrera-Brassols, N. and Zinck, J.A. (2003). Ethnopedology: a worldwide view on the soil knowledge of local people. *Geoderma* 111, 171-195.
- Bebbington, A. (1996). Organizations and intensifications: campesino federations, rural livelihoods and agricultural technology in the Andes & Amazonia. *World Development* 24: 1161-1177.
- Berkes F. & C. Folke (Eds) (1998). *Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience*. Cambridge UP: Cambridge, UK.
- Berkes, F., J. Colding, and Folke, C. (2003) *Navigating Social-ecological Systems: Building Resilience for Complexity and Change*. Cambridge U P, Cambridge, UK.
- Berman, M. and Kofinas, G. (2004). Hunting for models: grounded and rational choice approaches to analyzing climate effects on subsistence hunting in an Arctic community. *Ecological Economics* 49, 31-46.
- Berman, M., Nicoloso, C., Kofinas, G., Tetlich, J. and Martin, S. (2004). Adaptation and Sustainability in a Small Arctic Community: Results of an Agent-Based Simulation Model. *Artic* 57/4, 401-414.
- Bernard, Harvey R. (2002) *Social Research Methods: Qualitative and Quantitative Approaches*. Sage Publishing: Thousand Oaks, CA.
- Blaikie, P. & Brookfield, H. (1987). *Land Degradation & Society*. Methuen: London, UK.
- Blaikie, P. (1985). *The political economy of Soil Erosion in Developing Countries*. Longman Scientific and Technical P: New York, NY.
- Boyden, S. (1987). *Western Civilization in Biological Perspective: Patterns in Biohistory*. Oxford University Press: Cambridge, UK.
- Boyden, S. (1992). *Biohistory: the Interplay between Human Society and the Biosphere: Past and Present*. UNESCO: Paris.
- Brodt, S. (2001). A Systems perspective on the conservation and erosion of indigenous agricultural knowledge in central India. *Human Ecology* 29(1). 99-120.
- Brokensha, D.D., Warnen & O. Werner (eds). (1980). *Indigenous knowledge & development*. Lanham: University Press of Arizona.
- Buechler, S.J. (2000). El trabajo de las mujeres, niños, niñas y hombres en parcelas irrigadas de Guanajuato en épocas de crisis. In S. Buechler, & E. Zapata-Martelo (Eds.) *Anduve detrás de todo a la corre y corre...* Género y Manejo del Agua y Tierra en Comunidades Rurales de Mexico. IWMI Serie Latinoamericana 14. Mexico City, Mexico and Colombo, Sri Lanka: Internacional Water Management Institute.
- Cabrera, I.R.; Zapata Martelo, E. & Vazquez Garcia, V. (2001). Gender, rural households, and biodiversity in native Mexico. In: *Agriculture and Human Values*, 18: 85-93.
- Carlsson, L. & Berkes, F. (2005). Co-management: concepts and methodological implications. In: *Journal of Environmental Management*, 75: 65-76.
- Carney, J. (1994a). Contracting a food staple in the Gambia. In: *Living under Contract: Contract Farming & Agrarian Transformation in sub-saharan Africa*. Eds. P. Little & M. Watts. University of Wisconsin Press, Madison. 167-187.
- Carney, J. (1996b). Converting the wetlands, engendering the environment. In: *Liberation Ecologies: Environment, Development, Social Movements*. Eds. R. Peet & M. Watts. Routledge: NY. 165-186.
- Cashman, K. (1991). *The Fertilizer Bush Drama: Principle into Practice*. Development Communication Report. Washington, USAID.
- Chambers, R. (1994). The Origins and Practice of Participatory Rural Appraisal. *World Development* (22) 7, 953-969.
- Chayanov, A.V. (1986). The Theory of Peasant Economy. D. Thorner, B. Kerblay, & R.E.F. Smith (eds). The University of Wisconsin Press, Madison.

- Chuma, E., Mombeshora, B.G., Murwira, H.K. and Chikuvire, J. (2000). The dynamics of soil fertility management in communal areas of Zimbabwe in African farming systems. Hilhorst, T. and Muchena, F.M. (Eds.). International Institute for Environment and Development, London.
- Cleaver, F. (1998). Choice, complexity & change: gendered livelihoods and management of water. *Agriculture and Human Values* 15(4): 293-299.
- Cleaver, F. (1998). Incentives and informal institutions: Gender and management of water. In: *Agriculture and Human Values*, 15: 347-360.
- Cockburn, A. & Ridgeway, J. (1979). *Political Ecology*, NY Times Books. Harvard University Press: Cambridge.
- Comision Nacional del Agua (CNA), (1998). Diagnostico Preliminar sobre Superficies Regables y volúmenes Requeridos en las Unidades de Riego Organizadas y Sin Organizar. Comision Nacional del Agua (CNA) and Colegio de Postgraduados (CP). Montecillo, Mexico: CNA and CP.
- Comité de Mujeres de la Alianza Social Continental: Las mujeres en la defensa del agua como derecho humano fundamental, 2004. <http://www.comitemujeresasc.org/> Accessed on February 2, 2008.
- Corbeels, M., Shiferaw, A. and Haile, M. (2000). Farmers knowledge of soil fertility and local management strategies in Tigray, Ethiopia. *Managing Africa's Soils* No. 10, February. International Institute for Environment and Development, London.
- Coward, E., Walter Jr. (1986). State & locality in Asian irrigation development: the property factor. *Irrigation Management in Developing Countries: Current Issues and Approaches*, ed. KC. Nobe & PK Sampath. Boulder, Colorado: Westview Press.
- Cruz, Guadalupe Magana. Estudio de impacto ambiental de la Granja Acuicola Comunitaria. Tesis, Facultad de Ingenieria Ambiental, Universidad Veracruzana, Xalapa, Veracruz.
- Donahue, John M. and Barbara Rose Johnston, Eds. (1998). *Water, Culture and Power: Local Struggles in a Global Context*. Washington, D.C., Island Press.
- Data, D. (1998). Soil fertility management in its social context: A study of local perceptions and practices in Wolalta, southern Ethiopia in *Managing Africa's Soils*, No. 1, September. International Institute for Environment and Development, London.
- Davis, A. & Wagner, J.R. (2003). Who knows? On the importance of identifying experts when researching local ecological knowledge. *Human Ecology* 31(3): 463-489.
- De Janvry, A., Gordillo, G., & Sadoulet, S. (1997). Mexico's second agrarian reform: Household and community responses, 1990-1994. San Diego, USA: Center for US Mexican Studies, University of California.
- del Angel-Perez, A.L. & Mendoza, M.A. (2004). Totonac homegardens and natural resources in Veracruz, Mexico. In: *Agriculture and Human Values*, 21: 329-346.
- Dembélé, I., Koné, D., Soumaré, A., Dounanké, C., Koné, Y., Ly, B., and Kater, L. (2000). Fallows and field systems in dryland Mali in *Nutrients on the Move: Soil fertility dynamics in African farming systems*. Hilhorst, T. and Muchena, F.M. (Eds.). International Institute for Environment and Development, London.
- Demeritt, David (2006). Scientific Forest Conservation and the Statistical Picturing of Nature's Limits in the progressive-era US. *Environment and Planning: Society and Space* 19: 431-59.
- Demsetz, H. (1967). Towards a Theory of Property Rights. *The American Economic Review*: 57(2). 347-359.
- Dietz, T.; Ostrom, E. & Stern, P. (2003). The Struggle to Govern the Commons: Reviewing Tragedy of the Commons. In: *Science*, 30(2). 1907 – 1912.
- Dunning, N.; Luzzadder-Beach, S.; Beach, T.; Jones, J.; Scarborough, V. & Culbert, P. (2002). Arising from the Bajos: The evolution of a neotropical landscape and the rise of the Maya civilization. In: *Annals of the Association of American Geographers*, 92(2): 267-283.
- Durand, L. & Lazos, E. (2004). Colonization and tropical deforestation in the Sierra Santa Marta, Southern Mexico. In: *Environmental Conservation* 31(1): 11-21.
- Elias, Eyasu. (2000). Soil Enrichment and depletion in southern Ethiopia in African farming systems. Hilhorst, T. and Muchena, F.M. (Eds.). International Institute for Environment and Development, London.
- Eling, H. H., & Sanchez-Rodriguez, M. (2000). Presas, canales y cajas de agua: la tecnología hidraulica en El Bajío mexicano. In J. Palerm-Viqueira, & T. Martinez-Saldana (Eds.), *Antología sobre Pequeño Riego*, Vol. II. Organizaciones Autogestivas. Montecillo, Mexico: Colegio de Postgraduados.
- Erickson, P.J. and Ardón, M. (2003). Similarities and differences between farmer and scientist views on soil quality issues in central Honduras. *Geoderma* 111, 233-248.
- Eyasu, E. (1998). Is soil fertility declining? *Managing Africa's Soils*, September. International Institute for Environment and Development, London.
- Falkenmark, M. (2004). Towards Integrated Catchment Management: Opening the paradigm locks between hydrology, ecology, and policy making. In: *Water Resources Development*, 20(3): 275-282.
- Falkenmark, M.; Gottschalk, L.; Lundqvist, J. & Wouters, P. (2004). Towards Integrated Catchment Management: increasing the dialogue between scientists, policy makers, and stakeholders. In: *Water Resources Development*, 20(3): 297-309.
- Flanagan, C. & Laituri, M. (2007). Environmental Assessment: Local Cultural Knowledge and Water Resource Management: the Wind River Indian Reservation. In: *Environmental Management*, 33(2): 262-270.

- Gay, C.; Estrada, F.; Conde, C.; Eakin, H. & Villers, L. (2006). Potencial Impacts of Climate Change on Agricultura: A case study of coffee production in Veracruz, Mexico. In: *Climate Change* 79: 259-288.
- Gelles, Paul H. (2000). *Water and Power in Highland Peru: the cultural politics of irrigation and development*. London: Rutgers University Press.
- Glantz, M. (1977). The Value of a Long-Range Weather Forecast for the West African Sahel. *Bulletin American Meteorological Survey*, 58/2 150-158.
- Greenberg, J.B. & Park, T.K. (1994). Political Ecology. *Political Ecology* 1: 1-12.
- Grossman, JM (2003). Exploring farmer knowledge of soil processes in organic coffee systems of Chiapas, Mexico. *Geoderma*, 111, 267-287.
- Grothmann, T. and A. Patt (2005). "Adaptive Capacity and Human Cognition: The Process of Individual Adaptation to Climate Change." *Global Environmental Change* 15(3): 199-213.
- Guzman, E.; Regil, E.; Gutierrez, L.; Alberich, M.; Hernandez, A. & Regil, E. (2006). Contamination of corn growing areas due to intensive fertilization in the high plane of Mexico. In: *Water, Air, and Soil Pollution*, 175: 77-98.
- Haenn, N. (1999). The Power of Environmental Knowledge: Ethnoecology & Environmental Conflicts in Mexican Conservation. In: *Human Ecology*, 27(3): 477-491.
- Hardesty, D. (1977). *Ecological Anthropology*. Alfred Knopf: NY.
- Hawley, A. (1950). *Human Ecology: A Theory of Community Structure*. Ronald Press, NY.
- Heimo, M.; Siemens, A. & Hebda, R. (2004). Prehispanic changes in wetland topography and their implications to past and future wetland agricultura at Laguna Mandinga, Veracruz, Mexico. In: *Agricultura and Human Values* 21: 313-327.
- Hilhorst, T., Muchena, F., Defoer, T., Hassink, J., de Jager, A., Smaling, E. and Toulmin, C. (2000). Managing soil fertility in Africa: diverse settings and changing practice in African farming systems. Hilhorst, T. and Muchena, F.M. (Eds.). *International Institute for Environment and Development*, London.
- Hernandez, R. (1998). Agua para siempre: obtención de agua y conservación de suelos a través de la regeneración de cuencas. *XX Coloquio de Antropología e Historia Regionales. Agua, Medio Ambiente y Desarrollo en Mexico* (pp. 78-89). Zamora, Mexico: Colegio de Michoacán.
- Hoffmann, J. A farmer's view of the human constraints to the adoption of seasonal climate forecasting in Australia. In: Eds. Huda, A.K.S. and Packham, R.G. *Using Climate Forecasting in Agriculture: a participatory decision-making approach*. Australian Center for International Agricultural Research, Canberra.
- Huda, A.K.S., Packham, R.G., Clewett, J.F. and George, D.A. (2004). Introduction and Overview. In: Eds. Huda, A.K.S. and Packham, R.G. *Using Climate Forecasting in Agriculture: a participatory decision-making approach*. Australian Center for International Agricultural Research, Canberra.
- Huda, A.K.S., Selvaraju, R., Balasubramanian, T.N., Geethalakshmi, V., George, D.A. and Clewett, J.F. (2004). Experiences of using seasonal climate information with farmers in Tamil Nadu, India. In: Eds. Huda, A.K.S. and Packham, R.G. *Using Climate Forecasting in Agriculture: a participatory decision-making approach*. Australian Center for International Agricultural Research, Canberra.
- INEGI, Instituto Nacional de Estadística y Geografía. Carta Topográfica Xico E14B36: Puebla y Veracruz [Map]. 1: 50,000. Mexico City, 2000
- Jacome, A.G. & Rodríguez, S. (1999). *Agricultura y sociedad en Mexico: Diversidad, Enfoques, Estudios de Caso*. Universidad Iberoamericana, Mexico, DF.
- Jungerius, P.D. (1998). Indigenous knowledge of landscape-ecological zones among traditional herbalists: a case study in Keiyo District, Kenya in *GeoJournal* 44:1: 51-60.
- Kan, E.M. (2004). Totonacos. *Comisión Nacional Para el Desarrollo de los Pueblos Indígenas*, D.F., Mexico
- Katz, E. (1997). "Ritos, representaciones y meteorología." In M. Goloubinoff, E. Katz and A. Lammel (eds.), *Antropología del clima en el mundo hispanoamericano*. Tomo II. (pp. 99-134). Quito: Ediciones Abya-Yala.
- King, A. (2007). Trade and Totomoxtle: Livelihood strategies in the Totonacan region of Veracruz, Mexico. *Agriculture and Human Values* 24:29-40.
- Klooster, D. (2002). Toward adaptive community forest management: integrating local forest knowledge with scientific forestry, *Economic Geography* 78: 43-70.
- Kome, A. (2006). Introduction to collaborative water management, SNV.
- Kuhn, T. (1970). *The Structure of Scientific Revolutions*, 2nd ed., Chicago: University of Chicago Press.
- La Agenda Azul de las Mujeres (2006). La agenda azul de las mujeres. www.undp.org.mx/Doctos/Biblioteca/ Accessed on January 21, 2007.
- Lewis, M. P. (1993). "Real men don't speak Quich'e: Quich'e ethnicity, Ki-che ethnic movement, k'iche "nationalism."" *Language Problems & Language Planning* 17(1): 37-54.
- Lompo, F., Bonzi, M., Zougmore, R. and Youl, S. (2000). Rehabilitating soil fertility in Burkina Faso in *Nutrients on the Move: Soil fertility dynamics in African farming systems*. Hilhorst, T. and Muchena, F.M. (Eds.). *International Institute for Environment and Development*, London.
- Mackinson, S. and Nøttestad, L. (1998). Points of View: Combining local and scientific knowledge in *Reviews in Fish Biology and Fisheries* 8, pp. 481-490.
- Magaña, V. & Conde, C. (2000). Climate and Freshwater Resources in Northern Mexico: Sonora, a case study. In: *Environment Monitoring Assessment*. 61: 167-185.

- Margana Cruz, G. (2006). Estudio de Impacto Ambiental de la granja acuícola comunitaria. Tesis, Universidad Veracruzana.
- McNew, K., Mapp, H., Duchon, C. and Merritt, E. (1991). Sources and Uses of Weather Information for Agricultural Decision Makers. *Bulletin American Meteorological Society* 72/4, 491-498.
- Meinzen-Dick, R. & Zwarteveen, M. (1998). Gendered Participation in water management: issues and illustrations from water users' association in South Asia. In: *Agriculture and Human Values*, 15:337-345.
- Miller, K. et.al. (1997). Water allocation in a changing climate: Institutions and adaptation. In: *Climate Change*, 35: 157-177.
- Mutersbaugh, T. (1999). Bread or Chainsaws? Paths to mobilizing household labor for cooperative rural development in a Oaxacan village (Mexico). *Economic Geography* 75(1), 43-58.
- Nabhan, G.P. & Sheridan, T.E. (1977). Living Fencerows of the Rio San Miguel, Sonora, Mexico: Traditional Technology for Floodplain Management. In: *Human Ecology*, 5(2). 97-111.
- Nandwa, S.M., Onduru, D.D. and Gachimbi, L.N. (2000). Soil fertility regeneration in Kenya in *Nutrients on the Move: Soil fertility dynamics in African farming systems*. Hilhorst, T. and Muchena, F.M. (Eds.). International Institute for Environment and Development, London.
- Niemeijer, D. and Mazzucato, V. (2003). Moving beyond indigenous soil taxonomies: local theories of soils for sustainable development in *Geoderma* 111, pp. 403-424.
- Onduru, D., Gachini, G.N. and Nandwa, S.M. (1998). Experiences in participatory diagnosis of soil nutrient management in Africa in *Managing Africa's Soils*, No. 3, September. International Institute for Environment and Development, London.
- Orlove, B. and Tosteson, J. (1999). The application of season to interannual climate forecasts based on El Nino-Southern Oscillation (ENSO) events: Lessons from Australia, Brazil, Ethiopia, Peru, and Zimbabwe. *Berkeley Workshop on Environmental Politics: Working Papers*. Institute of International Studies, UC Berkeley.
- Orlove, B., Chiang, J. and Cane, M. (2002). Ethnoclimatology in the Andes. *American Scientist* 90, 428-435.
- Ostrom, E. (2003). How types of goods and property rights jointly affect collective action. In: *Journal of Theoretical Politics*. 15(3): 239-270.
- Oudwater, N. and Martin, A. (2003). Methods and issues in exploring local knowledge of soils. *Geoderma* 111, 387-401.
- Packham, R.G. (2004). A background to participative approaches for research and application of climate science. In: Eds. Huda, A.K.S. and Packham, R.G. *Using Climate Forecasting in Agriculture: a participatory decision-making approach*. Australian Center for International Agricultural Research, Canberra.
- Palacios-Velez, E. (1997). Las unidades de riego o pequena irrigacion. In T. Martinez-Saldana, & J. Palerm-Viqueira (Eds.), *Antologia sobre Pequeño Riego*, Vol. I. Montecillo, Mexico: Colegio de Postgraduados.
- Palerm-Viqueira, J. (2000). Organización social y agricultura de riego. In J. Palerm-Viqueira, & T. Martinez-Saldana (Eds.), *Antologia sobre Pequeño Riego*, Vol. II. Organizaciones Autogestivas. Montecillo, Mexico: Colegio de Postgraduados.
- Pasteur, K. (2002). Gender Analysis for sustainable livelihoods, frameworks, tools and link to other sources. www.livelihoods.org. Accessed on: 22.1.08
- Peet, R. and M. Watts (1996). "Liberation Ecology: Development, Sustainability and Environment in the Age of Market Triumphalism." In *Liberation Ecologies: Environment, Development, Social Movements*. New York, Routledge: 1-45.
- Pulido, J.S. and Bocco, G. (2003). The traditional farming system of a Mexican indigenous community: the case of Nuevo San Juan Parangaricutiro, Michoacán, Mexico. *Geoderma* 111, 249-265.
- Rappaport, R. (2000). *Pigs for the Ancestors: Ritual in the Ecology of a New Guinea People*, 2nd Ed. Waveland Press Incorporated: Long Grove, IL.
- Rattan, Lal ed. (2000). *Integrated Watershed Management in the Global Ecosystem*. CRC Press: London, UK.
- Robbins, P. (2005). *Political Ecology*. Malden, MA. Blackwell Publishers.
- Robichaux, D. (1997). "Clima y continuidad en las creencias prehispánicas en la region de La Malinche (Mexico)." In M. Goloubinoff, E. Katz and A. Lammel (eds.), *Antropología del clima en el mundo hispanoamericano*. Tomo II. (pp. 99-134). Quito: Ediciones Abya-Yala.
- Ryder, R. (2003). Local soil knowledge and site suitability evaluation in the Dominican Republic. *Geoderma* 111, 289-305.
- Sanchez-Rodriguez, M. (2000). De la autonomia a la subordinación: riego, organización social y administración de recursos hidraulicos en la cuenca del Laja, Guanajuato. Zamora, Mexico: El Colegio de Michoacán (mimeo).
- Sandoval, R. (2004). A participatory approach to integrated aquifer management: the case of Guanajuato State, Mexico. In: *Hydrology Journal*, 12: 6-13.
- Sauer, Carl (1925). *The Morphology of Landscape*. University of California Publications in Geography 2(2): 19-53.
- Sax, J. (2000). *Legal Control of Water Resources: Cases and Materials*. St. Paul, MN: West Group.
- Sayuti, R., Karyadi, W., Yasin, I. and Abawi, Y. (2004). Factors affecting the use of climate forecasts in agriculture: a case study of Lomok Island, Indonesia. In: Eds. Huda, A.K.S. and Packham, R.G. *Using Climate*

- Forecasting in Agriculture: a participatory decision-making approach. Australian Center for International Agricultural Research, Canberra.
- Schröter, D., C. Polsky, et al. (2005). "Assessing Vulnerabilities to the Effects of Global Change: An Eight Step Approach." *Mitigation and Adaptation Strategies for Global Change* 10(4): 573-595.
- Schroeder R, Suryanata K, 1996, "Gender and class power in agroforestry", in *Liberation Ecologies: Environment, Development, Social Movements* Eds R Peet, M Watts. Routledge, London: 188-204.
- Sonnett, J., B. Morehouse, et al. (2006). "Drought and Declining Reservoirs: Comparing Media Discourse in Arizona and New Mexico, 2002-2004." *Global Environmental Change* 16(1): 95-113.
- Scott, P. & Sullivan, S. (eds). (2000). *Political Ecology-Science Myth and Power*, London: Arnold.
- Scout, C. & Silva-Ochoa, P. (2001). Collective action for water harvesting irrigation in the Lerma-Chapala Basin, Mexico. In: *Water Policy*, 3: 555-572.
- Shah, T. (1993). *Groundwater markets and irrigation development: Political economy and practical policy*. New Dehli, India: Oxford University Press.
- Shiva, V. (1989) *Staying Alive: Women, Ecology and Survival in India*, Zed Press, New Delhi.
- Singh, N.; Bhattacharya, P.; Jacks, G. & Gustafsson, J.E. (2004). Women and modern Domestic Water Supplí Systems: Need for a Holistic Perspectiva. In: *Water Resources Management*, 18: 237-248.
- Smith, S. & Marin, L. (2005). Water and the rural poor in Latin America: the case of Tlmacazapa, Guerrero, Mexico. In: *Hydrology Journal*, 13: 346-349.
- Snowshoe, N. (2001). Local and Traditional Observations of Climate Change in the Mackenzie Delta. The Northern Review: A Multidisciplinary Journal of the Arts and Social Sciences of the North. Coates, K., Kleinfeld, J., Graham, A., Ogden, A., Graham, A. and Long, M (eds.). Yukon College, Whitehorse, Yukon, 47-48.
- Stevenson, M.G. (1996). Indigenous knowledge in environmental assessment. *Artic* 49(3): 278-291.
- Sumberg, J.; Okali, C. & Reece, D. (2003). Agricultural research in the face of diversity, local knowledge and the participation imperative: theoretical considerations. In: *Agricultural Systems*, 76: 739-753.
- Thompson, A., Robbins, P., Sohngen, B., Awai, J. & Koontz, T. (2006). Economy, Politics & Institutions: From Adaptation to Adaptive Management in Climate Change. *Climate Change* 78(1).
- Tortolero-Villasenor, A. (2000). *El Agua y su Historia: Mexico y sus Desafios hacia el Siglo XXI.: Siglo Veintiuno Editores:Mexico City*.
- Trimbur, T.J. & Watts, M. (1976). Are cultural ecologists well adapted? A review of the concept of adaptation. *Proceedings of the Association of American Geographers* 8, 179-183.
- Valbo-Jørgensen, J. (2004). The use of local knowledge in river fisheries research. *FAO Aquaculture Newsletter* 32, 4-7.
- Vasquez-Leon, M., C. T. West, B. Wolf, J. Moody, and T. J. Finan (2002). Vulnerability to Climate Variability in the Farming Sector. CLIMAS Report Series, CL1-02 December 2002
- Vazquez-Garcia, V. (2001). Coffee production and household dynamics. The Popolucas of Ocotil Grande, Veracruz. In: *Agricultura and Human Values*, 18: 57-70.
- Vazquez-Garcia, V.; Godinez-Guevara, M.; Ortiz-Gomez, A.; Montes-Estrada, M. (2004). Uncultivated foods in southern Veracruz, Mexico: Establishing the links between ecosystem health, food availability, and human nutrition. In: *Ecohealth* 1(2): 131-143.
- Walker, Andrew. 2003. Agricultural Transformation and the Politics of Hydrology in Northern Thailand.? *Development and Change* 34 (5): 941-964.
- West, C. T., and M. Vasquez-Leon (2003). Testing farmers' perceptions of climate variability: a case study from the Sulphur Springs Valley, Arizona. In: *Weather, Climate, Culture* Strauss, S. and B. Orlove, Eds. (2003). New York, Berg.
- Walaga, C., Egulu, B., Bekunda, M. And Ebanyat, P. (2000). Impact of policy change on soil fertility management in Uganda in African farming systems. Hilhorst, T. and Muchena, F.M. (Eds.). *International Institute for Environment and Development*, London.
- Walker, M. (2006). Women, water, policy, and reform: global discourses and local realities in Zimbabwe. Michigan State University, working paper.
- Walter, P. (2005). Political: Ecology: Where is the ecology? In: *Progress in Human Geography* 29(1): 73-82.
- Warburton, H. & Martin, A. (1999). Local people's knowledge in natural resources research. *Natural Resources Institute of the University of Greenwich. Department for Internacional Development: Kent, UK*.
- Watts, M. (2000). Political Ecology. In *A Companion to Economic Geography*. Eds. E. Sheppard & T. Barnes. Malden, MA, Blackwell Publishers: 257-74.
- Weeks, P. & Packard, J. (1997). Acceptance of Scientific Management by natural resource dependent communities. In: *Conservation Biology*. 11(1). 236-245.
- Wells, B. & Gradwell, S. (2001). Gender and resource management: Community supported agriculture as care-practice. In: *Agricultura and Human Values*, 18: 107-119.
- Wittfogel, K. (1957). *Oriental Despotism: A comparative Study of Total Power*. New Haven: Yale University Press.
- Zimmerer, K. (2007). Agricultura, livelihoods, and globalization: the analysis of new trajectories (and avoidance of just-so stories) of human-environment change and conservation. In: *Agricultura and Human Values*, 24: 9-16.

- Zube, E.H. and M.R. Sheehan (1994). "Desert riparian areas: Landscape perceptions and attitudes." *Environmental Management* 18(3): 413-421.
- Zwarteveen, M. & Meinzen-Dick, R. (2001). Gender and property rights in the commons: examples of water rights in South Asia. In: *Agriculture and Human Values*, 18: 11-25.
- Zwarteveen, M. (1998). Identifying gender aspects of new irrigation management policies. In: *Agriculture and Human values*. 15: 301-312.