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Fertile Lands and Bodies: Connecting the Green Revolution, Pesticides, and Women's Reproductive Health

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Introduction

The Green Revolution is widely understood as a wave of agricultural advancements in development, research, and technologies that washed over soils worldwide during the mid-twentieth century. The diffusion of high-yielding seed varieties throughout countries in the Global South answered the calls of governments in poverty- stricken countries faced with rising populations and food shortages. Following the global flow of the seeds were chemical inputs, such as the notorious pesticide, dichlorodiphenyltrichloroethane (DDT), to support the miraculous growth of the seeds in any climate, country, and culture. In the eyes of Western science, the Green Revolution's stimulation of rural agrarian economies represented the power of modernized agricultural techniques and knowledge. Understanding the impacts of the Green Revolution based on quantitative indicators, such as yields and profits, paints a picture of success. Yet, delving beneath the narrow conception of quantitative success of the Green Revolution exposes the widespread harm caused by its new technologies and ideologies. Women's centrality in agricultural production in the Global South subjected their bodies disproportionately to this harm. Just as DDT was at the crux of the Green Revolution's model, women's agricultural participation was at the crux of production in the Global South.

When I first began my research questioning the relationship between the Green Revolution and women's health outcomes, it was the centrality of both women and DDT to their respective systems that formed the basis of my hypothesis. I understood my research question as relatively simple instance of cause and effect; how did the Green Revolution's introduction of DDT into the Global South cause negative reproductive health outcomes for women? My initial understanding of what that question meant was based purely on

quantity; the Green Revolution used more pesticides and therefore, caused more health problems. In my mind, it was a simple equation. As my research expanded, however, I realized that I had fallen into the same, narrow reliance on quantitative measures that I was condemning the Green Revolution for adhering to. I had not taken into account the myriad social and economic variables that not only undergirded, but also fundamentally shaped, women's susceptibility to DDT exposure within the Green Revolution. The relationship between the Green Revolution, pesticides, and women's reproductive health outcomes emerged as anything but simple.

Throughout my research, I have come to acknowledge the integral role of women's social and economic patterns of production in the Global South in relation to women's pesticide exposure and health outcomes. Far from a linear progression of cause and effect, the relationship between the Green Revolution and women's health represents a complex nexus imbued with historical, social, economic, cultural, and biological variables. Women's reproductive health outcomes are at the center of a diverse range of discourses. My research shifted from a purely linear conception of the Green Revolution's relationship to women's health, to one that, instead, identified a multidimensional web of causality. From within this web emerged a more nuanced and integrated research question; how did the Green Revolution increase the exposure of women in the Global South to DDT to increase their susceptibility to adverse reproductive health outcomes?

To answer this broad question, I asked the following questions:

a) How and why were pesticides a critical component of the Green Revolution's model?

b) How did the Green Revolution facilitate women in the Global South into new roles of increased social susceptibility to DDT exposure?

c) What are the gendered biological mechanisms of DDT contamination that led to negative reproductive health outcomes?

d) What are the specific reproductive health outcomes for women that result from DDT exposure?

Answering these questions relied upon uniting diverse bodies of literature through theoretical analysis and deep contextualization of common themes. What emerged was a new perspective of the Green Revolution, exposing a new layer of disparity and bodily harm. Within this lens, the Green Revolution did more than merely introduce new levels of DDT into the lives of women in the Global South. It did more than restructure the social and economic structures of agricultural production. Together, the social, economic, and chemical forces of the Green Revolution cultivated a new, pervasive environment of harm for women living in the Global South. Within this new environment, women faced new social susceptibilities to pesticide contamination in addition to their biological predisposition. In this light, I argue that women's negative reproductive health outcomes in the Global South are byproducts of the technological undermining of subsistence agriculture. They are a hidden, and unexplored, legacy of the inherent social and economic inequality built into the core of the Green Revolution.

To substantiate the process through which the Green Revolution caused reproductive health problems for rural women in the Global South, I begin with a historical analysis of the Green Revolution. After exploring the gaps in literature concerning the

relationship between the Green Revolution and women's health, introducing my theoretical considerations, and expounding upon my research methodology, I delve into the history of the Green Revolution in Chapter 4. Building a strong historical foundation exposes both the technological and ideological underpinnings of the Green Revolution to show its inequitable ideology. Chapter 5 discusses how the introduction of pesticides and technologies reorganized social and economic structures and created new labor demands for women in agrarian economies. Across socioeconomic classes, agrarian change alters the social patterns of production to situate women in new spaces, in both the formal and informal labor forces. In Chapter 6, I explain the history of DDT and the chemical properties that situate it at the fulcrum of women's health concerns. Following this discussion, is my analysis of how the Green Revolution facilitated new social susceptibility of women to DDT exposure. I elaborate upon the biological mechanisms of pesticide contamination in Chapter 7 by investigating the process of endocrine disruption and review several epidemiological studies observing the relationship between DDT exposure, bodily accumulation, and reproductive health outcomes. Lastly, Chapter 8 provides a case study of the Green Revolution in Punjab, India to illustrate how larger theories, social relations, and biological processes manifested in negative reproductive health outcomes in a specific context.

Together, my multiple frames of analyses uncover the intricate web of social, economic, and technological inequalities through which the Green Revolution impacted the reproductive health of rural women in the Global South. Although examining the Green Revolution through a deeply analytical health-based lens has not been a project

undertaken by scholars, I show that it is a valuable and provocative exploration that should be brought to light.

* * *

I would also like to make a brief explanation and rationalization for my use of "rural women in the Global South." I am keenly aware and sensitive to the problematic nature of using "women in the Third World" or "women in the Global South" as a unit of analysis in a discussion of social and economic oppression on a global scale. Inspired by the feminist work of Chandra Mohanty, I believe that it is entirely inappropriate to infer the uniformity of women's individual experiences across diverse global spaces or to infer their global domination, especially within capitalist systems. Mohanty (1988) wholeheartedly rejects using "women" as a category of analysis as it assumes an "ahistorical, universal unity between women based on a generalized notion of their subordination" (p. 64). It is neither my intention to perpetuate this essentializing hegemony nor to rid women of their identities. I fully acknowledge that the effects of pesticides vary depending on the socio-political context of their use, however, I also acknowledge that the biological mechanisms through which they interact with the female body are shared across borders and bodies. My analysis does not intend to promote a message about women's shared social or economic oppression within the Green Revolution. Rather, I argue that DDT's biological and chemical properties unite women through a shared the experience of pesticide use, susceptibility, and exposure. Women worldwide experience the same biological processes of reproduction; it is within this framework that I understand the pesticides of the Green Revolution to have impacted the health of women in the Global South.

CHAPTER 1- Literature Review

Common Critiques

The Green Revolution promoted not only a surface level, technical restructuring of traditional farming techniques, but also a profound ideological shift. Put forward by the Rockefeller Foundation as a strategy to achieve social and economic stability through increased productivity, shortsighted Western assumptions of science and technology undergirded the Revolution (Perkins, 1990; Frankel, 1971; Griffin, 1979; Dahlberg, 1979; Kohler, 2007; Kesavan & Malarvannan, 2010). Kenneth Dahlberg (1979) asserts that the Foundation's lack of attention to farmers' unique needs and realities reflected an imperialist ideology of cultural and scientific domination (p. 49) Yapa (1993), in agreement with Dahlberg, elaborates upon this argument to blame the long-term negative side effects of the Green Revolution on its Western industrial model of agricultural science over a context-specific holistic system (Yapa, 1993: Dahlberg, 1979; Shiva, 1991). I argue that health impacts fall into the category of "unintended side effects" and are a crucial element of their argument.

At the core of the Green Revolution's agricultural science were Borlaug's high-yielding varieties (HYVs) of wheat and rice; an innovation he describes as a "miracle that has generated new hope for the future," or as a fix to "impoverished soils" of developing countries (Borlaug, 1970). The adaptability and growth of these seeds, however, were highly dependent on chemical pesticides, such as DDT. Environmentalists, economists, and social scientists voice a wide range of critiques concerning the radical agricultural change that resulted in pesticide- dependent production. Scholars concerned with the role of pesticides in causing environmental degradation (Shiva, 1991: Shiva, 1993; Merchant,

1996; Carson, 1962; Pimentel, 1994), economic polarization (Griffin, 1979; Bardhan & Bardhan, 1973; Shiva, 1991; Frankel, 1979), and the displacement of cultural knowledge and practices (Marglin, 1996; Shiva 1991; Bardhan & Bardhan, 1973; Pingali, 2013, Griffin, 1979) observe and condemn the impact of pesticides on local communities. Additionally, scholars concerned with women's experiences in large-scale agrarian change tend to focus specifically on how the Green Revolution impacted women's income (Boserup, 1986; Buvinic & Mehra, 1990; Ahmed et al., 1985; Ghosh & Mukhopadhyay, 1986), gender relations (Boserup, 1986; Ahmed et al., 1985; Ghosh & Mukhopadhyay, 1986), or migration patterns (Boserup, 1986; Buvinic & Mehra, 1990). When it comes to understanding how health fits into the analysis, such scholars do not go farther than to analyze how the Green Revolution affected the health of the soil.

Largely missing from these dominant discourses is the impact of the Green Revolution's excessive use of pesticides on women's health. Conventional critiques from environmentalists, social scientists, and economists have not expanded to include women's bodily experience of pesticide use as a side effect of Green Revolution development. It is newly emerging as an important line of inquiry that questions the individual, rather than cultural, experience of technology. Literature concerning the Green Revolution's impact on women's reproductive health is a patchwork of social and biological science. A report by the Institute of Medicine's Committee on Gender Differences in Susceptibility to Environmental Factors (1998) explains that sex is a proxy for social, cultural, and biological variables of health (Setlow & Woods, 1998, p. 13). Social scientists, therefore, explore the question of women's health and the Green Revolution by asking "why" women were increasingly exposed to pesticides through socialized roles and responsibilities. Their

critique includes examining the impact of the Green Revolution on women's labor demands as its lens of analysis. The more biologically based, scientific scholars however, seek to understand "how" pesticides interact with the female body and how those mechanisms situated women's bodies at a unique threat for reproductive health problems. Despite divergent lenses, scholars agree that gender differences increase women's risk of both occupational and environmental pesticide exposure.

A Shared Understanding of DDT and its Environmental Interactions

Despite divergent disciplinary underpinnings, literature investigating the role of the Green Revolution in threatening women's reproductive health rests upon shared knowledge about the nature of organochlorine pesticides, like DDT, those which were the most widely diffused during the Green Revolution's global transfer of agricultural technology (Carvalho, 2006). Though different bodies of literature emphasize varying routes of exposure or reach divergent conclusions about specific exposures and outcomes, the common understanding of organochlorines' biological properties unites the diverse voices engaged in the health conversation.

In their analyses, scholars of both social and natural science assert that the process through which DDT contaminates women's bodies rests on its chemical characteristics; it is are highly persistent in the environment and accumulates in fatty tissues once inside the human body. The contamination of air, food, water, and soils by persistent DDT residues expands the threat of exposure from a strictly agricultural realm to include women's homes, food sources, and water sources (Bouwman, 2006; Saxena et al., 1981; Siddiqui et al., 2002; London et al., 2002; Riazuddin, 2011; Pimentel, 1995; Forget, 1991;

Weisenburger, 1993). In the same vein, scholars such as David Kinkela (2011) argue that DDT use came at a significant cost; no discrimination exists between its impacts on helpful insects or people, and the targeted pests (Kinkela, 2011; Carson, 1962). Biologically persistent chemicals risk contaminating unintended targets. Given the lipid solubility of DDT, scholars continue to point out that women are increasingly targeted as they have a higher proportion of fatty tissues, such as breast tissue (Diaz-Barriga et al., 2003; Garcia, 2003; Bhatt, 2000; Lopez-Carrillo et al., 1996; Bag, 2000; Chikuni & Polder, 2003; Murray, 1994). Environmentalist Sandra Steingraber (2010) expands their explanation to say women's bodies "serve as storage bins for synthetic organic chemicals" (p. 94).

Finally, organochlorines are widely recognized by social scientists and biologists for their ability to distort the production and role of naturally occurring biochemicals, such as estrogen (Steingraber, 2010; Langston, 2011). Classified as endocrine-disruptors, organochlorines mimic naturally occurring estrogen and interrupt women's reproductive capabilities, processes, and outcomes (Sharara et al., 1998; McLachlan et al., 2005; Diaz-Barriga et al., 2003; Garcia, 2003; Jacobs, 2003; Chikuni & Polder, 2003; Pathak et al., 2010; Bouwman, 2006; Bretveld et al., 2006; Korrick et al., 2001). Miriam Jacobs (2003) emphasizes that endocrine disruption can occur at "levels far lower than those of traditional concern to toxicologists" thus requiring an increasingly nuanced understanding of women's exposures and susceptibilities (p. 177). When it comes to the DDT-environment interaction, social and natural scientists agree on the nature of its gendered threat. However, the varying perspectives from which DDT's gendered interaction is analyzed expose different aspects of the Green Revolution's role in perpetuating harm.

Social Scientists Examine Why Women Were women Increasingly Exposed to DDT

Social science based literature tends to focus on social factors shaping women's susceptibility and exposure to pesticides introduced during the Green Revolution. These analyses examine how the gendered divisions of labor, norms, and social organization in different cultures or countries placed women at an increased risk of contact with DDT. Gendered opportunities for exposure manifested in both occupational and non-occupational settings, such as the home or environment. Furthermore, this body of literature concerning pesticides' adverse effects on women's reproductive health explores the connection between socialized spheres of daily life, exposure to pesticides, and observed detriments to health. I highlight how the Green Revolution was instrumental in constructing new spheres of risk for women.

Social and economic scholars argue that the Green Revolution's model of development not only exposed rural communities to toxic pesticides, but also produce new social and economic demands that altered women's patterns of agricultural production in the Global South (Sobha, 2007; Shiva, 1991; Merchant, 1996; Billings & Singh 1969; Agarwgal 1984; Boserup 1986; Ahmad et al., 1985; Ghosh & Mukhopadhyay, 1986). In looking at general trends of agrarian development, a process that the Green Revolution pioneered, economist Ester Boserup (1986) explains how introducing machinery and intensive cultivation "often seems to raise the demand for female labor" (p. 80). Sobha (2007), understands Boserup's acknowledged shift through gendered terms, asserting that the Green Revolution's "paradigm of masculinity," based on reductionist science, altered rural women's roles from that of primary producers to wage earners on large-scale capitalist farms (p. 108). Leslie London et al. (2002) delves deeper into Sobha's analysis of rural female laborers to acknowledge a link between their changing roles and pesticide use;

"because [pesticide] work requires little skill, and is regarded as suited for temporary labor, it is frequently women who undertake it, often with little or no protective clothing" (p. 48). Despite a clear causal pathway to health outcomes due to increasing levels of exposure, such scholars do not continue their analysis to include how women's new roles on the farm were directly related to adverse reproductive health problems.

Other social scholars agree that the Green Revolution introduced women to pesticides through direct occupational means (London et al., 2002; Reeves & Rosas, 2003; Merchant 1996; Zwerdling, 2009; Dharmaraj & Jayaprakash, 2003) or through indirect environmental contamination through food, water, or clothing (London et al., 2002; Sobha, 2007; Kumar, 2011; Reeves & Rosas, 2003; Koepke et al., 2004; Carvalho, 2006). Nasira Habib (2003) specifies that women may have been exposed to pesticides by "helping to mix them, washing tanks, disposing empty containers, picking or storing heavily sprayed crops, or weeding newly sprayed crops" (p. 87). The Green Revolution introduced women to new pesticide-related responsibilities.

In the Global South, high rates of women's participation in both the formal and informal sectors place them at a higher risk of direct and indirect exposures and thus, adverse health outcomes. Understanding the gender dynamics of the family in different contexts requires acknowledging the processes through which roles are assigned to men and women. Gender scholars such as Michael Kimmel (2000) and Linda Lindsay (1990) hold than gender roles, like other social expectations, behaviors, and values, are learned through the process of familial and community socialization. Lindsay (1990) explains socialization as "The process through which individuals learn their culture and prepare to become functioning members of society" (p. 37). A central tenet of socialization is the

diffusion of expectations and roles associated with each gender. Considering the gendered division of household and economic labor, Kimmel (2000) explains, "Women are socialized to be more nurturing and maternal," so it is assumed by society that women should perform the work of mothering and domestic production (p. 13). He further characterized the family as a "gendered institution that reproduces gender differences and gender inequalities among adults and children alike" (Kimmel, 2000, p. 121). The socialization of women into substantial participation in the informal sphere of housework in agrarian communities throughout the Global South heightens their likelihood of coming into indirect contact with pesticide residues in the home.

Many scholars, such as Reeves and Rosas (2003), agree that carework, such as cleaning or handling food, may increase women's risk of exposure to pesticide residues (p. 23). Ana M. Garcia (2003) concurs with their analysis of "home contamination" and adds that the frequent practice of reusing pesticide containers for domestic use in developing countries adds yet another risk (p. 586). Garcia (2003), along with Habib (2003) and London et al. (2002), contends that women may come into contact with pesticides though washing clothes worn while spraying pesticides. Compounded with rural women's participation in agricultural production, their socialized roles as domestic caretakers served to open new routes of pesticide during the Green Revolution. However, the social analysis of why women were more susceptible to pesticide exposure through social reorganization or varying exposure routes, only tells half the story. To fully articulate the impacts of the Green Revolution on women's reproductive health, the social must be paired with the biological explanation of how women's bodies were uniquely susceptible to chemical mechanisms and outcomes.

Biological Scientists Examine How Women Were Exposed to DDT

Scholars oriented towards the natural sciences utilize the biological properties of pesticides to understand the mechanisms through which they interact with women's bodies. Biological studies analyze how sex differences between men and result in different DDT-induced health outcomes. While identifying similar exposure pathways as the more socially grounded scholars, the scientific body of research draws attention to women's increased biological susceptibility to pesticide-induced reproductive health problems. As mentioned above, epidemiological studies acknowledge the role of genetics, fat tissue, and sex hormones, such as estrogen, in their quest to understand *how* pesticide exposure manifests in reproductive health problems for women. This body of literature is focused on the biological processes through which DDT exposure results in specific health outcomes for women.

Using biological sex differences, scholars seek to show a direct relationship between pesticide residues in maternal serum or tissue samples and specific health events. Although several studies were inconclusive concerning specific outcomes, positive associations are widely acknowledged between DDT exposure, measured levels of residues in serum or tissue, and negative reproductive health outcomes for women. Commonly observed biological indicators of women's reproductive health include breast milk contamination (Bouwman et al., 2012; Koepke et al., 2004; Chikuni & Polder, 2003), spontaneous abortion (Korrick et al., 2001; Saxena et al., 1981; Kumar, 2011; Bretveld et al., 2006), impaired lactation (McLachlan, 2006; Cupul-Uicab et al., 2008; Koepke, 2004), impacted fetal growth and development (Siddiqui et al., 2002; Garcia, 2003) and preterm delivery (Saxena et al., 1981; Longnecker et al., 2001). Although the results and levels of

association differed across studies, they maintained a common line of inquiry; how do organochlorine residues in women's bodies affect their reproductive functioning and health.

The majority of studies indicate the importance of life long analysis considering the impacts of long term, low dose exposure and fetal exposure in utero. Waliszewski et al., (2011) conclude their study of pesticide exposure in women from three cities in Mexico by declaring the need for "repeated sampling of high-exposure subjects to provide more insight into the true nature of toxological consequences" (p. 5616). John McLachlan (2006) concurs that organochlorines may be "transgenerational" thus require transgenerational and repeated studies (p. 71). Longnecker et al., (2001), Sharara et al., (1998), and Pathak et al. (2010) conducted studies in the United States and India; they each posit that studies concerning organocholrine pesticide exposure received minimal attention and are often small scale. Sharara et al., (1998) contend, "single studies are difficult to interpret as they often lack appropriate exposure data, sample size, adequate control groups, and a variety of endpoints" (p. 613). However, despite varying sample sizes and locations, the majority of the studies exposed positive correlations between women's DDT exposure, bodily concentration, and hindered reproductive functioning.

While acknowledging the limitations of small sample sizes and time-exposure variables, this diverse body of biological literature accepts a positive correlation between organochlorine exposure and negative reproductive outcomes. Regardless of the context, women worldwide share the biological and hormonal implications of DDT exposure due to their biological sex characteristics. Scholars of social sciences and biology alike acknowledge the complex and indefinite associations of pesticide exposure and women's

impaired fertility and reproduction. Yet combining their analyses through a historical lens opens a new layer of analysis.

Minding the Gap and Connecting the Disciplines

As the majority of the epidemiological studies are strictly quantitative, few make direct associations between the socio- economic impact of the Green Revolution and the observed health outcomes. Yet in identifying the correlation between DDT exposure and negative reproductive outcomes, scholars provide the basis for a connection between the Green Revolution and women's health. The Green Revolution ushered excessive amounts of organochlorine pesticides, like DDT, into rural agriculture for the first time in history. The residues mentioned in epidemiological studies are the product of the Green Revolution model of production that relied upon environmentally persistent chemicals. Therefore, women's exposure and bodily accumulation of pesticide residues are yet another, though largely unexplored, legacy of Green Revolution development.

Despite ample research in the two fields of social and natural science concerning the Green Revolution, I found a dearth of literature marrying the two through their shared history—that is, how did the Green Revolution relocated women into places of increased pesticide risk and how do the pesticides that the Green Revolution deployed interact with women's bodies in gendered way? Connecting the two exposes the processes through which the social and economic impacts of the Green Revolution caused reproductive health impairments for women living in the Global South. In other words, drawing together the social analysis of women's experience of pesticide susceptibility in the Green Revolution and the biological mechanisms of pesticide contamination substantiates the role of the Green Revolution in causing biological outcomes. In the following chapter, I detail three

theories undergirding my health-based critique of the Green Revolution's pesticides: dialectical theory, structural violence, and ecofeminism. I argue that these theories explain the intricacies of the Green Revolution's web of disease causality and tie together seemingly distinct bodies of literature.

CHAPTER 2- Theoretical Considerations

Socially and biologically, women are more susceptible to pesticide exposure and thus, adverse reproductive health outcomes. Given the socialization of labor roles, domestic responsibilities, and agricultural practices of rural farming communities in the Global South, women are increasingly exposed to pesticides through occupational and non-occupational pathways. The Green Revolution's modernization of agriculture, however, altered the local social and economic structures of farming communities, therefore creating new instances of exposure for newly marginalized women. In conjunction with heightened pesticide exposure from the Green Revolution, women are biologically more likely to experience negative health outcomes. Extensive pesticide usage starting in the Green Revolution placed women's already susceptible bodies in increasingly hazardous social locations**.** I argue that women's health problems caused by pesticide exposure are symptoms of a larger social inequality created by the Green Revolution in the mid-twentieth century.

Relying on mechanized solutions for economic and social problems, the Green Revolution ideology promoted the promise of rapid production and progress. Such a promise neglected to consider the gendered ramifications of the technological and ideological transfer, both heavily dependent on pesticides, from the West. It is within this framework that I apply dialectical theory, structural violence, and ecofeminism to conceive women's reproductive health problems as the manifestations of the biased assumptions of Western science.

Dialectics: Deconstructing the Green Revolution as a System

As I begin my analysis of the relationship between Green Revolution and health with the history of the Green Revolution's model and ideology, the first theory I employ is equally as broad. The theory of dialectics provides a framework through which to understand the assumptions and model of the Green Revolution as inherently unequal. Understanding the ideological and theoretical framework behind the Green Revolution exposes the deeper significance of technologies, such as pesticides, as being more than neutral technologies of growth. Employing dialectics in the analysis of the Green Revolution's structure, the conception of its "parts" or "variables," and its notion of success exposes why it generated so many negative consequences, such as negative reproductive health outcomes for women in agrarian communities. Dialectics substantiates my perception of pesticides in the Green Revolution; the use of pesticides was both a reflection of the larger, epistemological assumptions of the Green Revolution in addition to being the instrument of harm. Yet, it also provides the basis for understanding that harm as the product of multiple variables, all of which were consequences of Western science's dominating ideologies at foundation of the Green Revolution.

Dialectics places the objectivism, that which has dominated Western science since the 17th century, under a critical lens. The Western system of objectivist science relies on ideals of rationality, order, and control that promote reductionist categorizations of reality. Western science's duality of human and nature reflects such reductionist ideology. The Green Revolution is the epitome of a universalist system as it spread its Western model throughout the world without adjusting it to specific contexts of diverse countries. Dialectics rejects the deterministic model of Western "systems" by offering a middle

ground between the objectivist tradition of mechanistic science and that of idealistic holism (Levins, 1998). More specifically, it deconstructs seemingly absolute systems, both reductionist and holistic, to expose social processes and constantly changing relations. Similarly, I situate my argument of the health impacts of the Green Revolution in this middle ground by moving away from its positivist assumptions of technology as merely a tool of growth, and acknowledging the role of such technology in instigating new processes and productive relations in various global settings.

Bertell Ollman (1993) characterizes dialectic theory as "a way of thinking that brings into focus the full range of changes and interactions that occur in the world (p. 10)." It does not fully reject the existence of difference or dualities in a system, those that Western science relies upon, but it rejects the notion that those distinctions are monolithic and detached from social contexts and relations. In this sense, dialectics honors diversity of place while not using that diversity as grounds of division. Similarly, dialectics does not fully reject holism. Yet, while it embraces interconnectivity, it does repudiate the idealist essentialism of the unity of all things (Levins, 1998, p. 380). I use this framework in my understanding of how women from diverse communities in the Global South experienced a shared biological experience of pesticides in their bodies, while existing in distinct social and economic realities.

Dialectics also provides the theoretical foundation for understanding how the conception of various "parts" of a system obscures the possibility for a more process-based value system. Levins (1998) explains, "[dialectics'] focus is on wholeness and interpenetration, the structure of process more than of things, integrated levels, historicity and contradiction (p. 378). Unlike systems in which distinct parts make up an absolute

whole, dialectics perceives those parts in constant dialogue with each of the other parts. Moreover, Levins (1998) describes all "parts as systems within themselves" (p. 394). The result of their interactions is a complicated web of systems that are closely interconnected and in constant dialogue. Levins (1998) spurns the systemic notion that "the only property of variables in a system is 'quantity'" (p. 394). It is within this framework that I understand the multifaceted role of pesticides as a technology, ideology, and mediator of women's reproductive health outcomes. Dialectics does not see its goal as a final, closed "system" detached from the social, economic, and political context in which it is based, but rather, an integrated and fluid analysis of change (Levins, 1998, p. 378). In this sense, it promotes the notion that science is a process bound in social realities, rather than an absolute prescription of those realities. The model of the Green Revolution suggests this absolutism as it ignored the multidimensionality of pesticides and the communities in which they were infused. I use dialectics to acknowledge the Green Revolution's impact on the social and economic relations, those outside of its "closed system," in the Global South that facilitated women's exposure to pesticides.

Finally, dialectics emphasizes the problematic ways in which science-based systems conceive outcomes and success. To understand this, dialectic theory rejects Western science's adherence to a linear model of growth and development, one that evaluates success purely on quantitative outcomes. Western systems value "hard" quantitative data over "soft" qualitative data (Levins, 1998, p. 389). Just as a system values each part of variable only by virtue of quantity, Levins describes, "its solution is the path of its variables" (p. 385). The Green Revolution promoted pesticides as the variables that would lead to the solution of abundant growth in the Global South. By only considering

quantitative outcomes of growth, the Green Revolution devalued the qualitative outcomes of its system. Dialectics, however, employs a non-linear understanding to development that embraces social relations and contradictions. Therefore, development and its success exist within a web of quantitative and qualitative variables. In this light, dialectics argues for a more "complex and hierarchical relation between quantitative and qualitative approaches to the world" (Levins, 1998, p. 390). Employing a dialectic epistemology breaks down the model and "variables" of Green Revolution to uncover their nonlinear relations and evaluate the qualitative outcome of women's health impairments. In this theory, health is an outcome of the Green Revolution's web of social, economic, and ideological relations.

Structural Violence: The Social Causes and Effects of an Inequitable System

Structural violence builds upon dialectic theory to explain how the inequality of the Green Revolution's system, that which was based upon the prioritization of quantitative variables in ignorance of social relations, leads to human suffering and disease. It provides a critical lens through which to understand how oppressive ideologies and systems manifest into power relations, infiltrate institutions, and perpetuate social inequality. Social inequality, according to structural violence theory, is the root of all negative health outcomes (Farmer, 2005). Originally to attributed to sociologist Johan Galtung, the notion of structural violence, refers to a form of violence where a social structure or social institution perpetually harms people by preventing them from meeting their basic needs (Galtung, 1969). The notion of "violence" within this ideological framework diverges from what is typically perceived as a direct, tangible act of harm to understand it as a more pervasive force. I consider protection from pesticides as a basic need for maintaining

healthy reproduction; the Green Revolution did not only fail to protect women from pesticides, but actually increased their susceptibility to exposure.

"Violence" in a theoretical sense is explained by Galtung (1969) as, "the cause of the difference between the potential and the actual, between what could have been and what is (p. 168). The incidence of disease in, what could have been healthy, bodies is a perfect example. Similarly, revered medical anthropologist, Paul Farmer, adopted the term into his social justice based approach to public health practice in the Global South. Farmer (2005) describes structural violence as "a broad rubric that includes a host of offenses against human dignity: extreme and relative poverty, social inequalities ranging from racism to gender inequality, and more spectacular forms of violence" (p. 8). As it provides the ideological bridge between unequal systems and outcomes, such as human health, it enables me to link my historical analysis of pesticide use in the Green Revolution to the epidemiological studies of those pesticides in women's bodies.

Structural violence contextualizes the relationship between social and economic justice and well-being by exposing how health outcomes are produced by mechanisms of exploitation built into a social or economic system. Galtung (1969) holds that the "general formula" behind structural violence is the embeddedness of inequality in the distribution of power (p. 175). Power was distributed unevenly on multiple levels within the Green Revolution's structure; not only did the Rockefeller Foundation have power over the local communities in the Global South with its spread of new Western technologies, but large farmers also had power over small famers who were unable to afford those new expensive technologies. It was this power differential that facilitated women into new spaces of pesticide exposure.

Structural violence theory lays bare how social institutions produce social inequality, which is then substantiated by powerful forces and actors. The science of social structure, the stratification, and distribution, of power determines who has access to resources, such as education and income. None of the farmers in the Global South had access to adequate pesticide education. Farmer (2005) asserts that structural mechanisms of exploitation and impoverishment generate both diminished access to resources and increased risks of pathogen exposure (p. 140). Within this model, mechanisms and conditions of harm are built into the very structures of societies and perpetuate poverty and disease. The question at the core of structural violence ideology is, "[h]ow do large-scale social forces become embodied as sickness" (Farmer, 2005, p. 19)?

Structural violence conceives disease as more than a biological event, but rather the physical embodiment of injustice. I framed my investigation around this notion by analyzing the how social and economic forces of the Green Revolution culminated into individual reproductive health problems. Galtung (1969) contends that inequality is evident through differential morbidity and mortality rates between individuals in a district, districts in a nation, and between nations (p. 177).[1] Therefore, disease is a biosocial phenomenon, one that results from the interplay of social and biological factors.

Farmer (1996) acknowledges that together, biological and social factors place the bodies of some at risk while protecting those of others (p.261). Social injustice situates the poor and marginalized populations of the world in disproportionately vulnerable positions of exposure and transmission of disease. Given the inequality of the social and technological

[1] Morbidity and mortality are epidemiological measures of death and disease in a given population. The former, morbidity, refers to the total number of deaths in a population. The former, mortality, designates total population illness including both new and existing cases of disease—or total disease incidence and prevalence (Friis & Sellers, 2009, p. 12).

factors during the Green Revolution, the biological outcomes did not emerge evenly throughout communities in the Global South; it was agrarian women who faced heightened risks and experienced negative reproductive outcomes.

Galtung's theory characterized those in vulnerable positions for bodily harm as "deprived" as the "structure deprives them of chances to organize and bring their power to bear against the top dogs" (Galtung, 1969, p. 177). Farmers were caught in a powerless cycle of dependence as they relied on the Green Revolution's technology for agricultural productivity, and thus, survival. Farmer (2005) characterizes the group suffering injustice as "the poor," or those who are "marginalized by economically driven forces and processes that conspire to constrain agency" (p. 40). Whether characterized as "the deprived" or "the poor," marginalized groups suffer disproportionate sickness and ill-health. I argue that health of rural women in the Global South suffered disproportionally from the pesticide use that was integral to a system they had no control over.

Through this lens, the presence of disease is largely a product of unequal power. The health of the poor is being "threatened by social and economic structures that foist injustice and exploitation" (Farmer, 2005, p. 10). The matrix of transnational connections, actors, and institutions produce power dynamics that determine the allocation of social and economic rights also serves to obscure its impacts. The ignored impacts are those also that Levins (1998) laments as being lost in systems that prioritize quantitative over qualitative outcomes. By turning a critical eye on forces of globalization, translational connections, and profit-based systems, like the Green Revolution, structural violence exposes how "the technocratic approach to development aid has mandated that some issues are brought to the fore while others are ignored" (p. 11). This lens considers the interests of the powerful

actors, those favoring efficiency over equity, as the foundation of harmful social and economic mechanisms in society. Therefore, the individual experience of distress and disease is embedded in a larger social matrix of "noxious discrimination" (Farmer, 1996, p. 261). It is around the qualitative impacts on women's well-being that I base my critique of the Green Revolution.

Employing the concept of structural violence in the analysis of health and the Green Revolution exposes what Farmer (2005) calls the "pathogenic role of inequality" (p. 20). That is, how the inequitable power and distribution of resources, such as technologies, rendered women's bodies more likely to experience negative health outcomes. Using this perspective, I propose that women's reproductive problems in the Global South are symptoms of unequal social structures that victimized the poor and powerless. The biosocial approach to health acknowledges the biological factors of disease etiology, yet goes deeper to consider how social conditions of inequality, those generated by social institutions, produce health outcomes. The "net result" of inequitable distribution and access, using Galtung's notion of "violence," is bodily harm (Galtung, 1969, p. 175). The lens of structural violence supports my understanding of women's reproductive impairments not merely as biological outcomes, but as embedded in a larger matrix of history, power, and domination. It provides the framework through which to understand how structural inequality manifests into women's individual experiences of health.

Ecofeminism: Women and Nature in Inequitable Systems

Ecofeminism emphasizes the unique experiences of women within the aforementioned oppressive systems, while also shining light onto how those systems relate

to environmental concerns. In this sense, ecofeminsim narrows the scope of structural violence to focus specifically on women and the environment, while concurring with dialectic theory's evaluation of power and systems. As the Green Revolution was ultimately based on environmental manipulation to increase yields, an analysis of its consequences would not be complete without an environmental perspective. Further, it was women's direct interaction with the environment, that which was flooded with pesticides, that caused the health issues I will highlight in later chapters.

Linking feminism and ecology, ecofeminism explores the relationships between the exploitation and domination of women with that of the environment. At its conception in the 1970's, ecofeminists argued that the inherent connection between women and nature is born through a shared oppression by Western patriarchical society (Buckingham, 2004, p. 174). At the root of the ecofeminist critique rests the dominant Western institutions perpetuating reductionist nature-culture dualities that percolate into social organization based on gender. A main tenet of early ecofeminism identified and deconstructed dualisms that produce antagonistic distinctions, such as male versus female and culture versus nature. Carolyn Merchant (1996) categorizes this lens as "cultural ecofeminism," based on employing a critique of patriarchal control and destruction of women and nature (p. 6). Ecofeminists have long criticized the Green Revolution's degradation of both the physical environment and women's traditional ecological relationship to it.

Prominent ecofeminists Maria Mies and Vandana Shiva (1993) contend that ecofeminism "condemns the patriarchal mentality that is built off of multiple systems of dominance to control women's bodies and ecology (p. 14). They, like Levins (1998), assert that the basis of reductionism and control are found in the history of scientific thought.

They claim that the "[f]athers of modern science and technology" rejected human dependence on nature and instead, sought to overcome and transcend any obstacle blocked their right to freedom (Shiva & Mies, 1993, p. 7). This liberation ideology was not based upon a universal right to freedom, but on a right to freely dominate nature to achieve their desired natural order. In this vein, the Green Revolution used technologies, such as pesticides and mechanized, to achieve unrestricted and supernatural growth. I argue that while pesticides were a key mechanism of reproduction for the new seeds, they hindered the reproduction of the women who planted them.

Since its initial emergence the ecofeminist scope has expanded beyond investigating exploitation within strictly gendered terms to look more broadly at the impact of systems of domination on women's bodies and the environment. Merchant (1996) characterizes this more system-based analysis as "socialist ecofeminism" (p. 15). This lens captures the essence of structural violence as it considers how larger systems of domination engender adverse outcomes for women. Shiva (1993) writes, "[Ecofeminism] problematizes 'production' by exposing the destruction inherent in much of what capitalistic patriarchy has defined as productive" (p. 33). The new hybrid seed was the pinnacle of Green Revolution's productivity, yet it resulted in a wake of harmful consequences for the well-being of women and the natural environment. Socialist ecofeminists respond to oppressive systems by asking "what is at stake for women and nature when production in traditional societies is disrupted by capitalist development" (Merchant, 1996, p. 15)? Focusing specifically on the centrality of pesticides in the Green Revolution's development model, I use this question as the basis of my health based analysis.

Ecofeminists adopt Galtung (1969) and Farmer's (2005) model, as they extrapolate women's social location as derived from oppressive social systems rooted in Western reductionist thought. Andrea Chircop (2008) explains, "ecofeminism has the potential to reveal an inherent, normative conceptual analysis and argumentative justification of western society that permits the oppression of women the exploitation of the environment" (p. 144). Moreover, by situating the analysis of unegalitarian systems in an environmental discourse, ecofeminism focuses on mechanisms through which women's bodies are exceedingly exposed to environmental "incivilities" (Buckingham, 2004, p. 147). I use Buckingham's (2004) understanding in my exploration of how the Green Revolution's social and economic shifts served as a gateway for women's adverse reproductive outcomes. Ecofeminism provides a theoretical exploration of the linkages between environment and health inequities "in a way in which gender, class, and the social as well as physical environments are interconnected to mediate health (Chircop 2008, p. 135). I explore the ways in which the Green Revolution formed those linkages through the introduction of technologies. Although I do not seek to conflate the Green Revolution's technological domination of the environment with that of women in the Global South, the two processes are born out of the same ideologies of patriarchy and dualities. The socialist ecofeminst lens enables me delve deeply into how the socio-political context engendered by the Green Revolution's structure resulted in negative health outcomes for women in the Global South.

* * *

Together, the theories of dialectics, structural violence, and ecofeminism enable me to question the entire "life-cycle" of the Green Revolution, from its broader systematic

framework to the individual's physical manifestations of its inequality. In addition, I am able to conceive technologies, such as pesticides, as more than "neutral machines," but instead as value-laden manifestations of the Green Revolution's modernizing project. In harmony with one another, each theory provided a "funnel effect," as I look first at the dynamics of the Green Revolution as a larger system and end with the individual female experience of reproductive health problems. Each theory provides critical insights as to how the Green Revolution relates to women's health outcomes through both social and environmental avenues Together, the three expose the interconnected matrix of causes and effects of women's health. In the next chapter, I explain the research methods that guided me through a vast body of diverse literature and enabled me to arrive at my conclusion that the Green Revolution negatively impacted women's health with its introduction of pesticides.

CHAPTER 3- Methodology

I argue that the women's pesticide-induced reproductive health problems experienced are results of the Green Revolution's uni-directional, technologically- based strategy to boost agricultural productivity in the Global South. The Green Revolution introduced DDT into the environment, and subsequently, women's bodies, as a key instrument in achieving agricultural development. I argue that the consequential reproductive outcomes for women newly exposed to occupational and environmental DDT exposes a new layer of inequality, one that manifested into physical bodily harm and disease. To understand the nature of the relationship between, and ideologies connecting, the Green Revolution, DDT, and women's fertility requires a combination of literature examining biological and social sciences. As I highlighted in my literature review, different bodies of literature focus on distinct dynamics and "side effects" of the Green Revolution. I draw a number of these critiques together to expand the reach of the Green Revolution's wake of consequences to include the hindrance of women's reproductive health in the Global South. Though divergent disciplines focus on different aspects of my question—the social impacts of Green Revolution technologies or the biological mechanisms of DDT contamination—I understand the convergence of the two under a historical lens as exposing a new analysis of the Green Revolution.

Grounded Theory

Using grounded theory, I developed my research focus and argument through qualitative textual and comparative analysis. Through qualitative textual analysis, I classified my research into different categories based on themes, such as health, history, or

social and economic impacts. As I gathered and analyzed my data, I found that my sources often fell into either social and historical analysis or epidemiology studies. In my investigation of pesticide-based epidemiological studies, using comparative analysis enabled me to engage in an intensive analysis of a small group of studies. In this sense, I analyzed biological case studies beyond their observed outcomes, but rather situated them in history and social context of the Green Revolution. I continually constructed and readjusted my theory concerning the nature of DDT-inflicted women's health problems as I accumulated different bodies of research and perspectives. Grounded theory methodology enabled me to partake in archival research of primary sources and records, to categorize research from epidemiologic studies, and apply existing social theories such as dialectics, structural violence, and ecofeminism to tie together my health-based historical inquiry. By combining medical journals and social science analysis, I employed a theoretical interpretation of epidemiologic data to explain an environmental health problem through a sociological lens. I then situated my analysis in historical analysis of the Green Revolution's social and economic impacts, those that I understand as having mediated women's exposure to pesticides.

I. Social Histories: Evaluating the Structure and Impacts of the Green Revolution

To understand the greater social and economic implications of the Green Revolution in the Global South, I began my research with secondary scholarly sources that provided both historical and consequential analyses. In addition to archival research, I collected social and historical literature from sources such as the Honnold Mudd Library's Blais Catalogue, Google Scholar, JSTOR, and EBSCOhost. I reviewed articles from

scholarly journals such as American Academy of Arts and Sciences, Science & Society, Economic Geography, Social Studies or Science, Geographical Journal, Nursing Inquiry, Crop Science, Agriculture and Human Values, Journal of Human Ecology, and the Handbook of Environmental Chemistry.

My research displays a chronology of the critiques of the Green Revolution that grew more specific with each decade of exploration. My initial historical analysis of the Green Revolution consisted of the following key terms:

- Green Revolution
- Rockefeller Foundation
- Norman Borlaug
- Development
- Agricultural development
- Mexican Agricultural Program (MAP)
- Pest management
- Chemical inputs
- Agrarian change
- Landless female laborers
- Mechanization

The 1970s: Early critiques of the Green Revolution

My primary investigation of secondary archival research provided insight about the political economy, underlying ideologies, and influential actors during the early development of the Green Revolution. The 1970's marked the rise of public discontent

with the Green Revolution. Using sources written during this time, such as Keith Griffin's acclaimed *The Political Economy of Agrarian Change* (1979) Kenneth Dahlberg's *Beyond the Green Revolution* (1979), Francine Frankel's *India's Green Revolution* (1971), provided critiques concerning the Green Revolution's alteration of social, cultural, and economic relations with technologies, while ignoring the question of equitable distribution. These, and other contemporaneous works, provided in-depth analyses of the underlying interests and motivations of the Green Revolution from its origins in Mexico (1943) and spread of organochlorine pesticides throughout Latin America and Asia until the late 1960's. The centrality of pesticide use emerged as a common theme in the early critical discourse

Though not related directly to the question of women's health, I retained sources that critically evaluated the impacts of the Green Revolution's technological transfer between the years 1943- 1968 to substantiate my theory concerning the uni-directionality of its strategy. Upon gaining an initial understanding of the social and economic impacts of the Green Revolution, I dove deeper into a critical analysis of those consequences, especially as they affected women. In addition to my primary terms, I included more theory-based themes to understand the relationship between technologies, nature, and women:

- Ecofeminism
- Socialist ecofeminism
- Environmental justice
- Environmental health
- Women and agrarian change

- Traditionally female farm labor

The 1980s- 1990s: Epistemological and Gender Critiques

Later work in the 1980's and 1990's by scholars such as Vandana Shiva (1991; 1993), Deborah Fitzgerald (1986), John Perkins (1990), and Lakshman Yapa (1993), and David Kinkela provided insight into the ways in which the Green Revolution's structure reflected its Western science-based ideology. The production and spread of pesticides, such as DDT, was of crucial importance in critiques condemning the structure of the Green Revolution. Such sources connected the epistemology of the Green Revolution with the long-term impacts that were emerging twenty years after the initial scholarly backlash began. Of the impacts noted by scholars such as Shiva (1991), Fitzgerald (1971), Perkins (1990), and Yapa (1993) were the environmental, economic, and cultural disruption caused by organochlorine pesticides like DDT. In addition, economists during this time period observed trends in women's experience of large-scale agrarian change, like the Green Revolution. Prominent economist Ester Boserup (1986), in addition to various other scholars and institutions, such as the International Center for Research on Women (1990) and the International Labour Organization (1985), recognized that the changing social and economic landscape of agrarian communities had unique impacts on women's roles in production. From this time period also emerged prominent ecofeminist critiques that addressed the dominating structure of the Green Revolution on the environment and women (Shiva & Mies 1993; Shiva 1991; Merchant 1996). Scholars from 1980s and 1990 voiced more women-centered criticisms that allowed me to draw connections between their social and economic roles and interactions with pesticides.

Similarly, this cohort of scholarly research did not address the impacts on women's health when evaluating the Green Revolution. However, I retained articles that highlighted women's changing labor demands, domestic responsibilities, and accused the Green Revolution of marginalizing women within its Western technological system. Women's experience of the Green Revolution's restructuring of social and economic relations substantiates my argument that technologies situated women in spaces that were increasingly exposed to DDT. Such spaces were both domestic and agricultural I found the specifics of pesticide-induced health impacts through more contemporary sources. To link the feminist arguments about women's spaces to physical pesticide exposure, I then explored women's various susceptibilities to pesticide exposure in agrarian communities. I included search terms such as:

- Food contamination
- Environmental persistence
- DDT and farm operations
- DDT residues
- Domestic contamination
- Women and DDT exposure
- Environmental exposure
- Occupational exposure

The 2000s: Pesticide Exposure and Health

Upon understanding historical and structural underpinnings of the Green Revolution use of pesticides, I gathered more contemporary social science sources that

focused on how women are exposed to pesticides through occupational and environmental pathways (Shiva, 1994; Setlow & Woods; 1998; Reeves & Rosas 2003; Wesseling 2003; McLaren Howard 2003; Chikuni & Polder 2003; Garcia 2003; Bag, 2000; Bhatt; 2003). As mentioned in my literature review, social and natural scientists agree that women face increased susceptibility to DDT exposure through their socialized agricultural and domestic roles. The connection of such exposures to health outcomes came to light in the 2000s. I, therefore, retained social science and geographic sources that analyzed the social mechanisms through which agricultural use of DDT is a serious threat to women's reproductive health. These sources did not address the biological mechanisms through which DDT facilitates adverse reproductive health outcomes, however, they suggested gendered social susceptibilities to DDT exposure that disproportionately placed women's bodies at harm. In my analysis, I connect the Green Revolution's social and economic implications on women's labor roles identified in early critiques to more contemporary understandings of the various routes of DDT exposure. Together, the alignment between women's social spaces and spaces of exposure reveals the complex relationship between the Green Revolution and women's increased DDT contamination.

II. The epidemiology of women's pesticide exposure

After acknowledging women's increased social susceptibility to pesticide exposure, I sought to understand the next step, that of the biological implications of pesticide exposure. I turned first to scientific journals to understand the biological impacts of women's pesticide exposure. Through databases such as PubMed, Medline, Science Direct, Elsevier, JSTOR, and Ebscohost, I collected literature from journals such as: the

American society for Reproductive Medicine, the American Journal of Industrial Medicine, Reproductive Sciences, Human and Experimental Toxicology, Elsevier, Environmental Health and Preventative Medicine, the Journal of Analytical Toxicology, American Journal of Epidemiology, Reproductive Biology and Endocrinology, and the Journal of Gynecology and Obstetrics

Next, I did a comparative analysis of epidemiological studies to exemplify outcomes, expose trends, and reach conclusions about women's shared biological experience of pesticide exposure. My search key terms throughout this stage of analysis consisted of:

- Pregnancy outcome,
- Spontaneous abortion
- Preterm delivery
- Organochlorine pesticides
- Pregnancy loss
- Epidemiology
- Agricultural exposures
- Maternal exposures
- Serum DDT
- Fetal development
- Estrogen
- Progesterone
- Lipid solubility
- Breast milk

- Persistent organic pollutants

Scientific Articles: Biological Mechanisms of DDT Contamination

Scientific, toxicological, and medical journals provided the biological data and studies I use to understand the role of organochlorine pesticides in causing adverse reproductive health outcomes for women. My initial research identified DDT's chemical characteristics that perpetuated its biologic mechanisms of harm. I built my theory of DDT's biologic impact on women upon emergent themes of DDT's environmental persistence, bioaccumulation, and endocrine disruption. As I focus on women's reproductive health outcomes, I utilized medical articles that specifically articulated the ways in which women's biological characteristics make them particularly susceptible to the properties of DDT. Through databases such as PubMed, Medline, Science Direct, Elsevier, JSTOR, and Ebscohost, I used journals such as: Journal of Human Ecology, The Handbook of Environmental Chemistry, Archives of Environmental Health, Best Practice & Research: Clinical Endocrinology & Metabolism, Fertility & Sterility, and Reproductive Biology and Endocrinology to understand women's biological susceptibilities to DDT and the gendered nature of its biological mechanisms once inside the female body.

Epidemiological Studies: DDT Exposure and Women's Reproductive Health

I based my research on analysis of available data on maternal occupational and environmental exposure to DDT and consequential reproductive outcomes. Subsequently, I identify emerging directions in research, elucidate biologic plausibility, and propose the correlation of DDT exposure and reproductive outcomes. I organized my findings by

uterine complication to determine the most prevalent outcomes observed in women exposed to DDT. Finding that spontaneous abortion and preterm delivery were among the most commonly observed DDT-induced pregnancy outcomes, I retained studies observing a dose-response relationship between DDT serum levels and one/both pregnancy complications. I selected both conclusive and inconclusive studies to illustrate that while there is an ample reservoir of observed associations between DDT and specific reproductive health outcomes, there still remains a dearth of conclusive, large scale studies. The available studies were conducted in the early 2000's, when increased attention focused on the public health impacts of DDT use in Mexico, India, China, and the US.

* * *

Through chronological interdisciplinary research and grounded theory, I extracted common themes and critiques that culminated into my health-based analysis of the Green Revolution. With each new perspective I gained, my understanding the relationship between the Green Revolution and women's health shifted and grew. Through my approach of interdisciplinary research, I combined social, economic, historical, and biological disciplines to better articulate the process through which the Green Revolution resulted in negative health impacts for women in the Global South. In the next chapter, I begin at the start of the Green Revolution in Mexico. The origins of the Green Revolution in the Global South exposes the influential actors and ideologies that shaped the future of agrarian relations and women's health.

CHAPTER 4- Change as Technology, Change as Ideology: A Brief History of the Green Revolution in Mexico and its Global Diffusion

The Rockefeller Foundation

The main, and most powerful, actor in advancing the Green Revolution was the Rockefeller Foundation. The mission of the Rockefeller Foundation from its founding in 1902, was "to promote the well-being of mankind throughout the world" (Rockefeller Foundation, 2013) Programs in the 1920's and carrying on until the 1940's concentrated their philanthropic work on scientific research and development aimed at social and practical problems—especially those in the areas of public health (Fitzgerald, 1986, p. 460). In partnership with the United States Department of Agriculture (USDA) in 1906, the Rockefeller Foundation acknowledged the potential of agricultural science in the betterment of rural livelihoods and economies. In the 1930's, the Foundation sought to achieve its mission through the "advancement of Western knowledge" to improve societies in fields such as agriculture, public health, natural sciences, and the arts (Rockefeller Foundation, 2013). It was a central force in the development of technologies and social practices that enabled farmers to increase their yields dramatically (Perkins, 1990, p. 6). Yet, in the wake of new agrarian knowledge and technologies flowed social and economic consequences that would be sown deeper into the lives and bodies of women in the Global South than any seed could have been.

Defining the Green Revolution: Change as Technology

The change in rural production took place in several developing countries at different times and in different ways. A commonly held notion is that there are two, albeit

interconnected, understandings of what the Green Revolution meant for countries involved in the scheme. The two meanings of the agricultural advancements that intended to address an increasing food demands lend themselves to various analysis and criticisms. The first, and most fundamental, significance of the Green Revolution is the technological transformation of agriculture witnessed in the Global South beginning in the mid 20th century in Mexico (Perkins, 1990, p. 6). According to Lakshman Yapa (1993), the official version of the Green Revolution story was the promotion of new seeds as a "significant breakthrough in the fight against hunger in the Third World" (p. 255). The prosperity of the seeds, however, relied on copious amounts of pesticides, especially DDT.

Through an agricultural "package" of hybridized seeds, irrigation, and chemical inputs, such as pesticides, the Rockefeller Foundation sought to employ a universal "fix" to the straggling economies of the Global South. The idea of an agricultural revolution driven by science and technology formed the basis of the Green Revolution's strategy (Shiva, 1991, p. 14). In this light, it emphasized the importance of agricultural science in curtailing the threat of rural food shortages. The expansion of food production following the widespread adoption of the new technologies would bear new fruits of synthetic prosperity (Yapa, 1993, p. 259). The sole focus on increasing yields is an early indication of the Green Revolution's systemic reliance on quantitative, rather than qualitative, outcomes.

The quantitative gains captured global recognition. Norman Borlaug, the man seen in the scientific eye as the father of the Green Revolution, won the Nobel Peace Prize in 1970 for his development of the high-yielding seeds (Marglin, 1996, p. 2). In his Nobel Lecture titled "The Green Revolution, Peace, and Humanity," Borlaug (1970) laments the strife of the hungry "victims of population growth:"

> "For the underprivileged billions in the forgotten world, hunger has been a constant companion, and starvation has all too often lurked in the nearby shadows. To millions of these unfortunates, who have long lived in despair, the green revolution seems like a miracle that has generated new hope for the future" (Borlaug, 1970).

He singles out Mexican dwarf wheat varieties as the principle catalyst of the rapid increase of wheat production per hectare in the Global South, or as Borlaug (1970) refers to it, "the forgotten world." Mankombu Sambasivan Swaminathan (2006), the director of the Indian Agricultural Research Institute (IARI) at the time of the Green Revolution in India, explains the new abundance as "the product of alteration in plant architecture and physiological properties through breeding in wheat, rice, and corn" (p. 2293). At the heart of the Green Revolution was the unprecedented scientific modification of agriculture; "one built on the assumption that technology is a superior substitute for nature, and hence a means of producing limitless growth, unconstrained by nature's limits" (Shiva, 1991, p. 24). Pesticides were a central component in ensuring the seed's global adaptability, or as I consider, forcibility. The ideology of the Green Revolution's "universal" model reflects, what Levins (1998) would describe as, a systems-based model of development in that its "outcomes are evaluated for their correspondence to the built- in purpose" (p. 387). The built-in purpose of the seeds was supplanting the natural fertility of nature to produce supernatural yields. The purpose of pesticides was protecting those seeds from native pest infestation. I, however, argue that the chemical protection of the new seed's reproductive capabilities, in turn, threatened the reproductive capabilities of the women who sowed the seeds. The quantitative-based notion of success ignored the nature of this harmful relationship.

Pesticides, such as DDT, were at the center of economic discourses as well. In

Refashioning Nature: Food, Ecology, & Culture, David Goodman and Michael Redclift (2002) are more critical of this technical definition, noting "the transition to more capital- and energy- intensive methods was facilitated by the available 'shelf' of Green Revolution technologies whose diffusion was actively promoted within the international scientific community and agro-industrial capitalists seeking to extend overseas markets" (p. 142). US based manufacturers of DDT benefitted greatly from the Green Revolution's reliance on chemicals as means of agricultural intensification. However, it became clear that DDT's entry into the global market instigated a new, more rampant, demand of pesticides (Bate, 2007). DDT, as a Western commodity, extended the scope of unequal power relations in the Green Revolution to include agrobusiness in its upper rungs. The Green Revolution cultivated a new economy of dependence, in which the survival of both farmers and their seeds rested in the application of pesticides. Both the use and ingestion of DDT through this dependence amounted in negative health impacts of women in the Global South's agrarian communities. The new, and highly unstable, standard of monoculture situated pesticides as the hallmark of the Green Revolution's global transfer. The first diffusion of US technology fell in the hands of Mexican farmers.

Modernizing Mexico: The Beginnings of the Green Revolution

The idea of agricultural development was first planted in the Western mind in 1940 after the then-US Vice-President, Henry Wallace, traveled throughout rural Mexico and was "appalled" by the poverty and living conditions of the local population. Considering Mexico's substantial dependency of imported corn and wheat, Wallace contended that improving domestic agricultural production would remediate the ills of the food-deprived

nation (Kohler, 2007, p. 51). He returned to the U.S. from Mexico convinced that modernizing Mexican agriculture was the answer to the, clearly inefficient, local techniques he observed on rural farms. Invigorated, Wallace proposed a Rockefeller Foundation program in health, education, and agriculture to Joseph Willits, the director of the Foundation's Division of Social Sciences (Marglin, 2011, p. 34). The convergence of such sectors through development could be the perfect vessel through which to promote the Foundation's philanthropic aims. It was also the perfect opportunity to promote the superiority of Western, scientific agriculture.

However, in a meeting of Rockefeller Foundation staff that year, plans turned away from the possibilities for public health and educational programs. Deborah Fitzgerald (1986) explains that "formal education was considered too controversial, and a public health programme was already underway in the International Health Board" (p. 462). Thus, increasing agricultural productivity was the only focus left on the Mexican agenda. As opposed to programs aimed at education and public health, those that would entail more community-based initiatives, the Rockefeller Foundation could address agricultural concerns through science and technological innovations. The automatic focus on agricultural production over more socially- based interventions exposes the Rockefeller Foundation's assumption that Western science and knowledge were universal answer to social problems in impoverished countries. This assumption ignored the qualitative impacts of scientific agriculture on women in the Global South, such as their physical well-being and social relocation within the economic structure of small-scale agriculture.

Meanwhile, new agrarian policies and land reform were already underway in Mexico. The new Mexican Government desired a program that would facilitate the

industrialization of agriculture.[2] Mexican industrial capitalists allied with large landholders against the peasantry and rural small holders to weld their elite interests of development and agriculture (Sonnenfeld, 1992, p. 31). Between 1930- 1940, agricultural policy shifted from supporting both commercial and collective farming to favoring agribusiness; the amount of land with favorable conditions for cultivation increased by nearly 2.5 million acres (Sonnenfeld, 1992, p. 31). As part of Mexico's overall development strategy, the new agrarian policy sought to extend their agricultural frontier through large-scale irrigation and the spread of chemical technologies, including DDT. The previously *ejido*-oriented agricultural system, one built upon communal landholdings, began to favor lager-scale industrialized agriculture. The election of President Avila Camacho in 1940 furthered the fundamental shift by welcoming American "guidance" over agricultural research and practices (Shiva, 1991, p. 50). Together, the hands of the powerful Rockefeller Foundation, Western scientists, and the Mexican Government constructed what would be the new realities of rural farmers. The totalizing power of national and transnational actors over the power of local communities exposes the uni-directionality of the Green Revolution's planning. Rural agrarian women were invisible in the process.

In the early 1940's, while agreements were still underway with the Mexican Government, the Rockefeller Foundation elected three professionals, each equipped with a team of scientists, to spearhead the evaluation, design, implementation the program in Mexico. After a two-month tour in Mexico, the teams of advisors and scientists prepared a report outlining the major "problems" of Mexican agriculture whose solutions were critical

[2] President Lazaro Cardenas ended his term in office in 1940, leaving more than 11,000 *ejidos*, or communal landowners, with more than 20,000,000 hectares of land. The effect of this land reform was to increase the amount of land to be cultivated to increase agricultural production. Avila Camacho succeeded Cardenas in 1940 (Sonnenfeld, 1992, p. 31).

to the success of the program (Fitzgerald, 1986, p. 463). Fitzgerald (1986) outlines the four primary problems highlighted in the report: the improvement of soil management and tiling practices; the introduction, selection, and development of superior varieties of grains and legumes; the control of pests and disease on a national scale; and the introduction of better breeds of cattle (p. 464). The control of pests was a crucial consideration in the initial planning stages of the Green Revolution.

As the program developed, the Rockefeller Foundation assembled a technological package to catapult Mexican agriculture beyond subsistence farming. State-of- the-art Western agricultural education, plant breeds, and chemicals would support the emergence of new, large-scale, commercial enterprises (Ganzel Group, 2007). Pesticides, such as DDT, were a central component of growth. In addition to the growth of the seeds, however, pesticides also enabled the linear development from subsistence farming to modernized agriculture; with measured inputs of DDT, the new yields of wheat would increase accordingly. Borrowing from Levins (1998), the notion of linear progress obscures the non-linear impacts of development on communities, such as health. Yet, in the early days of the Green Revolution, the potential impacts of the technologies on health were outside of the purview of the powerful—especially as it pertained to the plight of poor rural women.

In 1943, the Mexican Government and Rockefeller Foundation joined forces with the goal of increasing agricultural productivity to meet the needs of the growing, and increasingly impoverished, population. Such a problem provided the Rockefeller Foundation with the ideal opportunity to merge their philanthropic ventures in population control with biological science. Power was dealt relatively equally between the Rockefeller

Foundation and the Mexican Ministry of Agriculture; the Rockefeller Foundation would provide the experts and technologies and the Ministry would provide the land and the labor (Fitzgerald, 1986, p. 464). Initiated, financed, and supervised by the Rockefeller Foundation, the Green Revolution promulgated technological "packages" of chemicals and hybridized seeds for large-scale, irrigated, landholdings (Sonnefeld 1992: 32). Thus begins a story of how, under the name of science and innovation, powerful actors took control of the Global South's economies, environments, and health outcomes. Little did the Mexican government know, the Rockefeller Foundation's provision of technologies would leave a lasting legacy in the soils of their lands and bodies of their people. Serving as the "provisions of labor " to fit the increasing labor demands of high-yielding agriculture, women's bodies would also serve as new reservoirs of pesticide contamination within the new Mexican Agricultural Program.

The MAP Strategy: Implementing Modern Agriculture in Mexico

In 1943, the Green Revolution's strategy for developing, modernizing, and boosting Mexico's agriculture culminated into the creation of The Mexican Agricultural Program (MAP). The Rockefeller Foundation and Mexican Government emphasized three main goals of MAP: to improve yields of basic foods, create crops widely adaptable to a wide range of conditions, and to decrease reliance on the external global food supply (Kohler, 2007, p. 52). To attain these goals, the two parties devised a three-stage strategy for carrying out MAP's agricultural pursuit: research, diffusion, and training. The first stage sought to improve the varieties of crops and the methods by which they were produced. This stage relied on extensive scientific research in Western labs and the

exportation of philosophies from the Corn Belt in the United States (Marglin, 2011, p. 3). The surveys identified wheat production as particularly lagging and uniformly discouraging throughout Mexico. Of the most critical concerns for Mexican wheat was the deadly disease of wheat rust, a fungus that threatened the longevity of farmer's crops (Ganzel Group, 2007). Waging a biochemical war on rust had the potential to salvage multiple tons of domestic wheat production; pesticides were at the forefront of this biotechnological battle. Yet, it was a battle that simultaneously ravaged the reproductive health of rural female farmers and producers who sprayed them to protect their new crops.

To increase the quantitative success of their rural production, scientist Norman Borlaug turned to agricultural development and technology. Borlaug developed a new, disease resistant high-yield variety of wheat (Fitzgerald, 1986, p. 468). High- yield varieties (HYVs) are domesticated plants bred specifically to respond to fertilizers, acclimate to diverse environments, and produce an increased amount of grain per acre (Evenson & Gollin, 2003, p. 758). Through a process of selective breeding, Borlaug created a "miracle seed" that could adapt to any Mexican soils. These same seeds would later be sown throughout Latin America and Asia. Borlaug characterized the new cross-strains of wheat as superior to those in present use and distributed them to farmers (Kohler, 2007, p. 468). However, the growth of the seeds no longer relied on the organic soil community. Instead, the growth of the seeds relied on toxic chemicals. Permitting the success of the foreign seeds in diverse soils was an abundance of pesticides, such as DDT. Diverse hands throughout the Global South sprayed the same chemicals and diverse female bodies would foster their residues through the same biological mechanisms. In total

ignorance of this reality, the question of how to spread such technologies consumed the growth-hungry minds of Borlaug and the Rockefeller Foundation.

The second stage of the MAP strategy involved incorporating the new technology into the practice of Mexican farmers. The new high-yielding varieties were exemplars of American scientific advancements in agriculture and their adoption by local farmers was central to the success of MAP. Borlaug and his team gradually promoted their new "miracle" seeds to local farmers through a process of "diffusion of innovation."[3] Convincing the farmers to replace their traditional "outdated" techniques with Western ones was a slow process, one that required a full planting season to showcase the results of the new seeds (Ganzel Group, 2007). The desire to supplant generations-old techniques within the span of one season exposes the total disregard of the social and economic relations built into traditional systems. I later argue that upsetting deeply rooted social and economic structures in agrarian communities relocated women into new spaces of production and, subsequently, biological threats to reproduction.

Yet, gradually, farmers around the experiment station saw the results of the seeds and were eager to experiment with new farming practices to increase their yields. However, the success of the seeds was contingent upon inputs such as chemical fertilizers, pesticides, and irrigation; it was more difficult to convince farmers that the package was worth the cost (Ganzel Group, 2007). For large-scale commercial farmers with enough land and affluence to invest in the seeds, fertilizers, pesticides, and irrigation systems, the new seeds presented the opportunity for a new and improved productive capacity

[3] The diffusion of innovations is a theory, formalized by Everett Rogers in 1962, that studies the social and psychological processes involved in adopting new technology. It explains the lifecycle of technological adoption as beginning with a group of innovative farmers who experiment with the technology and is then passed on to neighbors who witness the success and adopt it on their own (Ganzel Group, 2007).

(Fitzgerald, 1986, p. 460). For subsistence farmers, the necessary land and capital investments rendered participation in the Rockefeller program impossible. Smaller farmers, especially women, engaged in small-scale subsistence farming, were left in the dust of agricultural development—their bare hands left to assemble its toxic pieces as laborers. Together, women's new roles and new technologies would surmount in increased pesticide exposure in the home, field, and body.

With new technologies, education, and ideologies of growth, the extensive undermining of local communities in the Global South bore much deeper than the newly monocropped soil. The quantitative indicators of success echoed throughout the world. Between 1940- 1965, Mexico's agricultural output increased fourfold (Sonnenfeld, 1992, p. 28). Later in 1968, Green Revolution wheat covered 90% of all Mexican land planted in wheat (Cotter, 2003, p. 234). The successful exportation of modern agricultural technologies to Mexico set the stage for the spread the Green Revolution's model across the globe. DDT as a universalized technology of growth ensured the adaptability of the new seeds to diverse soils and climates. However, it also created new cycle of pesticide dependency and I argue, bodily contamination. Although it remains to be to a widespread consideration, MAP left women's bodies to pay the biological price of a chemically-centered technological revolution

Global Diffusion of the Green Revolution

> "It is the unusual breadth of adaption combined with high genetic yield potential, short straw, a strong responsiveness and high efficiency in the use of heavy doses of chemicals, and a broad spectrum of disease resistance that has made the Mexican dwarf varieties the powerful catalyst that they have become in launching the green revolution." (Borlaug 1970).

Due to the success in Mexico, the following decade witnessed the diffusion of Green Revolution knowledge and technologies throughout the Global South. The Rockefeller Foundation, soon followed by the Ford Foundation, U.S. Agency for International Development (USAID), and the World Bank, used the Mexican model to promote the use Green Revolution technology packages around the world (Sonnenfeld, 1992, p. 30). Within the span of a few years, the transmission of the Green Revolution's scientific agricultural package rapidly transformed rural areas worldwide (Kinkela, 2011, p. 129). After its initial success in Mexico, the Rockefeller Foundation funded an agricultural development program in Columbia similar to MAP in 1950, shortly followed by Chile and other countries throughout Latin America (Kohler, 2007, p. 52).

The excessive use of pesticides in the agricultural package remained a central component in the success of Borlaug's seeds. David Kinkela (2011) describes, "As always, chemical pesticides followed the global flow of rice and wheat seeds" (p. 129). In 1960's, the Rockefeller Foundation established an international research institutes in the Philippines, Thailand, and perhaps most notoriously, India (Kohler, 2007, p. 54).[4] The international diffusion of knowledge and technology expanded at a rapid pace as national governments recognized the substantial agricultural gains possible through the "modernization" of agriculture. Shiva (1991) laments that "[i]n mistakenly identifying the sustainable and lasing as backward and primitive, and in perceiving nature's limits as constrains on productivity that had to be removed, American experts spread ecologically destructive and unsustainable agricultural practices worldwide" (p. 34). Also following in the Green Revolution's "global flow," however, were a growing number of women exposed to chemical pesticides. I argue that the global spread of technologies initiated the

[4] Chapter 8 provides an in-depth analysis of the Green Revolution in Punjab, India.

global spread of reproductive health problems for women as their communities were increasingly contaminated with the harmful residues of pesticides.

MAP's approach to agricultural development epitomized the answer to the question circulating in the Global South concerning how to drastically increase in domestic food grain production to meet growing populations and poverty. By the mid-1980s, approximately 50% of wheat and almost 60% of rice area of developing countries were sown with high-yielding varieties; they made up 95% of rice area and 60% of wheat area in China and Latin American respectively (Dalrymple, 1986, p. 1069). The Green Revolution promoted a technological fix to social problems, and DDT was at its forefront. While ignoring the social conditions of inequality that cultivated poverty and overpopulation in the first place, the Green Revolution promoted technologies, like DDT, as the solution to the social and economic woes of developing nations.

Farmer (2005) and Galtung (1969) would argue that the Green Revolution added to the existing violence of political systems in the Global South that already perpetuated varying degrees of human suffering. Rather than identifying the violence of social and political inequality facing impoverished communities, the promotion of a technological solution "hid the social complexities that lay behind their poor agricultural yields" (Perkins, 1990, p. 13). Ignoring the social and economic realities of poverty-stricken communities nods to the Green Revolution's disregard for a community's well-being that were based on variables other than quantitative food production. In this regard, the concern for women's health outcomes did not even reach the bottom rung of the Green Revolution's conscience. I will show how the adverse environmental and reproductive outcomes of pesticide use reflect this oversight in the following chapters.

Critique: DDT and the Pesticide Treadmill

However, amidst the praise of the Green Revolution's quantitative successes emerge critical voices of concern. Environmentalists, economists, and social scientists voice a wide range of critiques regarding the radical agricultural change that resulted in pesticide- dependent production. One of the most prevalent critiques of the Green Revolution's excessive use of pesticides is environmental degradation. This perspective emphasizes the technological impacts of the Green Revolution, more specifically, the role of chemical inputs in creating an unsustainable and depleted environment. In 1962, Rachel Carson crusaded the environmental argument in her seminal work, *Silent Spring*, by calling public attention to the environmental impacts of agrochemicals. The emergence and spread of DDT, Carson (1962) claims, marked the beginning of a "chemical war," or a "violent crossfire" in which all life was caught in a cycle of new toxic pesticides, evolution of immune pests, and environmental degradation (p. 8). Carson did not specify women as being caught in this new crossfire, yet her critique of DDT provides significant insights into how its harm continued to threaten women's bodies long after its dust had settled.

Specifically focused on organochlorines, such as DDT, Carson (1962) condemns the promulgation of pesticides for the subsequent assaults on the health of the biological world. She condemns the scientists and "control men" for whom "chemical control of insects seems to have proceeded on the assumption that the soil could and would sustain any amount of insult via the introduction of poisons without striking back" (Carson, 1962, p. 57). I expand this assumption to include women's bodies; the scientists gave no thought as to whether women's reproductive systems could withstand those toxic insults as well. Yet, how the soil and other affected communities would "strike back" to cause unintended

side effects and damage, did not enter the systemic considerations of the Green Revolution. Instead, the Green Revolution measured its success in yields gained as a result of pesticide use; the Green Revolution's profound adherence to reductionist thought manifest in a narrow, and I believe, harmful, conception of success. The indiscriminate use of technologies exemplified Farmer's (2005) conception of social inequity as they measured success based upon quantitative indicators that ignored the risk of external consequences; this notion of success ignored the Green Revolution's effect on "the innocent lives" (p. 161). I will later measure the mechanisms and magnitude of this effect by evaluating women's health outcomes.

The Green Revolution is responsible for setting farming communities in the Global South on what Robert Van Den Bosch (1989) famously coined, the "insecticide treadmill" (p. 23). The debut of pesticides, such as DDT, into the agrarian economies of the Global South disrupted the, once-organic, interplay between pests and their predators. Van Den Bosch (1989) holds that DDT impinged upon the "physical and biological factors in the environment that maintain all species populations within characteristic limits" to instead "kill good bugs as well as the bad ones" (p. 23). The result was the problem of increased pest resistance. The technocrat's answer is the application of more pesticides. Carson (1962) continues; "This happened because insects, in a triumphant vindication of Darwin's principle of the survival of the fittest, have evolved super races immune to the particular insecticide used, hence a deadlier one has always to be developed—and then a deadlier one after that" (p. 8). DDT perpetuates a self-fulfilling prophecy of functionalism; it effectively kills both pests and beneficial biota, which simultaneously creates a need for more application. I argue that rather than promoting a system of stability, DDT promoted a

system of social and biological instability and harm. The consequence was that farmers were forced into using increasing amounts of pesticides to maintain the same yields over time (Pingali, 2012, p. 12304). Hence, the production and spread of DDT during the Green Revolution in the Global South bound farmers into a perpetual trap of dependency. I propose that an additional component of that trap was negative reproductive health outcomes for the women who participated actively in the pesticide treadmill.

Prominent Green Revolution critic and environmentalist, Vandana Shiva, spearheaded the ecological crusade against pesticide use in the wake of Carson's turning-point work. In *The Violence of the Green Revolution*, Shiva (1991) laments the assumption that chemicals can replace fertility and enhance the fruits of the soil.
Condemning the incorporation of pesticides, such as DDT, into rural farming communities in India, she blames the Green Revolution's technological imperative for "having destroyed nature's mechanisms for controlling pests through the destruction of diversity" to instead become "mechanisms for breeding new pests and creating new diseases" (Shiva, 1991, p. 98). The technological conception of the Green Revolution captures the notion that technology exists in a vacuum; that simply replacing "less effective" methods with "modern" ones will not alter anything outside of its practical realm. Quite to the contrary, the use of new technologies caused social and economic shifts that reorganized women's patterns of production and the spaces in which they worked.

The technological mindset of the Green Revolution purported that agricultural technologies were transferred to the Global South to stimulate agricultural production. However, in subverting the local modes of production for the imposition of monoculture, the Green Revolution ignited "an addictive process that is magnified and prolonged by

genetic selection for insecticide resistance in the repeatedly treated pests" (Van Den Bosch, 1989, p. 25). The extent to which DDT-induced disease would come to threaten the health of farming women in the Global South is a new reality of the insecticide treadmill that binds women close to its core. Larger and larger quantities flooded not only the soils, but also the bodies of women who relied those soils for survival and income.

Critique: The Myth of Neutral Technologies

Following Dahlberg's (1979) argument against the transfer of a Western-based model to a vast array of countries and cultures around the world, Nancy Fitzgerald (1986) contends that the Rockefeller Foundation based their model of agrarian change off of their experiences with the American land-grant system—a system operated under the assumption that by means of "trickling down" from research scientists, practical information would "reach commercial farmers who could afford the recommended practices" (p. 478). Fitzgerald (1986) worries that critics focus too narrowly on the issue of subsistence disruption miss this crucial aspect of the Green Revolution. The vast differences between farming practices and populations in the Global South and those of the United States rendered integrating the development strategies promoted by the Rockefeller Foundation nearly impossible. Green Revolution scholar, Francine Frankel (1971), points out that in addition to intraregional tensions between small and large landholders in the same areas, the allure of technologies also spurred interregional disparities, as more arid districts would "inevitably fall farther behind" than those with greater rainfall (p. 9). Highlighting such discrepancies in access exposes the inherent inequality of the Green Revolution that perpetuated structural violence that culminated in adverse health outcomes.

Given the "prepackaged" model of the Green Revolution's technological fix, little consideration was given to the individual needs of culture, context, and community. The model ignored both the social and biological impacts women would soon bear. Herein lies the ignorance of the dialectical nature of technologies; technologies cultivate change insofar as they mindlessly interrupt place-bound social and economic relations. I will later discuss how the technologies interrupted women's social and economic lives, and further illustrate the link between those interruptions and new health risks. Fitzgerald (1986) also highlights the lack of "effective information- transmission systems" built into the structure of mechanized agrarian change (p. 479). By ignoring local contingencies of the Global South's dawn of new technological advancements, the Green Revolution overlooked how local agrarian economies and labor were saturated with gender relations.

The economic gains garnered through the utilization of the Green Revolution's agricultural package did not bear equally on all members of society. Shiva (1991) contends that the interests of the Green Revolution lay in "building on the best," an ideology that generated new social inequalities between farmers who could use the technology to profit, and "those for whom it was turned into an instrument of dispossession" (p. 45). The appeal of the new agricultural package lay not only in its promise of increased yields, but also in the increased profits that were promised to follow. However, the key to the profit-enhancing package of "miracle" seeds was the possession of enough capital to purchase the new seeds, necessary chemical inputs, and equipment. I expand Shiva's (1991) characterization of dispossession to include women's disposition of control over their pesticide exposure and reproductive outcomes. In the upcoming chapter, I show how

women, unable to control the new technologies as landowners, entered into new spaces and roles of risk.

Critique: The Landlord Bias of Technologies

Economist Keith Griffin (1974) draws in a new dimension to the analysis of the Green Revolution's inequity in his well-known work, *The Political Economy of Agrarian Change: An Essay on the Green Revolution*. The true reason for the bias of the Green Revolution, according to Griffin, lays in government policy through which the technologies were promoted. This analysis exposes the political component of structural violence. He argues, "[f]or many years research, extension and investment programmes in agriculture have been devoted to raising output (preferably exportable output); their primary concern has not been to increase the welfare of the rural population and improve the distribution of income and wealth" (Griffin, 1974, p. 53). His main critique investigates how issues of the neutrality or bias affect the distribution and favorability of newly introduced technologies, such as pesticides. Elaborating upon Fitzgerald's (1986) discussion of "fit" between the large farmer and technologies, Griffin (1974) introduces the concept of "landlord-biased" innovation, or "technical change only adoptable by those who enjoy a relatively low price of capital and material inputs" (p. 50). Unlike large farmers who received incentives to mechanize their farms, small farmers were often denied the credit necessary to obtain the seeds, chemicals, and equipment. "For example, in the wheat regions," Griffin (1974) writes, "45 percent of farmers in the lowest size decile used high-yielding seeds, whereas 90 percent of the farmers in the top decile used the improved varieties" (p. 56). The enhanced polarization between large and small farmers often forced

small farmers off their land and into the fields of commercial farmers. The bias of the Green Revolution placed capital-intensive inputs, such as pesticides, in the possession of the best endowed farmers in the best-endowed areas. Yet, although the control of pesticides was deflected away from small farmers in resource poor areas, they came into direct contact with them as agricultural laborers. The rural poor were excluded from the management of pesticides and other technologies, yet subjected to consequences of their exposure.

Defining the Green Revolution: Change as ideology

Analyzing the technological changes exported during the Green Revolution addresses only the top layer of a complex structure of change. The experiences of women with in that system, however, exist at a deeper level of analysis. The second understanding of the Green Revolution delves deeper into the ideological paradigms of crop production through technology and science. Kalpana Bardhan and Pranab Bardhan (1973), scholars from the Indian Statistical Institute and Agro-economic Research Centre of Delhi University, distinguish between the two dominant prevailing views on the Green Revolution. They articulate the first view as "to emphasize that the technology breaks the vicious circle of centuries-old stagnation in traditional agriculture," while the second, "is to focus on the forces generated by the Green Revolution, which tend to accentuate the existing enormous inequality in the economic systems" (Bardhan & Bardhan, 1973, p. 285). I situate the increased use of pesticides in the former and the analysis of their use on women's reproductive health in the latter. The values at the core of the Green Revolution were rife with reductionist and positivist ideologies that supported its model of uni-

directional development. Thus, a more nuanced level of analysis is needed to fully comprehend the role and impact of the Green Revolution on rural women's roles in the economies of the Global South and how those roles were related to spaces of pesticide exposure.

The mechanization of argoeconomies in the Global South denotes a deep restructuring of local agricultural philosophy. In addition to exporting new technologies and practices from the Western world into the hands of farmers in the Global South, the Rockefeller Foundation diffused an agricultural ideology built upon notions of industrialization, science, and modernity. Ecofeminist Carolyn Merchant (1996) argues that mechanized agriculture, that which gave man the power over nature, relied on ideologies of rationality and order—17th century values from the Scientific Revolution (p. 85). The Green Revolution's goal of increased productivity rested on manipulating natural processes of growth, pest management, and fertility through objective scientific knowledge and inputs. Borlaug's high-yielding varieties, those capable of growing in any climate, embody the very core of Western science—its universal truth. Lakshman Yapa (1993) argues that the success of the seeds "arrived in the villages carrying the authority of science and modernity" (p. 264). The power and triumph of Western scientific epistemology undergirded the seeds use and represented their universality. Shiva (1991) asserts that as products of Western science, the seed "cannot not be judged, it cannot be questioned, it cannot be evaluated in the public domain" (p. 21). The seeds were a manifestation of a discourse that changed how farming communities in the Global South conceived the their interactions with nature. I contend that the introduction of pesticides

into the once- organic natural environments of the Global South transformed the fields from a source of life for women to one of impaired reproduction.

The imposition of chemical pesticides into the once naturally sustained farming practices of the Global South substantiated Western science's capability to dominate nature in the name of development and progress. Pesticides, such as DDT, were at the crux of the Green Revolution's "universal" technological ideology. Their increased use meant not only a radical transition in agricultural practice that detached farmers from their traditional modes of the production, but also the implantation of Western scientific discourses into the agricultural mind of governments and farmers in the developing world. DDT represented "man's domination over nature" through uni-directional technologies (Shiva, 1991, p. 18). Farmers purchased DDT and, thus, had mechanized control over nature and its fruits. Of the position of the farmer within the epistemology Shiva (1991) writes, "The knowledge and power nexus is inherent to the reductionist system because the mechanistic order, as a conceptual framework, was associated with a set of values based on power which were comparable with the needs of commercial capitalism" (p. 23). I argue that the capitalist nature of the Green Revolution valued the desire for quantitative success over the basic human need of a healthy, chemical-free, environment; this clear prioritization left women to work in fields and homes that were increasingly exposed to pesticides. Its model marginalized women's basic health within the shadow of scientific innovation.

Capitalist values also served to co-opt farmers into producing as much as they could at any price. Not only were farmers in the global south trapped in a technological demand for pesticides, but also an ideological one that prided the modernization of their farms. Yet the modernization of technology came at a price. An ecofeminist understanding

of DDT exposes how pesticides, the key modernity, threatened the health and fertility of women in the Global South in more than a technical sense; they did so in an ideological sense. The lack of concern given to the "external" impacts of pesticides represents a larger ideological bias favoring production and profits over the well- being of women.

* * *

Intimately bound by the medium of technology, the two prevailing views of the Green Revolution capture its role in cultivating technological and social transformations. Yet the intersection of the two—of the technical and social—have yet to be fully articulated to illustrate how technological change influenced women's experience of health. The question of women's reproductive health begs an understanding of the physical effects of technology on women's bodies. The implications of pesticides on women's bodies expose the physical mark of, and explicit link between, the practical and ideological changes fueled by the Green Revolution. However, before that connection can be full enforced, one must understand how the Green Revolution mediated women's contact with harmful pesticides. This understanding requires a deeper understanding of how women's social and economic roles shifted within the new labor demands of large-scale agriculture. In the next chapter, I discuss how the Green Revolution's introduction of technologies relocated women into new patterns of agricultural and domestic production. They occupied new physical spaces in relation to the new technologies, such as pesticides. I expose the mechanisms through which the agrarian change of the Green Revolution facilitated women into new spaces; the same spaces created new social susceptibility to DDT contamination.

CHAPTER 5- Women and Agrarian Change: Patterns of Production and Women's Social Susceptibility to DDT

> "The uniqueness of women's experience lies in the central recognition that in general (1) women's access to resources and income is constrained in nature and intensity by additional factors that do not affect men; and (2) women's roles in production, consumption and exchange are linked to family welfare and survival in ways which men's are not; and it follows (3) women shape and respond to production. Given these differentials, it would indeed, be surprising if technical change in agriculture were to have a similar impact on men and women" (Jiggins, 1986, p. 44).

Looking Beyond Economics

The spread of the Green Revolution's technological package had clear impacts on the local environment, cultures, and economic structures in the Global South. DDT's central role in displacing traditional pest management techniques meant not only a shift in practice, but also in labor demands. Changing farm size, technologies, and field operations affected women's roles and spaces, both in farm labor and within the household. Given their dual role of producer and reproducer, rural women bore the brunt of economic shifts engendered during the Green Revolution (Sobha, 2007, p. 108). Similarly, as Janice Jiggins mentioned in the above quote, "women's roles in production, consumption, and exchange are linked to family welfare and survival in ways which men's are not" (Jiggins, 1986, p. 44). Yet, the economic ramifications of women's changing role in agrarian development are only the beginnings of a complex web of consequences. I will later show how that web was deeply bound to pesticide use and subsequent reproductive health outcomes, such as spontaneous abortion or breast milk contamination. Technologies modified local patterns of production and labor. Depending on their class, the utilization of those technologies, such as pesticides, changed women's roles in both the home and field.

It also changed their physical location in relation to the new pesticides that were heavily used in the field. The economic shifts experienced by women in the Global South facilitated their entry into locations of increased risk of pesticide exposure. The Green Revolution's reliance on purchased pesticides induced gendered changes in social relations by determining who could afford their use and who could not (White, 1985, p. 119). I change the focus of the economic critique to focus instead on how technology-induced changes in labor patterns increased women's risk of pesticide exposure in the Global South through their new physical spaces and gendered labor demands. Scholars have not yet analyzed the Green Revolution through a lens of how women's physical proximity to technological change caused negative health impacts.

New Labor Demands and Mixed Farming Economies

Leslie London et al. (2002) contend, "Because women are concentrated in the most marginal positions in the formal and informal workforces, and production is organized in a gender-specific way, opportunities to control their exposure to pesticides are limited" (p. 45). However, understanding how women were forced into those spaces of risk in the first place begs an analysis of how the Green Revolution's agricultural package altered labor patterns. Ingrid Palmer (1977) identifies that changes in women's work accompanying agrarian change, like the Green Revolution, depended on a number of factors, such as "the class-status of women, the preexisting sexual division of labor, the new technical and methodological requirements of the new crop, and forms of mechanization introduced" (p. 103). The social, political, and economic climates of the Green Revolution throughout the twentieth century varied greatly between country, culture, and community in the Global

South. Vandana Shiva (1991) argues that the specific changes of labor demand and patterns witnessed during the Green Revolution are largely indicative of "contextual causation" (p. 16).[5] Although no two women's experiences of the Green Revolution are identical, general trends emerge along gender and class lines that allow for tentative conclusions to be drawn regarding women's shared experience of large-scale agrarian change. I relate the trends of women's social relocation to new pathways of direct and indirect pesticide exposure.

Economist Ester Boserup (1986) asserts that agricultural modernization increases the proportion of female labor on the farm given the new demands of intensive cultivation and monocropping (p. 80). The influx of women's labor participation is a central component of agrarian change. Especially since the Green Revolution relied on a prepackaged model, one that did not adjust to meet the needs of specific communities, the labor demands that accompanied the model remained relatively constant. Examining how labor demands affected women in the wake of chemically-dependent farming, exposes the network of women's roles in the home and market economy. One characteristic of the agriculture sector in much of the Global South is the high level of participation of women in production, both informally in the home and formally (London et al., 2002, p. 47). Further, female headed households form, on average, 20-25% of households in developing countries, and in some areas may swell to 60-70% (Jiggins, 1986, 3). The preponderance of households headed by women among rural poor, coupled with the scale of women's agricultural participation, processing, and preparation rendered them increasingly

[5] Vandana Shiva uses the notion of "contextual causation" to describe the process by which "indications and suggestions are made of how the creation of certain context creates overwhelming conditions for certain processes to be unleashed" (Shiva, 1991, p. 16). The ways in which the Rockefeller Foundation's dismissal of the diversity of place caused unforeseen consequences exemplifies this idea.

vulnerable to the consequences of the new technologies. Reeves and Rosas (2003) assert that the situation of female farm workers within industrializing agriculture is "significantly worse" than men's (p. 16).

A class-based analysis provides the most comprehensive exploration of women's shifting labor demands and production patterns. For, it was not only women from poorer classes who experienced increased workloads during the Green Revolution. Women from larger farms that could afford technologies were dealt a new burden of work as well. The ways in which costly technologies, such as pesticides, initiated changes in labor demands created gendered susceptibilities for rural women who, depending on class, experienced either diminished or increased agricultural labor. Consequences of the Green Revolution affected rural populations differently depending on their status of occupation—whether they are wage earners, cultivators, or consumers—whether they were landed or landless, rich or poor, male or female (Aragwal, 1984, p. 39). Yet regardless of class, women's roles in agriculture shifted in response to new labor demands. Rich or poor, landed or landless, I maintain that women moved into spaces that increased their risk of pesticides exposure, even if their agricultural duties were actually reduced. Thus emerges a trend of pesticides as profoundly gendered in their domains of susceptibility, while relatively un-classed.

Landless Women and Increased Agricultural Labor

Janice Jiggins (1986) explains that the Green Revolution ignited a process of the "feminization of agriculture" wherein low-wage farm labor was increasing performed by landless women (p. 2). As mentioned, the bias of the Green Revolution towards large-scale capitalist farms excluded smaller farmers from reaping the benefits of the new

technologies. Therefore, the increasing need for cash incomes in rural household to cover the costly technological inputs forced more women to work as wage laborers (Food and Agriculture Organization [FAO], 1997). Large- scale farms in the Global South witnessed a general increase in hired farm hands during the 1960s and 1970s. The major pool of hired labor came from the poorest landless laborers displaced by the Green Revolution's landlord bias. White (1985) explains that landless households are the bottom rung of already-differentiated agrarian strictures (p. 124). For poor, and landless women, increased modernization of agriculture resulted in their increased participation as wage laborers in the field (Ahmad et al., 1985, p. 10). Lipton and Longhurst (1989) explain, "[f]emale labor use is positively related to proportion of rice HYV cultivation" (p. 265). Much like the socialization of women's domestic roles previously discussed, the socialization of agricultural roles characterized some operations as "female tasks." Boserup (1986) explains, "In both primitive and developed countries, the traditional division of labour within the farm family is usually considered 'natural' in the sense of being obviously and originally imposed by the sex difference itself" (p. 15). Like the socialization of domestic roles, tasks in rural agriculture were often determined by conceptions about women's nature and physical abilities.

"Traditionally female tasks" included operations such are harvesting, weeding, and processing (Buvinic & Mehra, 1955, p. 2). These tasks were done by hand and were, therefore, highly labor intensive. Within mechanized agriculture, like the Green Revolution, increasing amounts of hand operations were relegated to women as men controlled the new machinery (Boserup, 1986, p. 24). Women's lack of physical strength was noted as a reason for women's exclusion from using machinery; the heavy weight of

pesticide sprayers was seen as too much of a burden for women (Martin & Albright, 2003, p. 283). Therefore, the Green Revolution pushed poor landless women into increased manual labor that was necessary on the larger, more productive farms in the Global South. I will show how the nature of "traditionally female work" also increased women's exposure to pesticides.

The "feminization of agriculture" meant that growing numbers of women relied on temporary for-hire employment in traditionally female tasks, such as weeding, for much of their income (Lipton & Longhurst, 1989, p. 77). The Green Revolution's cultivation practices were more labor-intensive, thus requiring increased labor schedules and hours for landless women. Considering the increased requirement of weeding needed per crop, and the increased size of farm, hired female labor tended to increase in those operations specifically (Food and Agriculture Organization, 1997). Such activities provided the necessary wage opportunities for landless women seeking new, and more necessary, agricultural employment. The Green Revolution both displaced poor rural women and also increased the amount and intensity of their agricultural labor demands. I argue in later chapters that, in conjunction with women's elevated manual labor, the excessive use of pesticides rendered their bodies increasingly susceptible to DDT contamination and therefore, subsequent negative reproductive health outcomes.

The Experience of the Small Cultivator

Labor trends in agricultural modernization had mixed effects on women in small-cultivator households. Caught in between the landless households and the larger landholder, White (1985) describes these households as "deficit" households, or

households with "farms too small to provide a surplus, and less access to the inputs necessary to maximize profit" (p. 125). Though better off than landless households, agrarian change still marginalized these households as they may have experienced debts or become unable to maintain capital inputs for extended harvests. For many small households, the financial intensification of adopting the Green Revolution package increased the need for cash incomes. The Food and Agriculture Organization (1997) notes that the adoption of new agriculture had two effects on women from small farms; it either forced them to work as hired agricultural laborers or increased their work burden for family farming activities in their household's effort to avoid the use of paid laborers. The situation of women from small farms reveals Levin's (1998) notion of a "gradient" of experience (p. 382). Such women were caught in the middle of the technological struggle. Agrarian development does not work in linear or predefined ways, rather it is in constant dialogue, or dialectical interaction, with the social realities of the individual and their community. Small-scale farming women were in constant flux within the Green Revolution.

Landed Women and Increased Domestic Production

Conversely, for rural women from large-scale capitalist farms that could afford the agriculture package, the mechanization of agriculture pushed them out of direct agricultural labor. White (1985) explains that for these "large" farm households, the Green Revolution meant an increase in hired labor and adoption of the Western technologies and methods (p. 124). Women living on farms that now employed the temporary wage labor of landless women experienced shifting labor demands as well. However, their

socioeconomic standing directed them away from agricultural wage- labor and into more domestic production in the household compound. Rural lande*d*, as opposed to land*less*, women often experienced the indirect effects of the Green Revolution's agrarian change—those "mediated through women's positions within household and family structures" (Jiggins, 1986, p. 44). Within landed households, the amount of women's unpaid family labor in the home increased with the introduction of technologies and increased hired labor.

Women from large farms assumed the indirect effects of the Green Revolution's new labor demands; those of female- specific responsibilities in the home. Although agricultural mechanization meant that they could withdraw from direct agricultural labor, their total labor demands did not decrease. Women's workloads increased in the home; they were increasingly responsible for the preparation of hired field workers' meals, cleaning, and other compound-based crop processing operations (Agarwal, 1984, p. 41). Yet, despite decreased field-based labor, women from larger households also faced increased, albeit indirect contact with technologies. The proximity of housing areas and worker's compounds to commercial farms meant that women were not shielded from the impacts and residues of "modern agriculture" (London et al., 2002, p. 5). Given their physical proximity to the field, they were never far from the pesticides applied and processed by the hands of their landless counterparts. I will explain the specific characteristics and implications of various routes of DDT exposure in the following chapter.

Structural and Educational Inequality for Women in the Field

Despite their increased agricultural participation, education and training efforts concerning technology and DDT use rarely reached poor agrarian women in the Global South. Gender-based barriers to women's agricultural education and training reflect larger structural inequalities built into the Green Revolution. Abhilash and Singh (2009) explain that factors such as lack of training, ignorance about potential health impacts, poor literacy, inappropriate mixing and application of pesticides, a lack of protective and reliable equipment, and poor regulation are relevant to negative outcomes of pesticide use (p. 4). However, undergirding these functional inadequacies are social attitudes that situate women farther away from educational opportunities. Common societal, and I what I consider, sexist, attitudes discouraged women's participation in training in the Global South. One example is that males were considered to be the more appropriate recipients of agricultural training; women were considered unfit for training due to their lower educational levels (Pontius & Sri Lestari, 2003, p. 299). Therefore, women in the Global South had significantly less knowledge about DDT's toxicity and safe use than men (Chikuni & Polder, 2003, p. 131). These were the same women whose contact with DDT increased with changing labor demands.

Though the gender difference in understanding potential risks are largely owed to women's level of education, a problem existing before the onset of the Green Revolution, the new agricultural technologies exacerbated the consequences of this social inequality. The fact that the Green Revolution's blueprint made no concessions to communicate the risks to women—those who were increasingly in contact with pesticides—exposes how the inherent violence of the Green Revolution joined forces with the existing structural

violence evident in the gendered access to education. Women's lack of education translated into a lack of, what I call, technological literacy in the field. That is, the ability of women to read warning labels, understand toxicity, and take other pesticide-related health measures. Lacking technological literacy, within a system that did not consider its risk, illiterate women in the Global South were unable to protect themselves from the reproductive health impacts of pesticide contamination. In Chapter 8's case study of Punjab, India, I illustrate the direct relationship between female literacy, farm labor participation, and the occurrence of negative reproductive health outcomes.

Compounded with women's lower educational levels in the Global South, the small amount of training, and dissemination of knowledge about, new technologies focused on men (Jiggins, 1986). The exclusion of women exposes engrained structural violence based on gender difference; the Green Revolution enhanced already existing social inequalities. Traditionally, information and training activities addressed only men as women's labor was largely undervalued in agrarian development (de Garbino et al., 2003, p. 115). This oversight is a result of the blurred line between women's roles as producers and reproducers. What emerged was the assumption that women's work is not hazardous to their health, which led to the underreconition of women's multiple exposure sources and work-related health risks (London et al., 2002, p. 51). Gender hierarchies also manifested at the structural level of the Green Revolution. Throughout every professional level of Green Revolution research institutes, the majority staff was male (Jiggins, 1986, p. 35). The gendered division of labor may have determined why women were not included in the Green Revolution equation. Male extension workers were not only more likely to contact male farmers than female farmers, but have historically held the assumption that skills

communicated to men will "trickle across" to women (Jiggins, 1986, p. 39). The gender bias in agricultural training both maintained a gendered status quo that threatened the reproductive health of women who were increasingly unaware of their exposure to pesticides during the Green Revolution. I understand the gendered power dynamics of the Green Revolution as a primary mechanism of structural violence. These power dynamics manifested on an epistemological level as well. As I mentioned in Chapter 4, the Green Revolution mediated profound epistemological shifts concerning agricultural practice. In addition to changing women's physical locations in production, the Green Revolution marginalized women's roles as agricultural knowledge-bearers in the Global South.

The Industrialization of Women's Ecological Knowledge

In addition to reorganizing labor patterns, the Green Revolution undermined women's traditional agrarian knowledge. Women's epistemological role in agriculture shifted as the new social and economic climate of the Green Revolution marginalized their traditional knowledge. With the new encouragement of DDT, and other technologies, came a detachment from traditional technologies and methods of resources management, of which women had been the bearers. In this light, new technologies both undermined the embeddedness of women's knowledge in agrarian communities and altered their patterns of production. New farm management practices, such as monocropping, relied not on generations- old knowledge, but on technical understandings of chemical use. Sobha (2007) explains that the replacement of renewable inputs from the farm with non-renewable inputs, such as DDT, displaced women from their work of providing and maintaining the sustainable inputs (p. 108). With the changes of the Green Revolution,

women's main role was either that of wage labor or domestic support for the newly mechanized farms. Their epistemological ties to production were severed with the implementation of new technologies.

Compounded with the economic polarization engendered by excessive pesticide demands, women lost control over land and knowledge and were forced away from their subsistence practices. Gail Omvedt (1994) asserts that the Green Revolution's "encroachment on local decision-making power and local control of production processes contrasts with traditional patterns of local innovation and pro-colonial systems in which women normally had a substantial role and control" (p. 101). Under the banner of "modernity," the Green Revolution exchanged women's key role and knowledge in rural economies with that of imported research and technologies. Pesticides were the key to transforming the "backwards" traditional practices that bound peasant farmers in a "traditional culture of poverty" (Yapa, 1993, p. 246). I, therefore, argue that Green Revolution disregarded women's knowledge and their right to an unhindered future of reproduction. The Green Revolution supplanted the seed's dependence on women's knowledge for their growth with a new dependence on pesticides. Transforming seeds into, what Shiva calls, "corporate and military warriors," the Green Revolution waged a new war against women's health.

* * *

Conventional analyses of women and agrarian change focus on how new economic structures impact women's income, or how new social relations manifested into gender-relations in the work force. However, I shift the focus from economic or social gains to, instead, focus on the new physical locations of women in relation to the new technologies

of production. I understand the agrarian change of the Green Revolution as facilitating women into new spaces of exposure to DDT given their new roles in agricultural and domestic production. The forces promoting this shift relied upon undermining women's traditional and ecologically- based knowledge. The new spaces women occupied in response to the Green Revolution are the gateways to pesticide- induced reproductive detriments. In this lens, I argue that rural women of all socioeconomic backgrounds suffered greatly from new labor demands of the Green Revolution. However, before discussing the biological mechanisms of pesticide contamination, I turn to the Green Revolution's weapon against women's reproduction, DDT. The following chapter will outline the history of DDT, how it transformed local methods of pest control, and the impacts of the "revolutionary" pesticide on the environment and women's bodies. I contend that the Green Revolution, through shifting economic relations, created new pathways of DDT exposure threatening women's health outcomes in the Global South.

CHAPTER 6: DDT and the Green Revolution: How a revolutionary pesticide transformed lives and landscapes in the Global South

The Origins of DDT and American Exceptionalism

The history of DDT exposes why the Rockefeller scientists placed it at the core of the Green Revolution model without questioning its potential for harming women's reproductive capacities. Although Othmar Zeidler first synthesized chemical DDT in 1874, it was not until 1939 that Swiss scientist, Paul Muller, discovered its insecticidal properties (Abhilash & Singh, 2009, p.2). Muller observed that DDT not only killed flies he sprayed directly, but also killed flies put in the same container after it was wiped clean; he had discovered a chemical that was both powerful and persistent (Bate, 2007, p.1). I consider this observation as the earliest embodiment of its future implications on women's reproduction. After patenting DDT in 1940, the United States was eager to manufacture it for the global market (Davis, 1971, p 1). DDT came to rapid prominence during its early years as the most powerful insecticide the global market had ever seen.

In addition to nearly eradicating lice-borne typhus in European war camps during World War II, DDT also protected against other insect-borne diseases, such as malaria. In 1945, Muller was awarded the Nobel Peace Prize for medicine in recognition of his public health discovery (Dash et al., 2007, p.1). It was yet another notch in the belt of American scientific progress. The United States Public Health Service (PHS) funded the use of DDT for malaria control worldwide and none other than the Rockefeller Foundation jointly funded the program (Bate, 2007, p. 2). In 1945, DDT had become the most publicized synthetic chemical in the world and the pressures for DDT's prompt release were immense; there were great immediate profits to be made from DDT's manufacture,

distribution, and agricultural use (Davis, 1971, p. 1). As monoculture became the Green Revolution norm in Mexico, and throughout Latin America and Asia, farmers in the Global South used more and more DDT throughout the 1940's- 1960's (Davis, 1971; Bate, 2007). Unfortunately, the Food and Agriculture Organization for the United Nations (FAO) claims that there is no "continuous record of world production of DDT" (2007). Therefore, the full scope of DDT's harmful legacy will never be fully brought to light.

Simultaneously, the 1940's marked a time of renewed faith in American science, technology, and ideas—the same ideologies that drove the Green Revolution. There was an unwavering conviction within the scientific community that technology was the ultimate marker of modernity (Marglin, 1996, p.48). The increased production and spread of DDT for agricultural use marked the rise of technological control as the dominant strategy of pest control, both domestically and abroad. Produced by some of the largest manufacturing companies in the country, DDT was considered a "uniquely American pesticide" and the key to modernizing agriculture (Kinkela, 2011, p.6). At the same time, rising concerns about rapidly increasing populations echoed from governments in the Global South, such as Mexico and India. The "population question" was at the center of international agricultural research since the 1950's; the argument that more food from high-yielding varieties would "cure in adequate food consumption was deeply entrenched" (Lipton & Longhurst, 1989, p. 210). DDT was a central component in the growth of population-saving seeds. The same chemical that the scientific community regarded as "uniquely American" would be diffused throughout the Global South.

I understand this contradiction as reflecting the core of Western development ideology; that only Western technologies could remedy the deficiencies of the "other." The

decades after World War II witnessed a rise development projects aimed at "eradicating the problems of the past –disease, famine, and poverty—through strategic deployment of modern technologies, including DDT" (Kinkela, 2011, p.6). The Green Revolution was one such endeavor; it was an experiment in designing development and agriculture that prided itself on the deployment of toxic chemical technologies into the Global South. Due to its low-cost, effectiveness, simple application, and versatile environmental use, DDT was the Rockefeller Foundation's pesticide of choice (Kinkela, 2011, p.1). Yet the consequences of its use on women's health outcomes would long surpass its central role in stimulating and protecting agricultural productivity.

The Rockefeller Foundation and the DDT Dilemma

The rapid rate at which DDT claimed the global stage is largely responsible for the global ignorance of its harm. Sandra Steingraber (2010) claims that, as DDT was developed under emergency conditions of World War II, it was not adequately tested for safety (p. 92). Early reports from a small number of concerned scientists in the US indicated that conclusions about DDT were "contradictory" as they indicated the risk of its "indiscriminatory" sweep of both harmful and beneficial species (Kinkela, 2011, p. 71). Yet, considering the growing success of its agricultural salvation in the Global South, the Rockefeller Foundation ignored the calls of concern. Had they listened, the Rockefeller scientists may not have spread the toxicity of DDT at the rate at which they did. The glory of DDT in protecting Borlaug's seeds against insidious pests undermined any real attention to the potential side effects, such as health. One study observed "total pesticide consumption in Mexico surged from 14,100 tons in 1950 to over 113,000 tons by 1960"

(de Alcantara, 1976, p.84). The continued use of DDT despite inconclusive reports about its safety exposes a daunting characterization of the Green Revolution's industrial agriculture; there was a greater concern for short-term productivity and economic gain than for long-term human consequences.

DDT expert, David Kinkela (2011), further characterizes the continued use of DDT as a "paradox" wherein "the agricultural system embraced by [Mexican President] Avila Camacho and sponsored by the Rockefeller Foundation would put the bodies of many Mexicans at risk" (p. 64). Little did they know, the legacy of the Green Revolution's DDT dependency would remain in women's bodies for generations to come. Due to concerns about it biological persistence and potential threat to humans and animals raised in the mid-twentieth century, the use agricultural DDT was banned in the United States in 1972 by the US Environmental Protection Agency (Environmental Protection Agency, 2012). Although the passage of the Federal Environmental Pesticide Control Act restricted DDT's use in the US, agricultural use continued beyond its borders, including countries such as Mexico and India. The 2000 Stockholm Convention on Persistent Organic Pollutants marked a global phasing out of DDT production and use (Jacobs, 2003, p.99). However, despite the bans, DDT still threatened women's bodies as its residues remained in the environments of countries in the Global South that continued its agricultural use long after. Before I elaborate the specific manifestations of such harm however, a description of DDT's chemical properties shows how it is specifically instrumental in obstructing women's reproductive capacities.

DDT and Environmental Persistence

DDT's unique properties engender distinct mechanisms through which it enters the female body and interacts with the reproductive system. Characterized by chemical stability, a lipophilic nature, and a propensity to bioaccumulate in the food chain, DDT remains in the environment long after its application (Waliszewski, 2012, p. 5614). DDT, like other organochlorines, is highly persistent in the physical environment. When spray residues evaporate, they are swept into wind or water currents and redeposited into new vegetation, water, and soil (Carvalho, 2006, p. 689). DDT, therefore, threatens not only the direct source of its spray, but the surrounding environment and a host of unintended targets. Women in the Global South were one group of unintended targets. David Pimentel (1995) exposes the extent of the problem of drift; "More than 99.9% of the applied pesticide residues move into the environment where they can adversely affect beneficial biota and contaminate the soil, water, and atmosphere" (p.18). Therefore, the entire environment surrounding an agricultural area is at risk of contamination through persistent residues.

As DDT is virtually insoluble in water, the loss through runoff is low because DDT has a strong affinity for organic matter in soils and aquatic sediment (van den Berg, 2008, p. 9). As a result, sediments act as the primary reservoir for DDT and facilitates its the long-range transport of residues to other water sources and soils (Diaz-Barriga et al., 2003, p.375). Rural agricultural areas with poor drainage and sewer systems are at increased risk of localized contamination sources, as the residues are not adequately flushed from surface water. The Rockefeller Foundation implemented the Green Revolution in such rural agricultural areas. Further, DDT is particularly persistent in agricultural farmlands due to

the absorptive capacity of the organo-rich soils (Bag, 2000, p. 3383). The soils of the farming communities, those that women were increasingly cultivating, in the Global South acted as reservoirs for DDT's toxic persistence, due to its chemical properties.

The heavy use of DDT in Mexico during the peak years of the Green Revolution resulted in a significant build up of persistent chemicals in both the environment and the food chain (Murray, 1994, p.48; Kinkela, 2011, p.72). DDT is a particular public health concern as its chemical properties enable it to be transported from the pollution source to the human body. Food is a major pathway of exposure through the ingestion of contaminated plants, animal products or water. Airborne DDT settles and accumulates on the cuticle waxes of plant surfaces (Diaz-Barriga et al., 2003, p.378). In agricultural areas, diets rich in animal products, most notably meat and cow's milk, are of concern, as DDT levels would increase from the contaminated grass to the meat or milk to then accumulate in human tissues (Murray, 1994, p.48). Given the ubiquitous nature of persistent DDT residue, individuals and communities were often unaware of their exposure risks, especially those in the domestic sphere. I argue that women, through both agricultural and domestic labor were exposed to increased levels of DDT exposure due to its environmental persistence.

Furthermore, given DDT's high resistance to breakdown by chemical and biological means and lipophilic characteristics, persistent DDT residues are easily passed from environmental sources to human bodies, especially those with large fat stores. DDT's lipophilic characteristics, or fat solubility, mean that DDT residues in biological materials magnify as they move up the food chain (Saxena et al., 1981**;** van den Berg, 2008; Diaz-Barriga et al., 2003). The cycle of DDT's persistence in the environment, accumulation in

the food web, and absorption into the fatty tissues places women at increased risk of contamination. I contend that women's bodies face a uniquely gendered threat of toxic DDT accumulation due to the interaction between the chemical properties of DDT and women's biological sex characteristics.

DDT and Bioaccumulation: "Women's bodies are storage containers for DDT"

The first indication that DDT is a gendered chemical is its affinity for fatty tissue. The highest level of DDT concentration is measured in the fat cells of creatures at the upper end of the food chain, most notably, humans (Saxena et al., 1981, p. 6; Murray, 1994, p. 48). Women, due to biological sex-differences in genetics, fat tissue, and sex hormones, are more susceptible to this accumulation. Multiple factors strongly support women's distinct susceptibilities to the toxic action of DDT (Garcia, 2003, p. 585). The biological nature of women's increased susceptibility to DDT accumulation increased the risk of women's interaction with it during the Green Revolution. Margaret Reeves and Lucy Rosas (2003) explain, "women have proportionately more body fat than men, increasing their potential to accumulate more endocrine disrupting chemicals and/or face greater exposures related to changes in body fat levels" (p. 26). Women's breast tissues are primary factor in the higher proportion of fat in women's bodies. Illustrating this conclusion, Koepke et al. (2004) found that evidence of high-level exposure to DDT and DDE among pregnant women living in Chiapas, Mexico. They observed that women with a higher Body Mass Index (BMI), or proportion of body fat, had higher DDT and DDE serum levels than women with lower BMIs (Koepke et al., 2004, p. 562). Their findings

support the gendered mechanisms of DDT contamination that threaten females due to their biological sex differences.

Similarly, women experience more cycles of fat gain and loss. Women's hormone-related processes, such as puberty, lactation, pregnancy, and menopause are instrumental in mobilizing DDT residues stored in their fatty tissues (Setlow & Woods, 1998; Garcia, 2003). The mobilization of DDT in the body accelerates its typically, slow release, into the circulatory system. It is then transported throughout the body via the lipid and protein compounds of blood serum (Waliszewski, 2012, p. 5614). Men, who do not experience equivalent biological events or contain as much adipose tissue proportionately, have decreased susceptibility to DDT-related complications. I propose that, due to its chemical properties and affinity for fatty tissues, DDT is a gendered pesticide; it is more likely to accumulate in women's bodies and impair their fertility. The first example I provide highlights DDT's gendered mechanisms of harm; its accumulation in women's bodies has drastic implications for breast-feeding women.

Tainted Fertility: DDT Accumulation in Breast milk

The gendered nature of DDT's accumulation in fatty tissues initiates my discussion of how DDT causes negative reproductive health impacts for women. Given DDT's solubility in fatty tissue, the risk of its accumulation in women's breasts is a major concern. In addition to increasing women's bodily burden of DDT, it commonly results in the contamination of breast milk. As mentioned, breasts' high fat content acts as a reservoir for DDT. Once stored in the adipose breast tissue, DDT and its metabolites such as DDD and DDE, enter the circulatory stream and are translocated and excreted through

milk fat (Waliszewski, 2012, p. 5614; Diaz-Barriga et al., 2003, p. 378). The high fat content of breast milk readily enables DDT residues to accumulate in the milk duct. Human milk is measured to contain between 3%-5% fat content (Jenness, 1979, p. 226). As a woman breast-feeds her infant, her bodily burden of DDT is transferred into the body of the infant. Given DDT's bioaccumulation, the residues then concentrate in the fat stores of the baby. Infant ingestion of DDT is a direct route of susceptibility for continued bodily contamination because DDT will persist in the baby's systems just as in their mother's (Diaz-Barriga et al., 2003, p. 380). The contamination of women's breast milk transforms that which is intended to sustain the life into a instrument of bodily harm. An ecofeminist analysis posits that DDT disrupted a once life-sustaining cycle of human life, just as it did through the destruction of natural seeds as a source of women's survival and knowledge.

The contamination of breast milk posed an especial risk for women living in the Global South. Hindrik Bouwman (2006) explains in developing countries, breast milk is often the best, and in some contexts sole, nutrient source for infants from early to later developmental stages (p. 902). Therefore, women and infants living in the agrarian communities of the Green Revolution were increasingly vulnerable to this health outcome. Bouwman (2006) reported that mothers in KwaZulu-Natal, South Africa, a country with high levels of DDT residues in agricultural dwellings, indicated that they breastfed their infants for up to two years; this is a particularly long period that can lead to significant transfer of pollutants from mother to child (p. 903). Other positive associations between biological measures of DDT in breast milk and tissue have been widely associated with exposure to environmental resides and contaminated foods. Though this acknowledgment

is a valuable indicator of causality; I found a deeper connection between breast milk contamination and women's exposure to DDT.

I found that studies observing women in countries that used DDT during the Green Revolution were also those that had higher levels of DDT concentrations in their breast milk. For example, the breast milk of Mexican women living in agricultural areas that formerly used DDT had higher concentrations of it in their milk than levels measured in non-exposed women living in urban areas, where DDT was never used (Diaz-Barriga et al., 2003). Female farm workers in Nicaragua have nearly twenty times the level of DDT in their breast milk as non-agricultural workers (Merchant, 1996, p. 22). The Nicaraguan Government implemented the use of the Green Revolution's strategy, including DDT, in the early 1950s (Murray, 1994, p.16). Similarly, Ordias Chikuni and Anuschka Polder (2003) describe women in Zimbabwe as having among the highest levels of breast milk DDT and DDE in the world (p.128). Zimbabwe launched its Green Revolution in 1960 (Eicher, 1995, p. 805). The correlation between DDT exposure and contaminated breast milk exposes gendered toxicity of DDT that was exacerbated through Green Revolution technologies.

Yet it also exposes the deep historical ties to the Green Revolution. Using my historically-based understanding of the Green Revolution's dynamics, I argue that the high concentrations of DDT in women's breast milk in the Global South is a product of the blind deployment of pesticides for the sake of agricultural productivity. The women, who experience the highest levels of DDT exposure, and subsequent reproductive impairments, often live in the countries that continue to face the legacy of the Green Revolution's promotion of toxic DDT. Using my knowledge of DDT's environmental persistence and

bioaccumulation in women's fatty tissues, I now connect how the women's new spaces of production within the Green Revolution related to various routes of DDT exposure. I believe that women's new productive roles increased their susceptibility to those exposures.

Social Susceptibility: Female Farm Operations and Occupational Exposure to DDT

The biological mechanisms through which pesticides interact with women's reproductive systems place them at a higher risk of bodily accumulation and therefore, negative health outcomes. The Green Revolution enters the equation in two ways; it both spread excessive amounts of DDT into rural communities in the Global South and, as mentioned, altered women's roles and spaces within those communities. Both domestic and occupational spaces contained harmful levels of DDT residue. Social susceptibilities are the social pathways of exposure through which women were exposed to DDT. Given the relationship between women's new spaces of production and the increased use of pesticides in that production, I argue that their new social and economic locations acted as new environments of risk. Exacerbating women's already heightened biological susceptibility, the social susceptibilities of women to pesticide exposure increased during the Green Revolution. The "feminization of agriculture," the process that ushered large numbers of poor, women in the labor force, did more than minimize women's status on the farm; it placed them in the direct path of DDT's ubiquitous harm.

Poor, rural women who assumed new roles as wageworkers on larger commercial farms came into increased contact with DDT through the nature of their work in the field. Occupational exposure occurs through direct contact with DDT and its residues (Bretveld

et al., 2006, p.10). As previously discussed in Chapter 5, women were engaged in more labor-intensive work that did not require using machinery. Their farm operations consisted of traditionally female tasks such as harvesting, weeding, and processing (Buvinic & Mehra, 1990). As pesticide exposure and contamination arises from contact with its environmental residues, it is necessary to widen the scope of pesticide activities to include more than its direct application. Nasira Habib (2003) explains, "In order to fully comprehend women's encounters with pesticides, and the impact of those chemicals, it is necessary to look at their total farming workload" (p. 87). Although women often did not directly apply the pesticides, their exposure to the residues in surrounding environmental made them more susceptible to harm. Expanding the scope of pesticide activities exposes the extent and inequity of women's widespread risk of residue contact and therefore, negative reproductive health problems.

Tasks that occurred after the spray of pesticides included weeding, harvesting, and processing. These tasks are also those that were designated to women. As Ester Boserup (1986) indicated in Chapter 5, women's tasks were also manual (p. 24). Therefore, women handled the crops and soils that had just been sprayed with their bare hands. Considering DDT's environmental persistence and the considerable amounts of residues that land on the environment surrounding the crops, women's tasks situated them in the direct path of DDT exposure. Women also assumed a new job within the Green Revolution; they prepared and mixed the pesticides before their use. Women's interaction with undiluted pesticides before fully mixing them resulted in intense exposure to the toxic chemicals (Garcia, 1997, p. 323). Traditionally female tasks did not entail this overt risk before the Green Revolution introduced new demands for DDT. The Green Revolution, through the

reorganization of social and economic relations, facilitated poor, rural women in agricultural spaces that served as new routes of exposure to toxic pesticides. Yet, despite what I argue to be clear threats to women's health, the Rockefeller Foundation made no effort to educate the women about the new biological risks their jobs entailed. In fact, they did not acknowledge them as risks at all.

Absent Training: DDT use and the Safety of Female Farmers

The question of prevention is relevant at this point given the, seemingly simple solution of protection from the residues before women's health can be impacted. From its conception, agriculture education and training were at the core of the Green Revolution's mission. Seeking to cultivate a new generation of experts in the science of Western agriculture and Borlaug's "miracle seeds," the Rockefeller Foundation worked in partnership with national governments to build research institutes and educational centers (Dahlberg, 1979; Fitzgerald, 1986). Despite the attention given to education at an institutional level in the Global South, dismal effort was invested in the extension of education on a local level, especially to rural female farmers. Only when emerging reports of DDT's environmental and human harm threatened the reputation of the Rockefeller Foundation did they invest attention to farmer education (Kinkela, 2011, p. 77). However, for multiple structurally- induced reasons, those efforts fell short in adequately protecting farmers from toxic chemicals. Women were especially neglected due the reasons I mentioned in Chapter 5.

Women's role as wage-laborers typically locates them in low-status positions with little opportunity for safety measures (London et al., 2002, p. 47). The undervaluing of

women's participation often resulted in little to no provision of protective clothing (Hulshof & Sagnia, 2003; London et al., 2002; Murray, 1994). Women not only worked in higher-risk positions in relation to pesticide exposure, but were also given no resources to protect themselves from avoidable contact. In Malaysia, for example, the expansion of a cash crop economy increasingly marginalized women as they were moved into low paying agricultural jobs (Merchant, 1996). One study showed that, although women constituted 80% of those who interacted with pesticides, almost all of them do so without protective gear, even when pregnant or nursing (Merchant, 1996, p. 24). Given their lower-paid and lower-status positions, women's ability to avoid pesticide contact was diminished (Reeves & Rosas, 2003; Hulshof & Sagnia, 2003; Habib 2003; London 2002; Sobha, 2007; Wesseling, 2003). The neglect of gender considerations in the planning and implementation of the Green Revolutions chemically-dependent agrarian change resulted in the invisibility women' pesticide exposure in their new roles. The strategy imposed during the Green Revolution ignored how the new physical locations of women related to the new, potentially harmful, technologies.

Social Susceptibility: In Our Homes, In Our Bodies

Women from families that owned large- scale farms faced new routes of pesticide exposure as well. As mentioned in Chapter 5, women from these families were pushed off of the farm and into increased domestic production. Just as the field ushered in new social susceptibilities to occupational exposure for poorer women, the domestic sphere was a new space of increased social susceptibility to pesticides. As women in domestic spaces did not interact with DDT occupationally, their exposure occurred through environmental

pathways that transported DDT into their homes or compounds. Given the environmental persistence of DDT and its ability to travel from its source to new environments, the home became an additional reservoir of the new concentration of DDT in the Global South. "Home contamination" occurs when pesticide drift or resides enter the homes of farm workers, which exposes their family members indirectly (Garcia, 2003, p. 586). Pathways of home contamination include the reuse of pesticide containers for domestic purposes; handling and preparing contaminated food or water, or washing pesticide-covered clothing that was worn in the field (London et al., 2002, p. 50). Although women from landed households did not partake in direct agricultural labor, their domestic roles supported the labor in the fields. Catharina Wesseling (2003) characterizes indirect agricultural labor as "unpaid agricultural tasks" (p. 33). Women's domestic activities were closely associated to farming, since commercial agriculture is characterized by the close proximity of housing compounds to the fields (London et al., 2002, p. 50). They were, therefore, in close proximity to the excessive use of pesticides. Habib (2003) agrees, "Houses are surrounded by the fields that are sprayed, exposing all the inhabitants to deadly poisons" (p. 88). In this light, even women who were not involved in the Green Revolution's new agricultural practices were bound in the web of harmful exposure.

New domestic responsibilities for women, such as washing pesticide containers and contaminated clothing, arose from the Green Revolution's technological requirements. Such activities reveal the ways in which the Green Revolution exposed women to large amounts of pesticide residues, whether or not they were in the field. The Green Revolution subjected women at both ends of the economic spectrum to new social susceptibilities given their socialized roles and gendered divisions of labor. Through their socialized roles

as producers in the formal and informal sectors, women faced an increased threat pesticide exposure. Therefore, I argue that DDT contamination is gendered, to women's disadvantage, in both occupational and non-occupational settings.

* * *

Women's new social and economic spaces served as new pathways for occupational and environmental DDT residues to enter their bodies. Together, DDT's gendered properties and the tasks designated to women, in the field and home, during the Green Revolution, situated women at increased risk of pesticide exposure. This analysis suggests that the preliminary social and economic impacts of agrarian change are the gateway for another layer of negative consequences for women—increased pesticide exposure. In the next chapter, I delve the biological outcomes of women's pesticide contamination that I have alluded to thus far. Borrowing from Farmer's understanding of "pathogens," the following chapter highlights the biological pathogens to augment the many social "pathogens of inequality" that faced women in the Global South (Farmer, 2005, p. 20). To do this, I describe the biological mechanisms of DDT exposure in women's bodies, hormonal disruption, and the negative reproductive outcomes that emerge from this complex web of social and biological factors.

CHAPTER 7- Endocrine Disruption and the Reproductive Outcomes of DDT Exposure

A New Dimension of DDT's Gendered Chemical Properties

DDT's ability to mimic naturally occurring estrogen is its most distinct property and most potent threat to women's health. Characterized as an endocrine disrupting chemical, DDT has the potential to interfere with the body's hormonal signaling system (Langston, 2011, p. 4). DDT accumulation in women's bodies alters the natural production, operation, and balance of estrogen necessary for normal reproductive functioning and development. When absorbed into the body via occupation, environment, contaminated food, water, and/or physical surroundings, DDT mimics the effect of the body's natural estrogen and can disrupt important biological processes (Bhatt, 2000, p. 71). Estrogen is of considerable importance for women's health; starting at fetal development, through the initiation of puberty, during pregnancy, and to the onset of menopause, estrogen is the key hormone in women's reproductive life (McLachlan et al., 2006, p. 63). Estrogen maintains the necessary hormonal balance for proper functioning of the reproductive system.

Endocrine disrupters function in distinct ways compared to other chemicals. The difference lies in their dose-response mechanisms. Miriam Jacobs (2003) distinguishes endocrine disrupting chemicals from other toxicants, in that they do not have the classical toxic effect of carcinogens, neurotoxicants, and heavy metals; endocrine disruption can occur at lower levels of exposure than other toxic substances (p. 178). Through a mechanism called the "low dose effect," lower doses, or concentration levels, of DDT actually induce a more significant effect in the body than higher doses (Markey et al.,

2002, p. 236). As lesser amounts of DDT can initiate the same, or worse, impacts as larger amounts in the body, endocrine disrupters do not have a "threshold of safety," or a level at which exposure is safe to humans (Langston, 2011, p. 6). Although synthetic estrogens are less potent that natural estrogen, the two act additively, thus enhancing the amount of biological activity and altering subsequent chemical function in the body (Markey et al., 2002, p. 236). For this reason, long-term exposure to low-doses of DDT presents a pervasive, through invisible, threat to women's health. Ana Garcia (1998) notes that although women's participation in "field re-entry" activities, or those that occur after the spray of pesticides, exposed them to lower levels of pesticides, such jobs required many more hours in the field (p. 233). Women's low dose, yet long-term, DDT exposure, occurred through their involvement with agricultural activities such as weeding and harvesting. Again, the nature of female-specific labor in the Green Revolution, compounded with DDT's gendered chemical properties, culminated into circumstances that increased women's bodily accumulation of DDT. Once inside women's bodies, DDT's gendered nature assumes a new importance in determining reproductive outcomes. This process is largely owed to its interaction with estrogen.

The Biochemistry of Endocrine Disruption: DDT and hormonal chaos

Endocrine disrupting chemicals interfere with normal blood hormone levels to cause an imbalance between different bodily systems. The endocrine system is made up of a network of glands, organs, and tissues that secrete hormones into the bloodstream to control virtually every bodily process (Reeves & Rosas, 2003, p. 27). Just as the complex pathways of the feedback, receptor, and binding-protein system enable rapid adjustment of

estrogen levels in the body, they also allow synthetic chemicals to infiltrate in ubiquitous ways (Langston, 2011, p. 9). By introducing DDT into women's social and economic lives, Green Revolution's imposition in the complex "symphony of human development" involving cells, genes, organs, individuals, and environments, resulted in biological chaos.

When endocrine disrupting chemicals, such as DDT, enter the body, they are translocated into the bloodstream and move easily through cell membranes, just as endogenous estrogen. The molecular mechanism of endocrine disruption occurs when such chemicals enter the body and interfere with the delicate hormonal process. They mimic and antagonize normal, endogenous hormones, alter their pattern of synthesis and metabolism, and modify the hormone receptors (Markey et al., 2002, p. 236). Serum-binding proteins, those that determine the biologically activity of estrogens, may also mistake synthetic chemicals for endogenous hormones. When the proteins bind with DDT, rather than with natural estrogen, the biological activity of the estrogen in the body is increased, which causes excess in the blood stream and cell (Langston 2011: 9). The imitation of estrogen disrupts sensitive feedback loop that determines the levels and production of other key hormones. Nancy Langston (2011) explains:

> "When levels of the body's estrogens drop low below a certain amount, an organ called the hypothalamus secretes gonadotropin- releasing hormone (GnRH), which travels to an other organ in the body (the anterior pituitary gland), which then secretes yet another hormone called follicle-stimulating hormone (FSH), which makes its way back to the ovaries and stimulates more estrogen production (p. 8)."

When levels of other hormones, such as LH or FSH, drop, so too does the level of estrogen in the body. As a natural response to diminished estrogen levels, the hypothalamus is triggered to increase the production of GnRH, however the endocrine

disrupter prevents this signaling. Put simply, DDT confuses the negative feedback system that determines hormone levels in women's bodies. An imbalanced hormonal cycle threatens a woman's proper reproductive cycle and fetal development.

Further, estrogen is a crucial element in the development and maintenance of the female reproductive tract, menstrual cycle, pregnancy, and lactation in addition to the healthy development of a fetus (Markey et al., 2002, p. 236). Proteins in the bloodstream regulate estrogen levels by either permitting or inhibiting the estrogens from entering the cells (Langston, 2011, p. 8). Once estrogens bind to their receptors in women's tissues, they are biologically inactive and are unable to enter into the cells to continue their natural expression throughout the body. When estrogen levels drop, proteins release the estrogens to allow them to be biologically active again and enter the cells (Langston, 2011, p. 8). DDT disrupts this process and stunts cellular "communication."

Like DDT, estrogens are fat-soluble and their molecules enter the bloodstream until they encounter cells with specific receptor proteins that match their protein. Encoded by different genes, and found in different tissue groups, two types of receptors exist in women's breast, uterine, and ovarian tissues (Jacobs, 2003, p. 181). Women's reproductive tissues are the disproportionate targets of DDT's estrogenic activity. Bretveld et al. (2006) explain that natural, endogenous, hormones and receptors have a "precise fit" to ensure that the hormone can properly "convey their message" and produce normal functioning (p.6). When the specific shape of the estrogen receptor fits the specific shape of the estrogen protein, a change is triggered to form an entirely new molecule called a hormone-receptor complex (Langston, 2011, p. 7). Upon formation, the hormone-receptor complex enters into a cell's nucleus and binds to its DNA. The receptor then signals DNA

to initiate myriad gene expressions, tissue formations, and proteins (Langston, 2011; Bretveld et al., 2006). Without the cell-specific interaction of natural estrogen and its receptors, the reproductive process is altered. DDT causes hormonal chaos in women's bodies that obstructs the natural reproductive processes that lead to healthy births. Using biomarkers of DDT accumulation in women's bodies such as fatty tissue, blood, and umbilical cord serum, studies are beginning to expose the specific reproductive outcomes of DDT exposure. Two of the most common outcomes are spontaneous abortion and preterm delivery.

Spontaneous Abortion:

Spontaneous abortion (SAB), the most common adverse pregnancy outcome for women worldwide, mainly occurs in the first trimester of a pregnancy as a result of abnormalities in fetal cells (Korrick et al., 2001: 491). Hormonal factors, in addition to various occupational and chemical exposures are associated with abnormal fetal development (Korrick, et al. 2001; Venners, 2005; Saxena 1981; Petrelli, 2003). Women's exposure to DDT, both occupationally and environmentally, poses a significant risk for inadequate fetal development and pregnancy loss. By disrupting the fragile feedback loop responsible for proper hormone production, DDT decreases the production of ovarian progesterone and estrogen—two hormones that are critical in maintaining a healthy pregnancy (Petrelli, 2003: 77; Venners, 2005: 715). Multiple epidemiologic studies have observed a positive association between maternal occupational exposure to DDT and spontaneous abortion. Positive correlations between DDT exposure, bodily concentrations,

and spontaneous abortion affirm the bodily harm experienced by women in the Global South as a result of the Green Revolution.

Longnecker et al. (2005) analyzed blood samples of previously pregnant women in the US who were involved in a prospective study between 1959 and 1965. They consistently observed that the odds of fetal loss were higher for women with increased levels of serum DDE, a metabolite of DDT, than for those with lower levels of DDE (Longnecker et al., 2005, p. 130). An analysis of the biological mechanisms suggests that DDT inhibits the binding of progesterone to its receptor and may disrupt the sensitive sodium channel closure in the placental cell membrane (Longnecker et al., 2005, p. 113). This study concluded that DDE has an adverse effect on fetal loss. Venners et al. (2005) and Korrick et al. (2001) investigated the relationship between preconception serum DDT concentration and early pregnancy loss for women in China. Venners et al. (2005) noted a positive, dose-response association between preconception DDT exposure and the risk of subsequent pregnancy loss. They found a "linear trend" of increasing odds of early pregnancy losses with increasing serum total DDT concentration; the odds of spontaneous abortion were increased among those in the higher tertile of serum total DDT (Venners, 2005, p. 713). Similarly, Korrick et al. (2001) observed increased odds of spontaneous abortion for women with higher maternal serum DDT/DDE. Their results support their hypothesis that DDT and its metabolites are associated with spontaneous abortion-causing chromosomal abnormalities in occupationally exposed cohorts (Korrick et al., 2001, p. 494). DDT's alteration of hormonal processes is responsible for the abnormalities in cell development. Studies acknowledge the link between women's exposure to DDT and

increased odds of spontaneous abortion. The nature of women's intensified agricultural labor expanded their risk of direct contact with DDT that is linked to spontaneous abortion.

However, women who worked mainly in the home were also at risk of DDT-induced abortions by way of their husband's direct exposure. Two studies have noted the association of spousal DDT exposure and spontaneous abortion in India (Rupa et al., 1991) and Italy (Petrelli et al., 2003). "Para-occupational exposure" occurs when DDT is carried into the home on contaminated work clothing and exposes the worker's family members (Garcia, 2003, p. 234). Petrelli et al. (2003) found a significantly higher rate of spontaneous abortion among spouses of male agricultural workers exposed to DDT compared to women of spouses of the unexposed group. Of the 48 male workers, 11 reported DDT exposure and comprised 27.3% of the spousal incidence of spontaneous abortions (Petrelli et al, 2003, p. 79). The study is "in support of the hypothesis of an association between reproductive outcomes and occupational exposure to agrochemicals," such as DDT (Petrelli et al., 2003, p. 80).

Similarly, Rupa et al. (1991) found that the wives of Indian cotton field workers had significantly increased odds of spontaneous abortion and stillbirth. They also noted that the male field workers "mixed these pesticides with their bare hands and spayed using backpack sprayers without taking protective measures (Rupa et al., 1991, p. 124). Data on reproductive histories were collected from 1,016 couples in which the males were directly exposed to DDT and 1,020 couples who were not directly exposed. Their results revealed that 26% of exposed pregnancies resulted in spontaneous abortion, compared to 14% for unexposed couples (Rupa et al., 1991). These findings support that women's pregnancy outcomes were threatened, both by direct and indirect DDT exposure. During the Green

Revolution, women in the Global South bore the burden of pernicious pesticide use through the experience of pregnancy loss.

Preterm Delivery:

In addition to spontaneous abortion, DDT increases a woman's risk for preterm delivery. Preterm delivery is characterized as "birth at less than 37 weeks gestational age" (Windham et al., 2008, p. 111). Saxena et al. (1981) showed the relationship between DDT levels in maternal serums, such as blood, placenta, and umbilical cord fluids, and pregnancy outcomes. They conducted the study by comparing serum DDT/DDE levels in 25 pre-term labor cases in India compared with 25 full term delivery cases (Saxena et al., 1981, p. 6). The significant increases in the ratio between maternal blood DDE levels and negative birth outcomes following the trend: Spontaneous abortion > preterm > full term; the highest levels of DDT/DDE were associated with spontaneous abortion, followed by preterm delivery. (Saxena et al., 1981, p. 8). Although DDT acts with a low-dose effect when triggering endocrine disruption in the body, the degree of pregnancy disruption, such as full fetal loss compared with preterm delivery, follows typical dose-response model. Their results suggest that DDT/DDE's ability to disrupt the production of progesterone and estrogen may be involved in inducing the onset of early labor (Saxena, 1981, p. 6). Studies point to DDT's ability to induce specific enzymes that induce labor (Saxena 1981; Korrick et al 2001). The disruption of hormones is a result of DDT's estrogenic effect in women's bodies.

Other epidemiologic studies have agreed upon the positive associations between agricultural work and premature delivery. Longnecker et al. (2001) are credited for conducting a study with the largest population size exposed to DDT/DDE and observed a

dose-response relationship for preterm delivery. Measuring the DDE concentration in maternal serums stored during pregnancy, Longnecker et al (2001) found that the odds ratios for preterm birth increased steadily with increasing concentration of DDE (Longnecker et al, 2001, p. 112). They noted a substantial correlation between the mother's serum DDE level at delivery and the premature infant's cord serum. This correlation proves the harmful impacts of DDT's translocation from mother to fetus.

Saxena et al.'s (1981) finding of higher DDT concentrations in Indian mothers undergoing premature labor was found in a similar study of women in India experiencing low-birth- weight. Siddiqui et al. (2003) observed that women with low-birth-weight births had higher DDT concentrations in their blood, placenta, and umbilical cord compared to unexposed women with normal weight babies (p.75). They posit that DDT accumulating in the placenta may interact with hormone and nutrient transport systems thereby affecting the normal development of the child and pregnancy outcome (Siddiqui et al., 2003). Pathak et al. (2010) found that exposure to DDT may cause excessive oxidative stress during pregnancy by altering lipid and protein oxidation in the bloodstream and, therefore, result in preterm labor (Pathak, et al., 2010, p. 352). The various studies acknowledging the causal relationship between maternal DDT levels and reproductive outcomes, such spontaneous abortion and preterm delivery, provide important insights into the relationship between the Green Revolution and women's health.

Connecting Women's Health and History

Despite the myriad conjectures of biologic mechanisms, researchers have observed an association between maternal DDT serum levels and adverse pregnancy outcomes.

DDT's interference with action of key hormones that regulate growth, interaction with placental transport mechanism results in insufficient supply of nutrients to developing fetus to cause death or induce early labor (Korrick et al., 2001; Siddiqui et al., 2003). Though the studies may vary in size, scope, and location, their conclusions expose the positive correlations between women's DDT exposure, bodily accumulation, and outcomes, such as spontaneous abortion and preterm delivery. With a growing number of supportive studies, the scientific community is accepting the causal pathway between DDT and adverse women's health outcomes.

However, missing from each of these studies is the recognition of the history behind the pesticides or women's exposure to them. The majority of the studies highlight that the women were from locations of the agricultural or rural areas (Siddiqui et al., 2003; Saxena et al., 1981; Pathak et al., 2010), low socioeconomic status (Pathak et al., 2010; Rupa et al., 1991; Petrelli et al., 2003; Longnecker et al., 2005; Venners et al., 2005; Korrick et al., 2001), or were exposed to DDT through agricultural participation (Rupa et al., 1991; Petrelli et al., 2003). Yet, the studies make no mention of the social or economic processes through which women falling into the, above-mentioned, categories were exposed to DDT. Without the thorough historical analysis of the processes that situated women in spaces of exposure provided by previous chapters, the studies do not acknowledge the social and economic inequality embedded in women's DDT exposure. A hallmark of the Green Revolution, the production and release of DDT has, and continues, to diminish the reproductive health of women who live or work in agricultural settings around the world. The Green Revolution's relocation of women placed them involuntarily in pathogenic social spaces to meet the demands of modernization.

* * *

The highlighted studies provide a brief snapshot into the lives of DDT- exposed women around the world. Though they share common susceptibilities, their individual exposures are highly contingent upon their lived experience of specific social, economic, environmental contexts. Epidemiologic studies observe the surface level outcomes, yet are unable to delve into the intricacies of the women's larger social structures. In the following chapter, I provide a case study of Punjab, India to illustrate a specific experience of the Green Revolution. Although social, economic, and biological trends discussed throughout this work provide a commentary on the global impact the Green Revolution had on women, I wish to showcase a grounded example. To overlook the individuality of people, place, and politics would be to undermine the heart of a dialectical analysis how the Green Revolution impacted women's health.

CHAPTER 8- Case Study: Punjab, India

> "In a country like India, the concept of per capita income will not fully reveal the actual standard of living of the people owing to the gross unequal distribution of incomes" (Subramaniam, 1967, p. 283).

The specific experience of the Green Revolution is highly contingent upon its context, culture, and country. One of the Green Revolution's most prided success stories is the that of Punjab, India. In his Nobel Lecture, Borlaug (1970) prided the success of Punjab's Green Revolution in remediating the "divorce between intellect and labor… the bane of India's agriculture" through "agronomic research on wheat in India that is the best in the world" (1970). Although the story of the Green Revolution's technological transfer from Mexico to India embodies a similar plotline and cast of actors, the cultural landscape of Punjab sets a backdrop for new analyses and insights concerning the structural changes experienced by women in Punjab. A deep historical analysis of Punjab's rapid agrarian transformation exposes similar historical trends in economic cleaves; yet, it also creates the framework within which to recognize women's increased exposure to pernicious pesticides. Exploring the linkages between agrarian change in Punjab and women's reproductive health problems provides a grounded example of how socio-political implications of the Green Revolution accumulated into biological outcomes.

The Green Revolution in India

The transfer of American-style agricultural development is perhaps most notorious in India as scholars, such as Vandana Shiva (1991; 1993; 1994) have brought its story to the attention of the academic world. As in Mexico, scientific and political discourses were

intimately bound from the very start of the Green Revolution's implementation in India. In 1958, the Rockefeller Foundation joined together with the World Bank to organize the Indian Agricultural Research Institute (IARI), a program modeled after the, widely "successful," Mexican Agricultural Program (MAP) (Frankel, 1971, p.11). Meanwhile, India's economy was in the midst of its Third Five-Year Plan, a series of economic growth stimulating plans executed and monitored by the Planning Commission of India (Frankel, 1971, p. 5).[6] The Third Five-Year Plan, beginning in 1961, emphasized the centrality agricultural development in stimulating the country's economy (Dash, 2000, p.122). The desire to boost India's economy largely stemmed from concerns over its rapidly growing population. Again, the need for quantitative increases their food supply, rather than qualitative social interventions, was at the forefront of the governmental agenda.

The early 1960's were tumultuous for India's food economy. Under circumstances of conflict with Pakistan, which was one of India's main wheat suppliers, in addition to monsoon failures, India's imports and domestic production of food grains were severely stunted (Frankel, 1971, p. 3). Beginning his term in 1964, Chidambaram Subramaniam was one of the main actors on the Indian side of the Green Revolution exchange. As the Minister of Agriculture, Subramaniam set forth to reconstruct the Indian approach to agricultural development at a time when, he claimed "both nature and man seem to have conspired against a break-through in India's long history of poverty and stagnation" (Frankel, 1971; Subramaniam, 1967, p. 278). In this time of economic vulnerability and

[6] Prime Minister Jawaharal Nehru instated the First Five-Year Plan beginning in 1951 to 1956. The primary goal of the First Plan was to better the living conditions of the population through improved agricultural infrastructure and utilization of India's natural resources. Successfully, gross domestic product grew 3.6% every year between 1951-1956. The Second Plan (1956-1961) focused on the industrial and public sector as means of economic growth. This plan achieved 4% total growth (Dash, 2000, p. 114).

hindered agricultural production, Subramaniam fervently sought a solution to meet the needs of the growing populous nation. In his report, "Economic Development in India, 1961-1971," he stated that the "most pressing need of the hour for India is a massive break through on the agricultural front which can hedge both the current population explosion and spiral of rising prices" (Subramaniam, 1967p. 275). What he did not know, however, was that the answer to his call to "hedge" production problems would lead to a new host of problems, threatening the health of women in the population.

In 1961, the Third- Year Plan implemented the Intensive Agricultural District Program (IADP) to improve the production of wheat (Dash, 2000, p. 122). In 1963, Mankombu Sambasivan Swaminathan, the director of the Indian Agricultural Research Institute (IARI), wrote to Borlaug seeking his help in the development of a hybridized wheat crop to support the IARI's intensive agricultural research (Swaminathan, 2006, p. 2297). Swaminathan sought to conduct similar trials under the guidance of Borlaug who, upon his visit to India, provided the initial materials for pioneering an accelerated advance in wheat production. Upon sending 400kg of the Mexican semi-dwarf varieties to be tested in India, the Rockefeller Foundation approached Subramaniam for his support in rapidly introducing the new package as part of the Third- Year Plan (Shiva, 1991, p. 31). Subramaniam worked in conjunction with the new corps of Western-trained Indian scientists to devise a plan for implementing the new agricultural package into the economies of rural India. At the pinnacle of this plan, was the spread of DDT to combat the "local pests that ravaged the plants" (Borlaug, 1970). Subsequently, DDT would also be spread into the fields and homes of the women who cultivated the new yields. As described in previous chapters, this "external" reality was not on the modernizing mind of

the government or Rockefeller Foundation. DDT, along with the rest of the Green Revolution package, migrated rapidly throughout the country.

Subramaniam's New Strategy expanded the reach of the IADP to increase yields though the introduction of a Green Revolution in India. In 1965, the new policy was put into practice when 114 districts were selected as grounds for a "systematic effort to extend the application of science and technology," including the "adoption of better implements and more scientific methods" (India Planning Commission, 1964). Subramaniam etched the new miracle seeds, and necessary pesticides, into the foundation of his New Agricultural Strategy in 1965 (Subramaniam, 1967, p. 278). As was the case in Mexico, IADP shifted agriculture from an indigenous, ecologically based model, to one highly dependent on imported chemical-inputs and high-yielding varieties of wheat and rice. From the mid- 1960's onward, India imported high- yielding varieties of wheat from Mexico and rice from the Philippines (Farmer, 1981, p. 204). With the huge imports of "miracle seeds" came the emergence of DDT into the fields, hands, and bodies of women in India.

With the aid of the Rockefeller Foundation and Norman Borlaug, the face of Indian agriculture shifted remarkably to one of Western science, technology, and ideology. In his lecture, Borlaug (1970) spoke of the Green Revolution's success in India; "The result of a breakthrough in wheat production is neither a stroke of luck nor an accident of nature. Its success is based on sound research… which can serve as an elixir to cure all ills of a stagnant, traditional agriculture" (Borlaug, 1970). In each district appeared a new agricultural package mirroring that administered in Mexico a two decades prior—one that relied heavily on increased irrigation and the heavy application of chemical fertilizers and

pesticides. Costly pesticides were both the cause of women's relocation and the instrument of their impaired reproduction.

Punjab: The Bread Basket of India

Green Revolution scholar Francine Frankel (1971) claims; "No state is more closely identified with the gains of the Green Revolution than Punjab" (p. 12). Punjab is a Northwestern state in India considered to have brought about a real Green Revolution in rice and wheat production—it is one of the most celebrated agricultural successes. It has been acknowledged by economists to have "made more agricultural progress than any other region on the face of the earth for all time" (Singh, 1997, p. 71). As it is one of the most fertile regions of the world, known as the "bread basket of India," Punjab was selected as one of the five original IADP districts beginning in 1961 (Shiva, 1991, p. 19). The state was highly involved in agriculture; according to the 1970 Statistical Abstract of Punjab (1970), 76.9% of the population lived rural areas and more than half of the entire population was comprised of cultivators and agricultural laborers (p. 5). Frankel (1971) captures the plight of the depressed populations that made up 22% of the district of Ludhiana's population in 1961; "An overwhelming 87% of the population lived in rural areas, and constituted the major supply of village menials and agricultural laborers" (p.19). The modernization of agriculture that rapidly took over the lands of Punjab reflected a move away from local patterns of subsistence production to capital-intensive production that required the exploitation of technologies to increase yields. Again, pesticides were a central technology in the protection of the new, narrow genetic base of crops. Frankel (1971) characterizes the trend toward mechanization as "signaling the beginning of a

transformation of agriculture from an impoverished 'way of life' to a profitable business occupation" (Frankel, 1971, p. 13). The values of farming shifted from those of survival to those of profit. On an individual level, the new mode of agriculture meant a new identity for local famers; Stephen Marglin (2013) asserts "Without the institutions that gave meaning to community, farming gradually became less a way of life than a way to make a living; the farmer because the agribusinessman" (p. 9). Within this new business, pesticides supported the growth of seeds and profits while stunting the reproductive capacities of women exposed to them through rapidly industrializing agriculture.

Rapid Mechanization and DDT use in Punjab

Of the most significant characteristics of the Green Revolution model is its destruction of diversity in favor of monoculture. Shiva (1991) explains that "uniformity became imperative both from the view of centralized production of seeds as well as centralized provisioning of irrigation and chemical inputs" (p. 86). Genetically narrowed wheat and rice varieties, initially imported from Mexico and Philippines respectively, seized control of the soils that had once birthed multiple varieties of indigenous millets, oilseeds, and cereals in Punjab (Shiva, 1991, p. 82). The new monoculture boasted significant gains that promoted Punjab as the most "dramatic and sustained shift in agricultural productivity" (Singh, 1997, p. 71). From the onset of Punjab's Green Revolution in 1961-1962 to 1971-1972, the production of wheat increased from 1,765,000 tons to 5,600,000 tons (Randhawa, 1977, p. 655). Rice, a crop relatively insignificant in Punjab before 1965, underwent a production boom as a result of imported varieties as well. The once 5.5% of cropped area used for rice cultivation in 1966-67 expanded to nearly 24% by 1985 (Farmer, 1981, p. 204). Between the initial years, of 1965-66 and 1968-69,

the "acreage under the new Mexican dwarf varieties expanded from a miniscule 170 acres to an overwhelming 420,000 acres, or an area accounting for 90 percent of the total acreage under wheat production" (Frankel, 1971, p. 12). Table 1, taken from Pritam Singh's (1997) *Political Economy of the Punjab: An Insider's Account,* illustrates the increases in wheat yields, area, and production between 1959- 1994. Of note is the drastic expansion of wheat between the years of 1965 and 1971.

Table 1: "Area, Production, and Yield of Wheat in Punjab"

YEAR	AREA ('000 HECTARE)	PRODUCTION ('000 TONS)	YIELD PER HECTAR (KG)
1965-66	1,550	1,916	1,236
1970-71	2,299	5,145	2,238
1975-1976	2,439	5,788	2.373
1980-81	2,812	7,677	2,730
1990-91	3,273	10,988	3,51

(Source: Singh, 1997, p. 73)

At the heart of the substantial quantitative increases, was an abundance of pesticides. The soaring heights of wheat production during the Green Revolution infers a similar trend in pesticide use. Much of the World Bank's 2.8 billion dollar foreign exchange credit went to the purchase of pesticides (Shiva, 1991, p. 31). As insects that were considered insignificant in Punjab before the Green Revolution grew to be major threats to monoculture, pest management techniques relied on poisonous pesticides, such as DDT. An important component of Punjab's modernization is that it occurred almost entirely in the private sector; Billings and Singh (1969) explain that the "autonomous nature of mechanization indicates that policy makers found themselves unable to determine whether, or under what conditions pesticide use occurred" (1969: 223). Pesticide use was therefore poorly regulated and training was not required through policy. The lack of attention to training and regulation was a burden that fell largely upon poor rural women.

Again, the neglect of women's safety needs culminated into the health outcomes I will expound upon in a later analysis.

Pesticides were a central technology in Indian agriculture as they were necessary to limit the high levels of pest threat to monocropped wheat and rice. The Planning Commission recommended the "liberal use" of DDT as a necessary input for increasing agricultural production (Zwerdling, 2009). As previously discussed, DDT's low cost and versatility against multiple pests made it one of the most commonly used pesticides during the Green Revolution (Kinkela, 2011). In all budgets passed under the Third Five- Year Plan, the Indian parliament was in full support of DDT use for increasing economic productivity (Dharmaraj & Jayaprakash, 2003, p. 93). DDT was the hallmark of the Green Revolution; its use spread rapidly throughout India contaminating the environments, homes, and bodies of women without any afterthought.

India's initial use of DDT began in 1948, though its manufacture and distribution for Green Revolution agriculture did not begin until 1952 (Abhilash & Singh, 2009, p. 2). In the following years, given India's heavy reliance on DDT for agriculture and malaria control, the Indian pesticide production industry grew rapidly. By 1958, India was producing over 5000 metric tons of pesticides; organochlorines such as DDT and HCH accounted for more than three-quarters of total pesticide production in India (Gupta, 2004, p. 84). However, the U.S.'s concerns regarding the danger of DDT to the environment and wildlife population echoed in India, spurring the government to control its use. The Indian Government passed the 1968 Insecticide Act, "An Act to regulate the import, manufacture, sale, transport, distribution and use of insecticides with a view to prevent risk to human beings or animals, and for matters connected therewith" (Insecticides Act, 1968). DDT was

one of the listed pesticides. However, the insufficient implementation and regulation of the Act did not ensure the end of DDT's use, especially in rural areas (Abhilash & Singh, 2009, p. 5). Despite the bans, the private agricultural use of DDT continued, only to prolong the persistent threat of residues in women's workplaces and homes. The cost of DDT's overwhelming use on women's bodies has emerged as a price to pay decades after the Green Revolution.

Female Labor Demands and DDT Exposure

Despite Punjab's substantial gains, the Green Revolution engendered a slew of social consequences, many of which significantly impacted rural women's agricultural participation. Mirroring the trends discussed in Chapter 5, the Green Revolution's process of agricultural development in India drew increasing numbers of rural women into agricultural wage labor. The particular burden on female household members, especially among the poor, reflected their attempt to ensure the survival of their families—those victimized by the Green Revolutions unequal land and technological distribution (Ahmad et al., 1985, p. 11). Far from being a homogenous category, rural women's lives in Punjab exhibit great economic distinctions due to the varying climates, soils, and size of landholdings between different districts (Billings & Singh 1970: 171). However, disaggregating labor by specific farm operation and household work exposes trends of increased female labor in response to economic shifts of the Green Revolution. Women's increased formal and informal workloads indicate that women were more susceptible to DDT exposure through occupational and environmental pathways molded to fit the needs of the Green Revolution.

Women's agrarian labor: the occupational exposure of women in Punjab

As for many poor, rural women in the Global South intensified agricultural mechanization and cultivation resulted in increased wage labor demands for rural women in Punjab. The increased labor demands of Mexican wheat varieties, compounded by their large-scale introduction with the expansion of IAAP in the late 1960's, resulted in a significant need for casual, hired labor on large-scale farms. Increased farm labor resulted from the fact that Mexican wheat required more inputs, such as pesticides, and operations than local wheat (Sharma, 1974, p. 419). Further, the new level of affluence of large-scale farmers accelerated the pace of production, thus requiring more labor time. Interestingly, the introduction of high yielding varieties raised the demand for female wage labor relatively more for that of men overall (Ahmad et al., 1985, p. 9). This increase is largely indicative of the specific field operations that were left to manual labor within mechanized agriculture.

The female labor force was of vital importance in Indian agriculture; "more than half of the work in or related to agriculture was done my women, either as cultivators of their family land or as laborers" (Dharmaraj & Jayaprakash, 2003, p. 92). Women's participation in Punjab was equally as prominent. In 1961, female workers constituted 18.8% of total workers in Punjab; 80% of those workers were involved in agriculture (Billings & Singh, 1970, p. 169). Women participated in specific operations; the sexual division of agricultural labor maintained that certain jobs were "naturally" more suitable for women to perform (Boserup, 1986). Table 2, taken from Martin Billings and Arjan Singh's (1970) "Mechanization and the Wheat Revolution: Effects on Female Labor in Punjab," shows the wide range of farm operations that relied on women's participation.

Table 2: "Task Operations and Participation of Women Workers in the Different Regions of Punjab"

TASK OPERATION	PARTICIPATION OF WOMEN IN:			REMARKS
	Mountain-ous areas	S-West Districts	Central Districts	
Ploughing	No	No	No	In some parts of hills, women take part in ploughing
Planking and leveling	Yes	Yes	No	Women help in leveling where they participate
Farm yard manure application	Yes	Yes	No	Women help in loading, unloading and spreading of farm yard manure
Bundling and making water courses	Yes	Yes	No	
Irrigation	Yes	Yes	No	Women largely help in application of water in the fields
Planting and sowing	Yes	Yes	Yes	Transplanting rice mainly done by women in hilly areas and in the plains women help in preparing and sowing seed
Fertilizer application	Yes	Yes	Yes	
Hoeing and weeding	Yes	Yes	Yes	
Harvesting	Yes	Yes	Yes	Women help in harvesting wheat in the central districts and take active part in cotton picking,
Threshing	Yes	Yes	Yes	
Winnowing	Yes	Yes	Yes	
Transportation	Yes	Yes	No	Women in south-west districts help in loading and unloading only

(Source: Billings & Singh, 1970, p. 171)

Despite the increased mechanization of production on larger farms, specific operations continued to rely upon manual labor, the majority of which were traditionally female tasks. Women were primarily responsible for the most contaminated tasks. Table 3, taken from RK Sharma's (1974) "Green Revolution & Farm Employment: An Analysis of

Experience in the Punjab," shows the acceleration in labor input for wheat cultivation. Of note are the substantial amounts of labor days required for harvesting.

Table 3. Change in labor input per hectare of wheat (labor days per hectare)

OPERATIONS	1967-68	1968-69	1969-70	CHANGES 1967-69	% CHANGE
Sowing	3.25	2.73	2.93	-.32	(-10)
Preparatory fillage	14.41	12.15	10.17	-4.24	(-29)
Manuring	.84	1.05	1.38	.54	(64)
Interculture	3.55	5.93	7.87	4.32	(121)
Irrigation	7.40	12.28	12.12	4.72	(63)
Harvesting	12.73	13.04	15.07	2.34	(18)
Threshing & Winnowing	8.55	12.98	15.52	6.97	(81)
Others	1.33	2.04	2.57	1.24	(93)
Total	52.07	62.20	67.63	15.56	(30)
Source: Farm Management Survey of Ferozepur 1967-68, 1968-69, and 1969-70					

(Source: Sharma, 1974, p. 421)

The relationship between the increased need for agricultural labor and women's specific roles in agricultural production exposes why women were specifically vulnerable to pesticide exposure and the following health detriments. In Punjab, the Green Revolution instigated widespread labor demands on larger farms for tasks such as harvesting, weeding and transplanting (Sharma, 1974; Billings & Singh, 1970; Billings, 1969; Argarwal, 1984). Across various operations, the proportion of female labor in India is traditionally highest in weeding, transplanting and harvesting (Buvinic & Mehra, 1990, p. 1). It was women's tasks that were the most needed on newly mechanized farms. Women working on farms as hired laborers spent most of their time in tedious and laborious activities such as transplanting, weeding, harvesting, and processing (Billings & Singh, 1970). As mentioned in Chapter 6, such tasks were performed after the direct spray of pesticides and relied on manual labor. Therefore, women's new labor demands put them in increased contact with DDT as they cultivated the pesticide-covered crops by hand. The relationship between the

Green Revolution's labor demands and the local sexual division of farm labor created new risks for women's health by increasing women's chances of DDT exposure.

The demand for female farm labor for tasks, such as harvesting and handling was increased drastically with the onset of the Green Revolution. Therefore, a woman's chance of being exposed to the residues of pesticides upon re-entry into the field drastically increased. Billing and Singh (1969) observe that high- yield varieties, in conjunction with required chemical inputs, increased the average labor demand per acre from "51 man-days to 60 man days," and even more during harvesting months (p. 224). It was during the harvesting months that women's participation was at its peak. The Green Revolution's introduction of pesticides increased both labor demands on large farms to meet the production needs of landowners, and also pressure on poor rural women to enter the agricultural labor force to support their displaced families. Together, the two forces placed women at increased risk of pesticide contamination as they participated in activities that directly related to physical contact with pesticide residues. Poor rural women suffered disproportionally from social divisions of agrarian change (Ahmad et al., 1985). Coeval with an increase in DDT use, rural women's workloads shifted in both in the home and in crop production due to new economic needs. High rates of female illiteracy elevated their risk of exposure and contamination by pernicious DDT.

Female Literacy and Pesticide Exposure

Within the diverse districts of Punjab, female labor fluctuated greatly due to community varying values concerning women's participation in the agricultural sector. In the largely Sikh region of Ludhiana, for example, religious values and traditions did not support women's engagement in farm work (Frankel, 1971, p. 35). Inter-regional

socioeconomic factors also played a role in mediating women's participation in agricultural participation. Factors such as literacy, farm income, and the proportion of male to female workers were correlated to women's participation and roles (Billings & Singh, 1970, p. 170). The relationship between females' farm participation, literacy, and district development status indicate that women's participation was largely based on social class.

Table 4, taken from Martin Billings and Arjan Singh's (1970) "Mechanization and the Wheat Revolution: Effects on Female Labor in Punjab," shows regional trends in women's farm participation.

"Table 4: Participation Rate of Women Workers in Agriculture, Gross Value Product Per Agricultural Worker, Literacy Among Women, and Proportion of Workers Engaged in Agriculture in Punjab by Districts, 1961"

DISTRICT	PROPORTION OF FEMALES WORKERS TO TOTAL AGRICULTURAL WORKERS (PER CENT)	GROSS VALUE PRODUCT PER AGRICULTURAL WORKER (IN '000 RUPEES)	LITERACY AMONG WOMEN (PER CENT)	WORKERS ENGAGED IN AGRICULTURE (PER CENT)
Kangra	51.0	.77	11.3	84.1
Rohtak	41.8	1.10	8.9	71.7
Mohindergarh	38.3	0.52	4.5	81.2
Gurgaon	36.6	0.65	8.4	70.71
Hissar	34.1	1.10	7.4	79.9
Hoshiarpur	19.1	0.80	17.1	61.3
Sangrur	17.4	1.24	8.2	72.9
Karnal	17.1	1.39	9.6	68.1
Ferozepur	14.6	1.26	13.3	67.3
Bhatinda	12.3	1.42	9.5	70.0
Ambala	10.1	0.96	19.5	47.4
Ludhiana	3.8	2.32	27.4	44.7
Jullundur	3.8	1.63	23.8	43.1
Kapurthala	2.4	1.33	20.1	55.7
Gurdaspur	2.2	1.17	15.6	49.3
Patiala	1.8	1.19	15.9	58.6
Amritsar	1.7	1.43	21.4	47.2

(Source: Billings & Singh, 1970, p. 170)

Analyzing the information exposes a clear negative correlation exists between women's literacy level and agricultural participation, indicating that educated women, who

were generally of higher classes, did not partake in field work (Billings & Singh, 1970, p. 171). It can be inferred that the majority of the female agrarian labor force was comprised of illiterate women. As previously mentioned, a leading factor in rural women's pesticide exposure is the lack of training and technological literacy.

Table 5, taken from the 1961 Punjab District Census Handbook (1966), indicates the rates of female literacy in 1961. The vast discrepancy between male and female literacy rates is especially jarring in rural areas. Similarly, it was in the rural areas of Punjab that the Green Revolution took hold.

Table 5: "Literates per Thousand Population Above the Age of Five Years, 1961"

	HISSAR DISTRICT						PUNJAB					
	Total		Rural		Urban		Total		Rural		Urban	
	M	F	M	F	M	F	M	F	M	F	M	F
Total	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Illiterate	687	909	743	952	395	680	611	831	681	896	346	569
Literate	313	91	257	48	605	320	389	169	319	104	654	431
Literate w/o Education	148	50	134	31	222	153	167	85	155	63	211	175
Primary or Junior Basic	130	36	105	16	261	141	166	70	137	38	276	200
Matriculation	35	5	18	1	122	26	56	14	27	3	167	56

(Source: Anand, 1966, p. 30)

According to the Census data, only 17.4% of females were literate as compared to nearly 40% of males (Anand, 1966, p. 30). Although this data precedes the full expansion of the Green Revolution in Punjab, it exposes clear literacy trends between men and women as well as between urban and rural women. As shown in Table 4, rural areas such as Kangra and Rohtak had the highest rates of female agriculture; Billings & Singh (1970) characterize these areas as low on the index of economic development (p. 170). Given the decreased rates of literacy among rural women, and the negative association between women's literacy and farm work, I argue that illiterate rural women comprised the large

majority of poor landless laborers during the Green Revolution. In addition to governing women's farm participation, illiteracy also mediated exposure risks once in the agricultural labor force.

Female illiteracy is one of the root causes of pesticide contamination. Illiterate women, left untrained, were unable to read the directions and warning labels on pesticide containers. I understand individual's ability to understand the relationship between technology and health risks as "technological literacy." Women's technological illiteracy rendered women unable to recognize that the "red triangle marked on the label indicated the high toxicity of the chemical used" (Dharmaraj & Jayaprakash, 2003, p. 94). Therefore, educational level can be used to explain differences in knowledge of potential toxicity of DDT. The National Public Radio program, "In Punjab, Crowding Onto the Cancer Train," (2009) reported that the high rate of farmer illiteracy is one of the largest risks facing farmers in Punjab. The report claimed, "Government leaders pushed [the Green Revolution in India] before they had any safeguards to protect the population. For instance, the chemical industry says '[w]e put pesticide warnings on the pesticide bottles. If the farmers ignore them, it's their own fault.' But many farmers in India can't read" (Zwerdling, 2009). As highlighted in Table 4, it is largely women who make up the illiterate rural population of farmers.

Illiteracy leads farmers to overuse the pesticides or to handle the toxic chemicals incorrectly, without protective clothing. One Punjabi farmer reported; "When spaying pesticides, we get totally covered by the chemicals; on our hair, body, and in our eyes" (Zwerdling, 2009). Women's higher levels of illiteracy place them at heightened risk of ignorance about the use and threats of DDT use. In addition, the rationalization for

excluding women from what small educational efforts existed in India was their low education level. Therefore, a woman's illiteracy served as both the cause and justification of their DDT exposure through misuse. Such structural attitudes were perpetuated by the hierarchical structure of the Green Revolution that removed itself from local social relations—unless they stood in the way of progress. Borrowing from Paul Farmer's notion of biosocial disease, DDT- induced reproductive health problems in Punjab are symptomatic of the Green Revolution's blind faith in pesticides and neglect of gender concerns in training efforts. The role of illiteracy in facilitating women's increased DDT exposure was exacerbated by the structural violence and ignorance of the Green Revolution.

Epidemiological Studies of Women's Reproductive Health Outcomes

A small group of epidemiological studies have focused specifically on women's exposure to DDT and subsequent negative health outcomes in Punjab. Many of the studies indicate that DDT concentrations in the Indian population are among the highest in the world (Abhilash & Singh, 2009**;** Gupta, 2004**;** Buvinic & Mehra, 2001; Aulakh et al., 2007; Kalra & Chawla, 1980; Kalra et al., 1994). Aulakh et al. (2007) measured the occurrence of DDT residues in samples of human adipose tissues from women in Punjab. They acknowledged the indiscriminate use of DDT for agriculture throughout India in the 20th century as leading to the contamination of the environment and accumulation of residues in the fatty tissues of human populations (Aulakh et al., 2007, p. 330). The study collected 55 samples of women's tissues from the Punjabi district of Ludhiana and tested them for traces of DDT residues. DDT residues were found in all 55 samples, including a 7-month year old female child (Aulakh et al., 2007, p. 332). Aulakh et al. (2007) contend

that high levels of pesticide residues at such as young age are due to the exposure to DDT both in utero and through breastfeeding (p. 331). They also found higher levels of DDT in older women with, thus indicating that the bodily burden of DDT increases with age due to DDT's bioaccumulability. It is also possible that older women were exposed to more DDT if they experienced the Green Revolution's shifts first hand. The findings show that despite bans and restrictions of DDT, its residues remain in the environment and continue to accumulate in women's bodily systems, breasts, and babies. The study also affirms the positive correlation between the agricultural use of DDT and increased DDT accumulation in women's bodies.

Two studies examined DDT concentrations in samples of Punjabi women's breast milk. R.L. Kalra and R.P. Chawla (1980) conducted the first report on DDT residues in human milk in 1980. They collected milk samples from 75 lactating women living in Punjab to test for pesticide residues. They found that DDT and its metabolites, DDE and DDD, were present in each of the 75 samples. They wrote, "The mean level of DDT from the samples was more than the level reported from the USA, Canada, Europe, and Australia" (Kalra & Chawla, 1980, p. 405). They also concluded that if an infant were to ingest the milk samples through breastfeeding, they would take in 18 times the acceptable daily intake of DDT (.005mg/kg/day) (Kalra & Chawla, 1980, p. 405). This primary study illustrates the high levels of DDT accumulation in women's bodies as a result of its excessive use in prior decades. Similarly, a study conducted by Kalra et al. in 1994, compared human milk samples from women living in highly agricultural areas to those from non-agricultural areas in Punjab. The study collected samples from 82 lactating women living in, Faridkot, a cotton-growing area and 47 from women living in, Ludhiana,

an area where cotton is sparsely grown.[7] Again, all of the samples showed residues of DDT and its metabolites; at least 73% of the samples exceeded the tolerance limit (Kalra et al. 1994: 147). The samples from the cotton growing area showed significantly higher concentrations of DDT than those from the other, nonagricultural, district. Kalra et al. (1994) concluded, "[t]he differences in the residue levels of pesticides in the two areas might be related to the fact that Faridkot district is an extensive agrarian community, therefore provided more exposure for its residents to pesticides than the urban community in Ludhiana" (p. 148). In addition, the mean level of DDT residues in the samples was higher than the level reported from most other countries in the world.

Both studies highlight the persistent risk posed not only to women, but also to breast-feeding infants. Furthermore, the higher concentrations of DDT in women's milk samples from agricultural areas indicates a relationship between the Green Revolution's introduction of DDT into Punjab's agriculture and the long legacy women of women's bodily contamination. Though the latter study did not comment on the women's direct participation in cotton cultivation, the fact that their DDT levels were significantly higher than those from the non-agrarian community reinforces the ubiquitous threat of DDT on women's bodies throughout the entire agrarian community—in their homes, fields, and foods. Although the available studies did not address the impacts of their observed high levels of DDT in women's bodies in Punjab, the previously acknowledged mechanisms of biological harm, such as endocrine disruption, allow the conjecture to be made that results

[7] Cotton, while only grown on 5% of the cultivated areas in India, consumes 45% of total pesticides used in the country (Abhilash & Singh, 2009, p. 4).

such as spontaneous abortion or preterm delivery were likely to have occurred in rural agricultural areas.

A deep historical analysis of the Green Revolution's implementation in India, and more specifically, Punjab exposes the political motivations, economic concerns, and social inequities that supported the myriad shifts in agricultural technique and ideology. Central to in the fundamental restructuring of Punjabi agriculture was the substantial use of DDT. Although Punjab is prided as the Green Revolution's most notorious success in the quantitative eye of Western economists, the drastic qualitative implications of the new technologies are evident through the careful extrapolation of local social and economic ramifications for labor demands and women's social participation. Mirroring general trends of women's experiences in agrarian change, labor demands moved women into spaces of increased pesticide risk due to the nature of their socialized roles in the home and field. Through this lens, a complex web of forces emerges illustrating the mechanisms through which the Green Revolution situated women under a cloud of DDT residues that lingered over homes and fields of in Punjab.

Conclusion

In Mexico and Punjab alike, the impact of pesticides on the reproductive health of rural agrarian women reflects the convergence of historical, social, and biological forces. The questions of how the Green Revolution increased the exposure of women in the Global South to DDT and how that exposure culminated into adverse reproductive health outcomes, can only be answered through a deeply analytical lens to draw together the multidimensional impacts of the Green Revolution. Throughout my research, the bodies of historical, economic, and biological literature that I had, at first, perceived to be to distinct categories of analysis, began to blend together in ways I had not considered. The commingling of literature and analysis concerning the impacts of the Green Revolution culminated into a profound illustration of how women's health outcomes are intimately bound to the complex realities of social and economic relations. The Green Revolution's alteration of such relations in throughout the Global South through technological change is the underlying force driving women's adverse reproductive outcomes, such as toxic breast milk, spontaneous abortion, or preterm delivery. Just as the use of pesticides in the Green Revolution supplanted the organic fertility of the earth, their use undermined the fertility of women in the Global South.

By weaving together history, impacts on women's roles in production, and health outcomes, I propose that pesticides represent the Green Revolution's value of production and growth regardless of its dispossession of farmers and destruction of life-sustaining cycles. Uniting the diverse discourses of power, change, and health embedded in the relationship of the Green Revolution and women's health, are theoretical considerations of dialectics, structural violence, and ecofeminism. As my research progressed, I relied on

each theory to bridge the ideological gaps in analysis between the history of the Green Revolution's use of pesticides, the relocation of women into new social spaces, DDT's gendered chemical properties, and the biological mechanisms that produce adverse reproductive outcomes. Crafting a cohesive body of analysis, from the broad frame of history down to the narrow frame of a woman's individual experience of health, exposed the vast social and biological pathogens that situated women's bodies in the center of the Green Revolution's profoundly unequal system that valued quantitative gains over qualitative realities.

Medical Ecofeminism: Contributing a New Frame of Analysis

I conclude with a contribution of "medical ecofeminism" as a new lens through which to understand the relationship between women's health, power, and the environment. Through this framework, the values and teachings of dialectics, structural violence, and ecofeminism coalesce and expand. While maintaining ideological ties to the roots of ecofeminism, those valuing the ways in which women are caught in the process of environmental domination, medical ecofeminism emphasizes the importance considering how women's health is a crucial outcome of that relationship. Within this new framework, women's health outcomes are an index through which to recognize environmental injustice and social inequality. Borrowing from structural violence, medical ecofeminism enables a nuanced understanding of how unequal structures manifest in disease. However, adds to the considerations of structural violence by emphasizing the environmental basis of development. In my understanding of "environment," I consider the vast social, economic, and political elements of an environment to be equally as important as the physical

elements. For this expanded understanding, I credit a dialectical view of the environment as an interconnected web of social, ecological, and political forces and relations.

Medical ecofeminism values the measured physical outcomes of highly uni-directional power relationships for providing a social commentary, as much as they do biological evidence. I, therefore, conclude that my analysis of women's health experiences born through the agrarian change of the Green Revolution captures the quintessence of medical ecofeminism. Medical ecofeminism draws from the power-related considerations at the cores of dialectics, structural violence, and ecofeminism, to promote a framework that embraces the interdisciplinary web of women, health, and the environment. Had the Green Revolution not introduced the toxic technology of DDT into once- ecologically based farming practices, had its forces not destroyed the social and economic structures that once supported subsistence agriculture; women's bodies would be free of the devastating impacts of DDT on their reproductive capabilities. In my eyes, the health threats of the pervasive technological and social restructuring are physical representations of the true violence of the Green Revolution.

I conclude with a quote from Dr. Paul Farmer that I believe captures the essence of my intensive personal and scholarly journey of connecting the global and local, the technological and social, and the productive to the reproductive; "What these victims, past and present, share are not personal or psychological attributes-they do not share culture, language, or race. Rather, what they share is the experience of occupying the bottom rung of the social ladder in inegalitarian societies" (Farmer, 2005, p. 263).

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