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Vulnerability of women to climate change in arid and semi-arid regions: The case of India and South Asia

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ABSTRACT

This article is a collation and synthesis of the literature review with the focus on the vulnerability of rural women in developing countries to climate change on the one hand and being pro-active in adapting to climate change on the other. The geographic coverage of the literature is global but with specific examples from India. The information presented in this paper is derived from diverse sources including journal articles and thematic books, and indicates severe adverse impacts not only on women's livelihood opportunities but also on exacerbating the workload and fatigue while decreasing their self esteem and forcing them to undertake some high risks and hazardous activities. The literature indicates that poverty, gender inequality, insecure land rights, heavy reliance on agriculture, less access to education and information are among the principal reasons for their vulnerability to climate change. The vulnerability is also confounded by the meager asset base, social marginalization, lack of mobility and exclusion from the decision-making processes in response to a disaster. However, the literature also shows that women are not only the passive victims of climate change but are also pro-active and agents of hope for adaptation to and mitigation of abrupt climate change. They utilize their experience and expertise to reduce the adverse impacts by adopting prudent strategies. They are also concerned about environmental issues, and are highly supportive of policies regarding environmental restoration. Large knowledge gaps exist regarding the vulnerability of women to changing and uncertain climate especially in arid regions. Authors of this article suggest some action plans and strategies to minimize vulnerability to climate change such as empowering women economically and educationally, organizing training and outreach programmes, and involving them in formal climate change mitigation and adaptation policies and programmes. Authors also outline research needed in order to identify and implement strategies regarding climate change. Collective and continuous efforts are critical to finding the sustainable solutions for this global phenomenon which is adversely impacting the most vulnerable but critically important members of the society.

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1. Introduction

Climate change is defined as 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods' (UNFCCC, 2011). It refers to the long-term changes in the components of climate such as temperature, precipitation, evapotranspiration along with intensity and frequency of extreme events such as

drought and floods. Being a significant anthropogenic environmental challenge, it is a common topic of discussion, study and research. Though climate change has occurred throughout Earth's history, the recent rate of warming far exceeds that of any previous episode in the past 10,000 years and perhaps far longer (Blois et al., 2013). The years 2014–2016 were the warmest since the records were first documented in 1890. The recent anthropogenic emissions of greenhouse gases (GHGs) such as CO₂, CH₄ and N₂O are the highest in magnitude since approximately 800,000 B.C. (IPCC, 2014). Increased energy consumption driven by an affluent life style is believed by many to be primarily responsible for global climate change. Other contributing activities include cement manufacture, deforestation, expansion and intensification of

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agriculture and numerous human developmental activities.

Global climate change has observable effects on the environment and its components. The atmosphere and oceans have warmed, glaciers have shrunk, and the sea level has risen (IPCC, 2014). Deserts are becoming hotter and drier, extreme and violent weather events are becoming more frequent and agricultural land is becoming less productive (Elsner et al., 2008; Christiano, 2014; Gentle et al., 2014). Since the 1950s, many of the observed climatic changes are unprecedented and have severe negative impacts on all ecosystems, economies and enterprises (Dankelman et al., 2008; IPCC, 2014). Some of the most vulnerable sectors include agriculture, forestry and energy (European Commission, 2009). Climate change also distorts natural habitats and is likely to become the dominant driver for the loss of biodiversity and other natural resources by the end of this century (WRI, 2005). Agricultural production, fuelwood supply and water security is threatened by adverse impacts of climate change (Piao et al., 2010; Wheeler and von Braun, 2013). Climate change is also regarded as 'the biggest global health threat of the 21st century' (Costello et al., 2009).

According to the literature, the adverse effects of climate change cannot be compartmentalized within the boundaries of a region, religion, caste, creed and gender. However, different stakeholders in different regions perceive the impacts of climate change differently. Furthermore, the extent of vulnerability depends on different rights, roles and responsibilities. Indeed, climate change is not a gender-neutral phenomenon. Women of the underprivileged and labour class living in arid regions, such as in India and elsewhere in South Asia, tend to be more affected by the adverse impacts of climate change than men because of more poverty, less education and training, less access to institutional support and information, and less participation in decision making bodies (Goh, 2012). Further, diverse behavioral, customary, attitudinal, economic and many other socio-cultural prohibitions make their lives more miserable during and after the climate change induced disasters (Nellemann et al., 2011; Yavinsky, 2012).

Literature shows that women are not only first observers but also among the first victims of adverse impacts of the climate change by virtue of their roles in looking after the family and responsibilities of collecting fodder, fuel wood and water (Nellemann et al., 2011; Nwoke and Ibe, 2014). They are the first to observe the decreased productivity of farmland as crop yields decline, soils degrade, and water reservoirs deplete, contaminate or pollute. When the rural area is unsustainable, it is the women whose lives are the most disrupted because of the scarcity of fuel wood, water and fodder. None-the-less, women are also the effective agents of change as they often cope and adapt to climate change differently than men by using their particular knowledge and livelihood strategies (Israel and Sachs, 2013). Alas, the tough life of women in arid and semi-arid countries is getting tougher and more torturous with every increment of anthropogenic climate change, with gender being a critical factor in women's vulnerability. Thus, it is necessary to have a gendered focus to the global understanding of climate change.

The objective of this article is to deliberate the differential impacts of climate change on women living in arid regions, explain various causes of their vulnerability, and outline possible ways to reduce their vulnerability. The literature is specifically focused on girls (10–15 year) and young mothers in the rural communities of South Asia and other developing countries in general but of India in particular. The rationale for focus on India is because it represents a region with a large population density and a complex social structure where women are underprivileged and resource-poor. India, with 17.6% of the world population (1.34 out of 7.6 billion, U.N., 2017) has 2.4% of world's land area and 4% of the fresh water

resources. The water crisis will be exacerbated by the climate change and women of the rural India will be worst hit (Lal, 2016). India also provides an example where several initiatives have been undertaken to adapt to climate change. Thus, this article is also aimed at learning from past initiatives, identifying knowledge gaps, and describing the issues of climate change in the context of women's vulnerability under harsh conditions of India and South Asia. It also deliberates the contribution of women towards climate change adaptation and mitigation.

2. Methodology

This article is based on literature review of peer-reviewed and generic literature. The information was taken from different sources such as a worldwide accepted scientific database (Scopus (<http://www.scopus.com>), Pubmed (<http://www.ncbi.nlm.nih.gov/pubmed>), Science Direct (<http://www.sciencedirect.com>), Springerlink (<http://www.springer.co.in>), Google Scholar (<http://www.scholar.google.co.in>) and Wiley (<http://www.onlinelibrary.wiley.com>)), theses, acknowledged books, abstracts, conference proceedings and non-impact and non-indexed journals. The advance search option was adopted for the literature survey from web sources with keywords viz. 'climate change', 'women vulnerability' and 'arid environments'. Specific emphasis was placed on studies conducted in developing countries in drylands in the 21st century. The retrieved information is presented in form figures viz. confounding effects of climate change on women (Fig. 1), women's role in climate change adaptation and mitigation (Fig. 5). Social, economic and cultural factors making women more vulnerable to climate change and some probable solutions to reduce women's vulnerability and enhance adaptation are also presented.

3. Factors affecting women's vulnerability in arid and semi arid region

It is recognized that women in general and those living in arid parts of India and South Asia in particular are disproportionately more vulnerable to climate change and the ecological crisis because numerous interacting factors. Their heightened vulnerability is rarely due to any single reason, rather, it is the product of diverse and interacting social processes that result in inequalities in socio-economic status on the basis of gender, class, ethnicity, age, and (dis)ability (IPCC, 2014). Socially, economically, culturally, politically, institutionally, or otherwise marginalized women; are especially more vulnerable to climate change. The confounding effects of climate change on women are depicted in Fig. 1 and described below.

Workload and long working hours hinder education: Literature shows that women in rural India and South Asia have low education and high poverty. This is especially true for the teenage girls and young mothers of underprivileged classes. The female literacy rate in rural India (%) was 4.9 in 1951, 10.1 in 1961, 15.5 in 1971, 21.7 in 1981, 30.2 in 1991, 46.7 in 2001 and 58.8 in 2011 (Census of India, 2011). In 1991, less than 40% of the 330 million women aged 7 and over were literate. It means that there were more than 200 million illiterate women in India, and most of these were in rural areas. In six out of the 24 states in 1998, only 25% or less of the women in rural areas were literate (Velkoff, 1998). In the desert state of Rajasthan, only 12% of the rural women were literate. As many as 45% of the girls dropout of the school between grades 1 and 5. Thus, only 13% of all Indian women have more than primary education and only 1% have college education. A study conducted by Kookana et al. (2016) showed that in Gujarat, 41% of the mothers of interviewed students did not receive any school education, 38% had received primary education, 18% had received secondary level

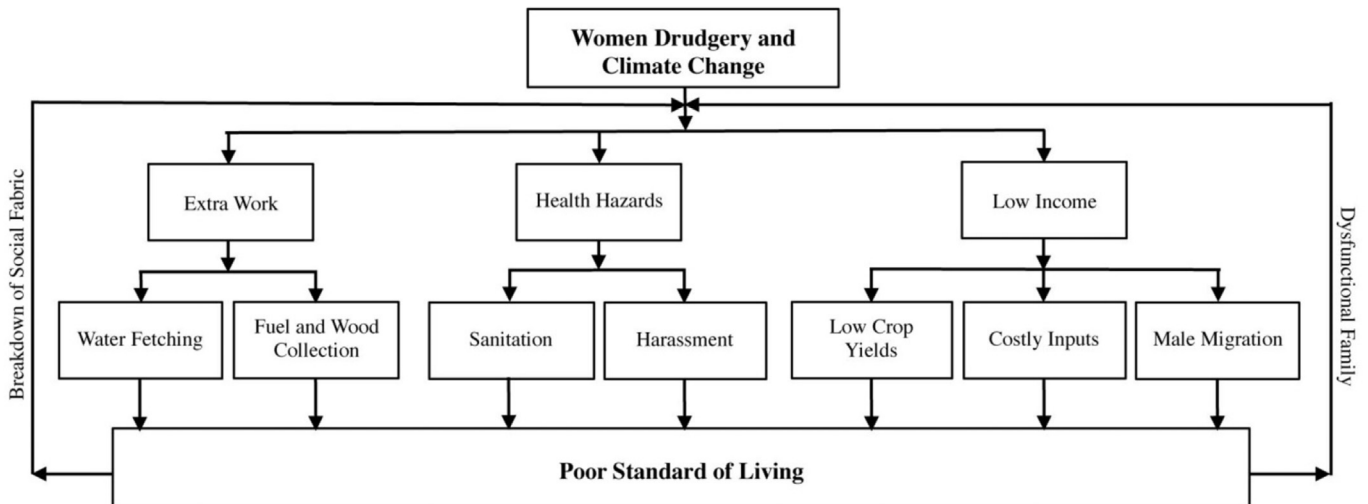


Fig. 1. Confounding effects of climate change on increase in drudgery, health risks and breakdown of social fabric.



Fig. 2. Women carrying water from long distances in arid parts of northern India in 2014.

education and only 3% received tertiary level education. In Rajasthan, 58% of the mothers did not go to school, 26% had received primary education, 14% had received secondary level education and none had received tertiary education. Therefore, it is the illiterate rural women in India who are responsible for household work (i.e., cooking, cleaning, washing, collecting fuel wood, fetching water). Rural women in India are also involved in harvesting and carrying fodder for cattle. This workload is in addition to farming and related activities such as seeding (i.e., transplanting of rice), weeding, harvesting and threshing. Increase in frequency of extreme events (i.e., drought and heat wave) are likely to exacerbate women's workload, specifically in water fetching, and fuel wood collection. Carrying of heavy loads on their heads or on their backs (Fig. 2, Fig. 3a and 3b) can cause severe backaches and spinal injuries.

Water collection: Arid regions in India and South Asia are prone to chronic water shortages and climate change is decreasing the availability of clean water for drinking and other household uses. Worldwide, women in almost two third of the households, are responsible for collecting water for drinking, cooking, sanitation and other productive tasks (FAO, 2003). Most countries in the Near East and North Africa suffer from acute water scarcity, as do countries such as Mexico, Pakistan, South Africa, and large parts of China and India (UN-Water, 2007). But the majority of traditional water reservoirs in arid and semi-arid regions of the world either have disappeared or are degraded beyond repair, and many of the existing ones are heavily polluted and unfit for use. For example at the beginning of 1960s, Bangalore (India) had 262 lakes but now only 10 lakes hold water. Another example is Delhi. In the year

2010–11, it was found that 21 out of 44 lakes in Delhi were gone dry due to rapid urbanization and falling water tables (Singh and Bhatnagar, 2012). In the 19th century, the Madras area had at least 43,000 functioning water tanks. It was also estimated that just two decades ago, there were at least 650 water bodies. But, today only a fraction (less than 30) of them remain. Like these, there are endless examples in India which show the sorry state of water bodies (Times of India, 2013).

Under the climate change scenario, nearly half of the world's population will be living in areas of the highest water stress by 2030 (UNCCD). All Arab countries are considered water-scarce. The region has less than 500 m³ of renewable water resources available per person annually. About 66% of Africa is arid or semiarid, and more than 300 million people in sub-Saharan Africa live on less than 1,000 m³ of water resources each (WWAP, 2012). India is also one of the most water-challenged countries in the world. 54% of India's total area is facing high to extremely high stress— putting almost 600 million people at higher risk of surface-water supply disruptions. Women in rural areas often rely on common water resources such as small water bodies, ponds and streams to meet their water needs. However, in many regions these sources have been eroded or have disappeared due to changes in land use, or have been appropriated by the state or industry for development needs or to supply water to urban areas.

Literature shows that the groundwater in the Indo -Gangetic Plains is falling at the rate of > 1 m per year (Kerr, 2009; Pathak et al., 2014; Biswas and Tortajada, 2017) and will have severe impacts on women and small landholder. Sometimes, women lift



Fig. 3. (a) Women carrying fodder in district Jhajjar of Haryana state in India in 2016.
(b) Women carrying fuelwood in district Rewari of Haryana state in India in 2016.



Fig. 4. Women labourers working at a brick kiln in outskirts of Delhi, India in 2015.

water from wells, where the water table is low and rapidly falling, making the task even more tedious (Sharma et al., 2012). In general, girls under 15 are in-charge of water collection (Fig. 2). In search of sufficient and clean water, young girls and women have to walk longer distances and spend more time purifying water (Mitchell et al., 2007). World Bank (2004) reported that rural women spend about 1 h per day fetching water. For example, in villages of Northern India, women and children walk 4–8 km to fetch drinking water from the government-managed tanks. In rural areas of

Guinea, women spend more than twice as much time fetching wood and water per week than men, while in Malawi they spend over eight times more than men on the same tasks. Girls in rural Malawi also spend over three times more time than boys fetching wood and water (UNIFEM, 2009). In arid regions of South Asia and Africa, girls and children walk about 6 km per day to fetch water, and it is estimated that as many as 40 billion working hours are used every year to collect water in Sub Saharan Africa and 150 million work days every year in India to fetch and carry water (U.N.,

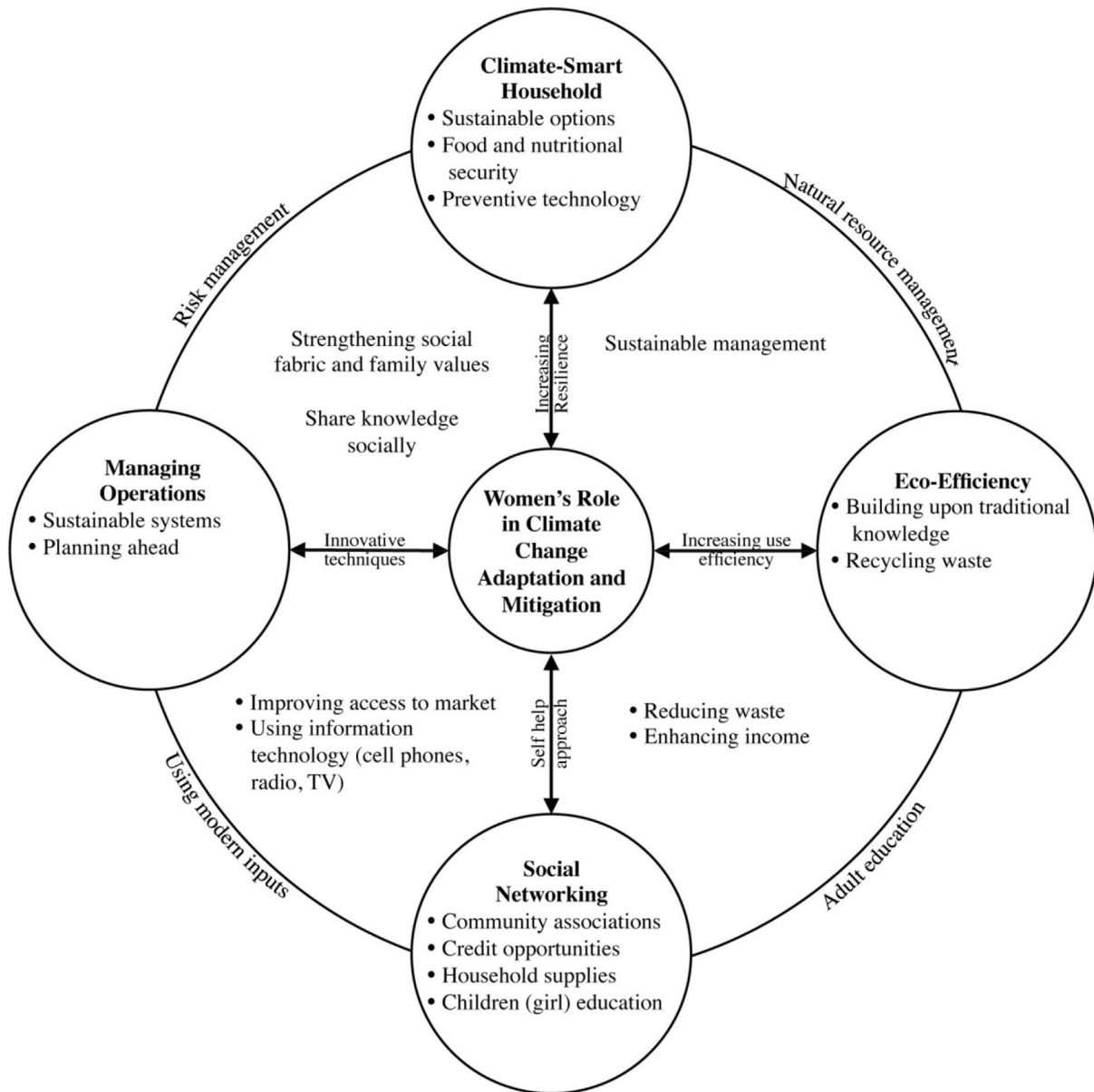


Fig. 5. A conceptual outline of women's role in climate change adaptation and mitigation. The authors of this article propose the strategies for NGOs, governments and other development organizations to create climate-smart house-holds, improve eco-efficiency, strengthen social networking, and manage critical operations. These proposed strategies will lead to improved resilience, enhanced use-efficiency of inputs, strengthened self-help capacity, and increased adoption of innovative options. Examples of technological options to implement these strategies are outlined within the circles and quadrants in the schematic. Arrows indicate strong interactions among variables.

2013). In rural Rajasthan and Gujrat, water access can influence schooling opportunities for girls. Kookana et al. (2016) reported that in Rajasthan, the frequency of female students missing schools for 5 or more days per month was on average 2 to 10 times greater than that for males. The ground water scarcity in the study area and the consequent demand on their time for fetching drinking water are the contributing factors for their absence from school. Indian women are worst hit by the water crisis (Lal, 2016).

Fodder and Fuel-wood collection: Fodder and fuel wood scarcity has vitally affected the lives of millions of women economically, socially and physically especially in arid and semi-arid regions of developing nations (Waris and Antahal, 2014) (Figs. 3a,b). Fuel-wood accounts for between 50 and 90 percent of the household fuel used in developing countries (FAO, 2010). About 70% of the households use traditional energy (fuel wood, dung, crop residues)

for cooking and heating. On average, women in India spend 374 h collecting fire wood or animal dung and 1460 h cooking every year when using a traditional stove (Alliance News, 2015). Thus, 80% of rural women in India are exposed to smoke from traditional stove (U.N, 2010). Similarly, World Bank (2004) reported that women in India spend 40 min per day collecting fuel wood (Fig. 3b). A survey conducted by the Global Alliance for Clean Cook stoves in South Asia indicates that women spend >20 h per week in collecting traditionally used fuels (wood and dung) and 4 h per day in cooking (Bloomfield, 2014). As much as 80% of rural women in Asia, 60% in Africa and 40% in Latin America are affected by a shortage of fire-wood (UNDP, 2009). They are forced to go to rough, remote and unsafe places to collect fuel-wood, and gather fodder at odd hours (Figs. 3a &b). When they carry heavy loads from long distances, they become more prone to spine injury, pregnancy complications

including miscarriage, and maternal mortality (Huyun, 2005), and face increased risks of sexual harassments including rape (UNDP, 2005).

India has 17.7% of the world population (1.34 billion out of 7.55 billion; UN, 2017), of which 68.8% lives in rural areas. Yet, India has only 2.4% of the world's total land area and 4% of the world's fresh water resources (Pathak et al., 2014). Climate change will adversely affect the fresh water resources, both the surface and ground water (NIC, 2009; Biswas and Tortajada, 2017), and rural women in India will be the most adversely affected by the growing water crisis.

4. Health and mortality

Climate change puts at risk the basic determinants of human health, and is regarded as the biggest challenge to global health (Costello et al., 2009). Extreme weather events (i.e. heat waves, droughts and windstorms) disproportionately affect women (Kovats and Hajat, 2008; Pascual et al., 2002). The declining natural resources have serious adverse impacts on women's health, and the climate change will worsen human health conditions, especially in the tropical regions. Heavy workload, early childbearing, high fertility, increase in climate-related disease outbreaks and absence of health and family planning facilities make them weak and highly vulnerable (WHO, 2010). Indirect effects of climate change on women's health may arise from the disruption of natural systems, causing infectious diseases, malnutrition, food and water-borne illnesses (Nwoke and Ibe, 2014). In India and Africa, global warming signifies an increase in mosquito populations, thus escalating the risk of malaria, dengue fever and other insect-borne infections (Kasotia, 2007). Increase in temperature and scarcity of clean water for drinking purpose is becoming a leading cause of kidney stone problems (Tasian et al., 2014).

Climate related drought or famine disrupt the social structure, leaving women and children unaccompanied, separated or orphaned (Nellemann et al., 2011), leading to the loss of financial security. The loss of household dwellings, security, safety nets, and the aftermath of the disasters increase the economic pressure on women (IPCC, 2014). Climate change also breakdowns social fabric, increases unrest, and exacerbates women's vulnerability. In some cases, women's greater vulnerability to climate change may also relate to her basic physiology. For example, many women may be pregnant at any given time and less physically able to escape or survive during and after disasters (Mutunga and Hardee, 2010; WHO, 2010).

Decreasing food production and high food prices lead to insufficient intake and less nutritious food (ADB, 2013). Though women prepare food for the whole family, they are often the last to eat whatever remains. Because they prioritize food for the family, they often have to forgo meals (Tirado et al., 2010). Such 'food hierarchies' exacerbate protein deficiencies in women, decrease immunity and increase susceptibility to diseases (Haigh and Vallye, 2010; Newcourse, 2010). Pregnant and nursing women face additional challenges. While their mobility is limited, they have an increased need for food and water (Nwoke and Ibe, 2014) and the access to food is limited by scarcity and hierarchy in priority.

In most of the arid regions of the world, little water is available for cleanliness and hygiene. The problem is especially dire with pending water crisis with the projected climate change. Surface and ground water availability is around 1869 billion cubic meter (BCM), of which only 60% (1121 BCM) is available, and only 3% (33.6BCM) is used for domestic sector (Khurana and Sen, 2017). India has a rural population of 920 million spread over 15 diverse ecoregions, many of these in arid and semiarid climates. Even if 33.6BCM is distributed evenly among rural and urban population, which is unlikely, total available water resources for 920 million rural population is

23.1BCM or 25.1 cubic meter per year or about 70 L per day for bathing, drinking, washing and sanitation. Even the best-case scenario is not adequate by international standards. The water crisis will exacerbate the health and environmental sanitation (Kumar et al., 2011). Less than 60% of the rural households have individual household latrines (Mandal, 2009), and more than 500 children under the age of 5 die each day from diarrhea and other water borne diseases. Climate change, aggravating food shortage and water crisis, will exacerbate malnutrition and lack of sanitation and expose women and girls to severe health hazards. For example, 16 million (50%) Kenyans do not have adequate sanitation; more than 90% of the water and sanitation related disease outbreaks occur in the rural areas; 50% of rural households have no toilet facilities at all, and where they exist they are generally unhygienic (UNICEF). Of the 1.1 billion people in the world who do not have toilet facilities, 626 million people in India defecate into open space every day and are prone to several health hazards (Lu, 2017). In Odisha, India, Sahoo et al. (2015) conducted a survey to assess the sanitation-related psycho-social stress. They observed that sanitation practices encompassed more than defecation and urination and included carrying water, washing, bathing, menstrual management, and changing clothes. It is during these activities that rural women encounter three broad types of stresses; environmental, social and sexual. These stresses may be exacerbated by climate-induced increase in water scarcity.

Severe water stress fosters a range of long-term public health challenges to rural women and girls facing water shortages (Kovats and Hajat, 2008; Alston, 2013). Globally, 15% of all maternal deaths are caused by infections in the six weeks after childbirth (Schechtman, 2013). Similarly, neonatal causes account for 44% of all deaths of children under five. The reduced availability of clean water results in urinary tract infections, diarrhea, skin problems and issues related to menstruation (Nwoke and Ibe, 2014). All these factors lead to increased mortality of women in disaster prone areas of the world. Women and girls are more likely to die than men during and after climate-related and other natural disasters (Enarson, 2009; Harris, 2010; Lambrou and Nelson, 2010; Neefjes and Valerie, 2010; Odigie-Emmanuel, 2010; Vincent et al., 2010; Tovar-Restrepo, 2010; Alston, 2011; Resurrección, 2013). The gender gap in mortality is worse when the drought-flood syndrome and the heat-cold wave are more severe and people are poor (Neumayer and Plümper, 2007). For example, the death rate for women was almost five times as much in the 1991 cyclone in Bangladesh as that of men (Röhr, 2007; Newman and Stephenson, 2010).

The literature indicates that women and girls are also vulnerable to gender-based domestic violence and sexual harassment during and in the aftermath of climate-related disasters (Nellemann et al., 2011; Uji, 2012). There are approximately 800,000 people trafficked across international borders annually and, of these, 80% are women or girls (Doyyadaitis, 2010). According to the United Nations Office on Drugs and Crime (UNODC), the greatest numbers of traffickers are from Asia. In the Asia-Pacific region, women are particularly at risk of sexual violence following a disaster (Alston, 2013). Increased levels of intimidation, sexual assaults and rapes occur in temporary shelter camps (Bartlett, 2008). During 1996, 1997, approximately 90% of the reported rapes in northeast Kenya's Dadaab refugee camps occurred while Somali women were gathering water, fuelwood and livestock grazing (UNHCR, 2001). A survey conducted in Bhopal, India, showed that 94% of women interviewed reported facing violence or harassment when going out to defecate, and more than one-third had been physically assaulted (Schechtman, 2013). Thus, under the Swachh Bharat Programme, India has made toilet construction as among its highest priorities (Lu, 2017).

5. Gender inequality and social wellbeing

Girls are always the first casualty of the school dropout syndrome, and the drop-out rate for girls increases during and after disasters (Brody et al., 2008). Following a long periods of drought in Malawi, more girls dropped out of school to save money and to assist with household tasks than boys (Valentini, 2005). Increased workloads also forces girls out of schools to help in domestic and agricultural tasks (Brody et al., 2008; Baten and Khan, 2010). In Rajasthan, the desert region of India, 61% of the farm women are illiterate (Sandhya and Dashora, 2003). Indeed, the lack of education has aggravated and sustained gender inequality, perpetuated cycles of chronic poverty and increased environmental degradation (Newcourse, 2010).

Extreme Climate change is leading to climate refugees (Haigh and Vallely, 2010). In extreme poverty, destruction of livelihoods and erosion of productive assets, men emigrate for employment opportunities and abandon their family (Nellemann et al., 2011), resulting in a *feminization of responsibilities* (Olsson et al., 2014; UNDP, 2012). This puts extra pressure on women to do more work and handle the responsibility of the household (IOM, 2009; Resurreccion, 2009; Laczo, and Aghazarm, 2009). Intensification of the workload of women accentuates difficulties in accessing resources, particularly food, feed, fuel and water (CIDA, 2002). Climate change is not only reducing the chances to achieve gender equality but also exacerbating the existing inequalities (Neumayer and Plümper, 2007). The intensity of adverse impacts is increased by other extraneous factors which further increase gender inequality. Important among these are land tenure and property rights, degraded soils and lack of access to essential inputs. Efforts and targets of achieving gender equality are also threatened by climate change (Skutsch, 2002; Hemmati and Rohr, 2009), because of the scarcity of natural resources and property right laws which favor men. In India, Giovarelli et al. (2013) reported that less than 10% of privately held land is in the name of a woman. While the formal laws may be beneficial to women, they are often irrelevant in practice because of social and cultural factors.

Another key impact of climate change is increased human trafficking. Among those who are trafficked internationally, 70%–80% are females, of which about 50% are girls (Curtol et al., 2004; Hodge and Lietz, 2007; US Department of State, 2004). Trafficking may increase by 20–30% during disasters (Nellemann et al., 2011). Disintegrated societies and disrupted protective patterns in families and communities make women more vulnerable to the exploitation of criminal human trafficking. Disasters leading to increased physical, social and economic insecurity aggravate human trafficking (Nellemann et al., 2011). Among trafficked women, about 70% are coerced into sex trade and other forms of sexual exploitation (Demir, 2003). Extreme climate change and loss of income may also push women into high-risk activities including sex trade or the so-called survival sex (Bishop-Sambrook, 2004). Girls of economically impoverished families are particularly more vulnerable to forced labour and the sex trade (ILO, 2011).

Migration of men, abandoning of women and lack of income are responsible for an increase in modern day slavery, forced and bonded labour in homes or in industries like brick kilns (Fig. 4). Brick kiln industry in India probably employs the largest unpaid female workforce in the world. The wealthy state of Punjab (India) is home to more than 300,000 women workers in brick kilns. With no labour records, a woman labourer is neither recognized nor valued. If working with her husband, a woman is not paid separately because wages in brick factories are on piece-rate or task basis and for the most part the male head of her family is paid for the entire family's labour (Sekhar, 2015).

Many of the women workers are sexually abused, and

conditions for pregnant women are particularly bad, as they do not have access to medical facilities, and are forced to work well into their pregnancy (Chandran, 2016). Women lacking sufficient food have 80% higher probability of selling sex for money or resources, a 70% higher probability of engaging in unprotected sex and a 50% higher probability of intergenerational sex (Actionaid, 2008). Women and children from violence and famine-hit Somalia are being trafficked into Kenya and sold into prostitution (Kahare, 2011). Many underage girls are also trafficked for sex tourism in these regions. Poverty and lack of economic independence puts women in a weak social position, and makes them either unaware or unable to insist on safe sex practices, and are at higher risks of sexually transmitted diseases such as HIV/AIDS (Newcourse, 2010; Nellemann et al., 2011; Dintwa, 2012). The unwanted pregnancies and the lack of access to birth control pills further exacerbate their vulnerability (Alston et al., 2014).

Women living in arid regions are disproportionately more vulnerable to climate change and the ecological crisis due to factors discussed below.

Poverty: Poverty is one of the major driving forces behind people's vulnerabilities to climate change. One reason why women living in arid regions constitute the largest percentage of the world's poorest people is because they have far less access to resources that are essential to disaster preparedness, mitigation and rehabilitation. 70% of the world's poor are women and own only 1% of the world's titled land. Insecure land tenure and other resource rights further exacerbate their vulnerability (Lambrou and Piana, 2006; Aguilar, 2009; Dankelman, 2010; Solar, 2010; Nellemann et al., 2011; Yavinsky, 2012; Farming First, 2013; Tuana, 2013; Leichenko and Silva, 2014).

Informal workforce: Almost 70% of employed women in South Asia and more than 60% of employed women in Sub-Saharan Africa work in agriculture. Women make up the larger share of the informal workforce and are responsible for multiple tasks during and after the climate event disasters (Loughran and Pritchett, 1997; Gender and Water Alliance, 2003; Aguilar, 2009; Lane and McNaught, 2009; UNDP, 2009; Solar, 2010; Nellemann et al., 2011; Yavinsky, 2012; Ghosh, 2015). Of the 207 million agricultural labour force in India, 92 million (30%) are women. Of these, 50% are casual labourers (FAO, 2011) with little financial security. In Orissa, India, women of family contribute 62% of the labour in harvesting and post-harvesting operations of rice (Thakur, 2013). In the book *“Staying Alive: Women Ecology and Survival in India,”* Shiva (1988) emphasizes the role of women as conservationists, life-enhancing and equity seeking. Her focus is on rural and tribal women in India who are specifically identified with nature and the human community.

Heavy reliance on meager natural resources: Women in rural India, especially those of underprivileged classes and landless laborers, are heavily dependent on natural resources for their livelihood and subsistence income. In South Africa and Mozambique, 60%–70% of women rely on natural resources for their survival. In Sub-Saharan countries of Africa, women derive 30–50% of non-farm income from natural resources (Adger et al., 2003; Mutangadura, 2004; Aguilar, 2006; Blackden, 2006; Lambrou and Piana, 2006; Dankelman and Jansen, 2010; Newcourse, 2010; Waris, and Antahal, 2014). Loss of vegetation, degradation of soil and pollution of water put extra pressure on women. When natural resources degrade, limited economic opportunities for women are jeopardized and poverty intensifies.

Less access to education and training: Women constitute the majority of illiterates in rural India, and especially in the dry regions. They make up over two-thirds of the world's 796 million people who are illiterate, and many of them live in rural areas. For example, in Cambodia 48 percent of rural women are illiterate

while in Burkina Faso 78 percent of rural women cannot read and write (FAO, 2010; IFAD, ILO, 2010). Women have less access to education and training opportunities concerning climate change mitigation and adaptation strategies. Moreover, they are discouraged from learning lifesaving skills. The lack of female educators, outreach experts and agricultural extension agents hampers women's access to information; resources and technology which further increases their vulnerability (International Federation of Red Cross and Red Crescent Societies, 2010; FAO, 2011; Newcourse, 2010; UN Women, 2013). A survey conducted by Haugen et al. (2011) in 28 African countries showed that while female teachers make difference in girl's education, many countries have a relatively few females in the teaching force. Furthermore, men generally dominate the control of resources and women have less ownership than men of required resources for a basic livelihood. In developing regions, women own substantially less land, get lower wages and have less access to financial institutions than men (Deere and Doss, 2006; Haigh and Vallely, 2010; Newcourse, 2010; Solar, 2010; Nellemann et al., 2011; Yavinsky, 2012; Alston, 2013; Tuana, 2013; Carr and Thompson, 2014).

Underrepresentation of women in national parliaments and climate change negotiations: A disproportionately small percentage of women are represented in regional and global climate meets and their percentage of participation in UNFCCC is 15–25%. Furthermore, their position in the social hierarchy is low, which makes them unable to raise their voices even after participation (Denton, 2002; Resurreccion, 2009; Solar, 2010; Nellemann et al., 2011; Yavinsky, 2012; Tuana, 2013; UN, 2013; Kruse, 2014; Weiner, and MacRae, 2014).

In addition, there are gender-biased development processes and programmes which place women at a disadvantageous position and may exacerbate general impacts and risks. In Odisha, India, a survey by Routray et al. (2017) showed that decisions on the construction of household level facilities were made exclusively by the male head in 80% of households; and in 11% the decision was made by men who consulted or otherwise involved women. Restrictive policies and programmes are often gender-insensitive, and place them at the ground zero of climate change vulnerability (Skinner, 2011; Weiner, and MacRae, 2014; Allwood, 2014). Furthermore, socio-cultural customs and traditions prevent women from engaging in activities outside of the household. Lack of independent decision making power, traditional norms of dressing, cultural restriction on movement and restriction of relocation without the consent of a male hinder their progress and make them more vulnerable during and after disasters (Ikeda, 1995; Neumayer and Plümper, 2007; Mehra and Hill Rojas, 2008; Aguilar, 2009; Newcourse, 2010; Nellemann et al., 2011; Yavinsky, 2012; CARE International, 2013).

6. Contribution of women to climate change adaptation and mitigation

Despite numerous challenges and constraints, women are at the center stage of climate change adaptation and mitigation programmes (Nellemann et al., 2011). Women's role in climate change adaptation and mitigation is outlined in Fig. 5, and discussed below.

The schematics in Fig. 5 show that women play an important role in developing climate-smart households through sustainable options for managing the household gardens, ensuring food and nutritional security, increasing diversity of food sources and by adopting preventive measures such as boiling and filtering water and using mosquito netting, etc. They also enhance eco-efficiency by combining the traditional with the modern knowledge and recycling wastes as compost in the home garden. Social networking is an important tool used by women and it involves community

associations, credit opportunities (e.g., *grameen bank*), household supplies and providing education to girls. Managing operations through sustainable systems and planning ahead are among the innovative options. Specific examples of the concepts outlined in Fig. 5 are also discussed in the following sections. [provide references].

Food production: Women have been the primary growers of food and nutrition throughout human history. They play a key role in food production, and are the backbone of the rural economy (Farming First, 2013). Worldwide, women contribute to 43% of the workforce in agriculture but produce 50% of the total food (FAO, 2011). Women are reportedly responsible for 65% of the total household production in Asia and 75% in Sub Saharan Africa (UN Women Watch, 2013). Indigenous biodiverse varieties of edible plants grown by women provide far more nutritional food than the commodities produced by industrial agriculture (Shiva, 2015). Given below are specific examples where women are adopting climate-smart agricultural techniques (refer the section on page 9 in the section on Women-led Initiatives) and are growing climate-resilient crop varieties (Brody et al., 2008). Women are already adapting to climate change by diversifying their agriculture, food habits and devising long-term food storage techniques. For example, women in the deserts of Rajasthan (India) have taken on many innovations such as growing improved crop varieties including that of pearl millet and other crops suited to the region; planting fruit trees to provide nutrition and income; constructing embankments to capture rainfall and prevent runoff and soil erosion; and planting grasses and fodder trees to provide fodder for cattle (ICRISAT, 2015). Biodiverse ecological agriculture (i.e., compound gardening based on multiple species including vegetables and medicinal herbs) practiced by women is a solution not only to the malnutrition crisis, but also to adaptation and mitigation of changing and uncertain climate (Shiva, 2015). Shiva (2000) described the social and ecological costs of indiscriminate agricultural intensification, especially those, as she calls it, hidden and unnoticed factors affecting the women workers. The work by Shiva is also supported by that of Bourne (2015) who has emphasized the pollution of water and air because of the excessive and indiscriminate use of agro-chemicals, and the victims are the rural women and children. With the help of Swayam Shikshan Prayog (Self Learning Experiment), a Pune (India) based non-profit organization, lives of nearly 72,000 women farmers have been transformed by adopting sustainable and climate-resilient agro-ecological farming. This initiative has also created 5500 self-help groups that supported women to engage as farmers, entrepreneurs and leaders. Under the one-acre model, multiple crops are grown to boost nutritional security, soil fertility, agro-biodiversity and income viability. Women in this region practice sustainable methods such as use of bio-pesticides, organic fertilizers and water conservation techniques like drip irrigation, sprinklers, farm ponds, recharging of bore wells and tree plantation to augment precious and scarce groundwater and to improve soil fertility.

Traditional Knowledge Custodian: Women are regarded as custodians and carriers of traditional knowledge (Agarwal, 2009). By performing essential activities (e.g. fetching water, growing food, gathering fuel wood, tending domestic animals, rearing children and caring for elders) women have gained special knowledge about the local environment and other natural resources (Dankelman, 2001; Jara, 2012). Women are knowledgeable and willing to use traditional knowledge related to natural resources, climate change, species composition, medicinal uses of herbs etc. (Kanwar and Sharma, 2011). It is also the women, for the most part, who transmit to the next generation these values as part of their stewardship role. With the knowledge of natural resources, women can also influence development and implement policies

and programmes relating to climate change not only at the local level but also at the national and international levels (Resurrección, 2013). The Grandmothers' University and Diverse Women for Diversity initiatives by Navdanya (An Indian based International NGO) is aimed at both celebrating and validating the wisdom of grandmothers and also for transmitting this knowledge to future generations to arrest the rapid erosion of skills, knowledge and values which women have evolved over millennia to live sustainably. Diverse Women for Diversity echoes women's voices from the local and grassroots level to global fora and international negotiations. Through these initiatives, Navdanya has connected over 5 million women from 22 states of India as one force for sustainability and women's empowerment (Shiva, 2015).

7. Environmental management and activism

Women are well suited to find solutions to prevent further degradation of soil and water resources and to adapt to the changing climate. Their behaviour, on average, contributes less to pollution (Polk, 2009) than that of men. They express more concern for the environment and support policies that are more beneficial to the environment (Norgaard and York, 2005). They are more likely than men to recycle waste, buy organic food and eco-labeled products; place a higher value on energy-efficient transport and tend to vote for leaders who care about the environment (OCED, 2008; McCright, 2010). Having little access to modern devices and thus relying on traditional tools (i.e., hoe, manual sprayers, traditional threshing), women use less fossil fuel than the motorized equipment used by men which run on fossil fuel; and are more likely to ratify international environmental treaties (Polk, 2009; Aguilar, 2013; European Commission, 2014). A survey of 30 villages in Maharashtra, India, indicated women farm labourers specifically performed in-hand weeding operations, sowing seeds, and threshing and winnowing operations (Rani, 2011). There is a strong need to adapt and refine women-friendly tools and equipment for drudgery reduction in farm operations such as pedal operated thresher, hanging type grain cleaner, tubular maize sheller and groundnut decorticator (Sundram, 2013; Bhatt, 2013; Singh, 2013). Women also look after grain storage and other post-harvest operations. Yet, women are not trained in post-harvest know-how, and thus, high post-harvest losses aggravate food insecurity (Sidhu, 2007).

Globally, traditional practices used by rural women are by nature eco-friendly systems (Nellemann et al., 2011). Thus, projects designed and run with full participation of women are more effective than those without them (Agarwal, 2010). For example, in Northwestern India, tree cover increased by 75% when women were included in the process of protecting forests (Agarwal, 2009). Women's participation is also strongly associated with the effectiveness of water and sanitation projects (UN Water, 2006).

Women are also moving into the forefront of environmental activism and are leading protests against deforestation, industrial pollution and the construction of ecosystem-altering dams. Countries in which women and their organizations are active tend to have less deforestation than those in which such activism is rare or absent (Shandra, 2008; Engelman, 2010). Given below are several examples of women's involvement in continuation of a centuries old tradition of protecting the environment. The tradition goes back to 1730, when women in India protested against the king's men who were attempting to cut green trees. Amrita Devi, leader of the group, sacrificed her life along with 363 other women (including her three daughters) to save the Khejri (*Prosopis cineraria*) green trees from being felled by the King of Marwar, Rajasthan. During the early 1970s, women organized advocacy groups to protect the trees from being cut, and they hugged (chipko) the trees. Thus, the

protest was called the "Chipko" movement, and the indigenous women from India protected the trees from the massive threat of logging (Jain, 1984). In 1980s, Wangari Maathai founded the Green Belt movement to mobilize women to reforest degraded land in Kenya (Maathai, 2004). In Guatemala, women farmers are planting trees to sequester carbon and improve farming techniques. In Ghana, propelled by women's leadership, the Ghana Bamboo Bikes Initiative is tackling climate change and creating an income stream for women by training them to build and sell high-quality bamboo bicycles. In Australia, 1 million women have taken the initiative to become the country's largest women's environmental organization – with a goal for these women to take small steps in their daily lives that shrink their carbon footprint (Figueres, 2004; Brown, 2015). Similarly, low-income women along the US Gulf Coast played a significant role in environmental restoration after the hurricane Katrina (David and Enarson, 2012).

Women led initiatives for adapting to climate change: The literature shows that several initiatives have been undertaken throughout the world to tackle the menace of climate change, and a large proportion of these are led by women. Examples of some initiatives aimed not only to reduce women's vulnerability but also to help them in mitigating the impact of climate change and adapting them include the followings: Grandmothers' University and Diverse Women for Diversity Initiative of Navdanya in India; Low Smoke Stoves Project in Darfur, Sudan; Ghana Bamboo Bikes Initiative; Women Advancing Climate and Climate Change Sciences (Women-ACS); Caribbean Farmers Network (CaFAN); Jamaica Network of Rural Women Producers; Africa Adaptation Programme (AAP); Climate-Smart Agriculture in Kenya; Crop Diversification in Nicaragua; Applying Local Knowledge to Crop Production in Bolivia; Solar Sisters in Nigeria Uganda, and Tanzania; Blue Ventures in Madagascar; and Sustaining Partnerships to Enhance Rural Enterprise and Agribusiness Development (SPREAD) project in Rwanda etc. (Brown, 2015; Shiva, 2015; Wedeman and Petruney, 2016).

Approaches to reducing women's vulnerability to climate change: Despite the knowledge regarding the role of rural women in climate-resilient systems (as discussed in the previous sections on the basis of literature surveyed), women living in arid and semi-arid regions, constituting the majority of the world's poor, are still among the most vulnerable to the adverse impacts of climate change. While, worldwide efforts to reduce their vulnerability to climate change and to increase their adaptive capacity are in progress, the available knowledge has not been translated into effective action. Therefore, the way forward is to develop policies to promote adoption of some of the approaches and options required for enhancing adaptive capacity and reducing women's vulnerability to climate change. Specific strategies to surmount the barriers to adoption of the climate-resilient systems by women are as follows:

Poverty eradication and economic empowerment: The first step towards tackling the challenges of climate change is empowering women to safeguard the environment. Poverty eradication is an essential prerequisite for reducing women's vulnerability. Economic empowerment is important in guaranteeing their overall well-being. When economically empowered women raise healthier and better educated families, it increases their adaptive capacity. Innovative approaches and partnerships are needed to design and develop women-friendly and climate-resilient economic policies. Providing employment opportunities, credit facilities, savings and insurance schemes with gendered contexts are important options (Grown et al., 2006; Prowse et al., 2009; Solar, 2010; Bätthge, 2011; Hill, 2011; OECD, 2011; Farming First, 2013; CARE International, 2013; Leichenko and Silva, 2014).

Infrastructure and assets development: Infrastructure

development reduces women's work burdens, improves their health and increases their efficiency. Improving women's access to alternative and affordable sources of energy, reliable public transport and traditional risk sharing mechanisms, can reduce women's vulnerability to climate change. As women's assets largely determine their capacities and response to the impacts of climate change, so more actions are required to strengthen the asset base as a fundamental principle in climate adaptation strategies (Hill, 2011; Grown et al., 2006; Aguilar, 2009; Solar, 2010; Nwoke and Ibe, 2014).

Secure resource and property rights: Secure tenure to resources and gender-equal land rights enhance productive efficiency, increase adaptive capacity to climate change and improve overall wellbeing. Formal ownership and control over farmland improves women's productivity and increases their coping capacity to the climate change. Securing women's rights to land and other resources also has ancillary benefits which reduce their vulnerability when economic shocks occur, and make it easier to obtain loans (Grown et al., 2006; Rodgers and Menon (2013); Nwoke and Ibe, 2014; WOCAN, 2014).

Promoting gender equality: Gender equality is also increasingly recognized as a critical crosscutting issue in major environmental agreements and climate change negotiations. Until gender inequality is addressed, women will continue to suffer climate injustice. Concerted efforts are required to reduce gender inequalities and to provide equal rights, resources and opportunities in all spheres (Grown et al., 2006; Haigh and Vallely, 2010; Sasvari et al., 2010; Solar, 2010; WOCAN, 2014; Weiner and MacRae, 2014; Allwood, 2014).

Education and information dissemination: Education for women is not only the most powerful most instrument of changing their position in society but is also a key in reducing their disaster fatalities and enhancing adaptive capacity. Capacity building is an essential preparatory step in adaptive strategy in climate change. Empowering the next generation of women through universal education should be an essential element in climate change adaptation and mitigation strategies. A variety of approaches in women's education, literacy, vocational and life skill training are needed to reduce their vulnerability to the climate change (World Bank, 2004; Hill, 2011; Nwoke and Ibe, 2014; Lutz et al., 2014). Training programmes on alternative cultivation methods, efficient domestic and agricultural use of available water resources, alternative sources of domestic energy are required especially for rural women. Women should be provided with skill training and access to credit facilities to start their own enterprises at the village level. Local women should be involved in outreach activities and programmes related to climate change and environmental awareness (Aguilar, 2009; Bähge, 2011; Nwoke and Ibe, 2014; Lutz et al., 2014).

The importance of climate change awareness, early warnings and prior information are critical to minimize fatalities during disasters. Relevant information given well in advance helps women in better disaster preparedness and significantly reduces fatalities. There is a need to utilize new and existing educational, outreach, training, and capacity building programmes to disseminate information and resources related to climate change (UNFCCC, 2011; Bähge, 2011; Nwoke and Ibe, 2014).

Diversification of livelihoods: Among the majority of poor women who practice subsistence agriculture, diversification of agriculture and livelihood are of critical significance. Thus, women farmers should be motivated to adopt climate-smart agriculture. Adaptation efforts often emphasize changes in livelihood strategies, so diversification of livelihoods to include activities outside agriculture is an important strategy for managing climate risks (Solar, 2010; Ajani et al., 2013; Nwoke and Ibe, 2014). Women's lives

are intertwined in a reciprocal relationship with natural resources. They are heavily dependent on natural resources for fuel wood, fodder, medicines, subsistence food and income. So, there is a need to maintain sustainability of ecosystems and conserve natural resources. Sustainable use of resources should be promoted in the society (Lambrou and Piana, 2006; Newcourse, 2010; Sasvari et al., 2010; Hill, 2011).

Shift in existing policy framework and interagency coordination: Women are not merely vulnerable to climate change but are also effective agents of change in relation to both mitigation and adaptation. They have considerable knowledge, experience and expertise regarding climate change mitigation, disaster reduction and adaptation strategies. To be agents of change, it is critical to engage them in climate change mitigation and adaptation policies and programmes (Grown et al., 2006; Nellemann et al., 2011; Weiner and MacRae, 2014; Allwood, 2014).

There is an urgent need to revise existing policy frameworks and investment strategies related to land rights, forests, water, energy and agriculture to integrate women's concerns. Climate change adaptation and mitigation planning strategies need to be incorporated into existing state and local developmental policies and programmes (Prowse et al., 2009; UNFCCC, 2011; Weiner and MacRae, 2014; Allwood, 2014). Inter-agency coordination and synergies is required in poverty reduction, women empowerment and climate change policies. Poverty reduction and adaptation measures should be fully integrated to maximize climate mitigation and women's adaptation co-benefits. There is a need to build cross-sectoral, multi-stakeholder platforms to drive innovative gender-responsive approaches and collaboration between climate change adaptation practices and implementing agencies (Lambrou and Nelson, 2010; CDKN, 2011; Hill, 2011; CARE International, 2013; WOCAN, 2014).

The literature show that for climate change adaptation policies and programmes to reach the most vulnerable women, they must have a voice in the decision making processes. Their full participation in negotiations and decision-making is not only helpful to them but also essential to enhance food security, boost biodiversity, protect fragile natural resources, improve water management, and reduce GHGs emissions. Their greater participation is also likely to enhance the effectiveness and sustainability of climate change projects and policies. Enabling women's leadership in climate change mitigation and adaptation policies and programmes may be potentially the most positive step to achieve the desired targets (Lambrou and Laub, 2004; Norgaard and York, 2005; Aguilar, 2006; Grown et al., 2006; Neumayer and Plümper, 2007; UNDP, 2007; UNDP, 2009; Nellemann et al., 2011; Parikh et al., 2012; Mlambo-Ngcuka, 2014; Kruse, 2014).

Additional research is required to better understand women's concerns and to design effective gender responsive initiatives. Processes and contents of climate change frameworks on the one hand, and women's vulnerability on the other, must be understood to unearth clues about critical linkages (WOCAN, 2014; Uji, 2012; Solar, 2010; Prowse et al., 2009).

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