Measuring Women's Empowerment in Agriculture under Climate Variability: A Micro Study from Nepal

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Abstract

This paper attempts to measure the level of women's empowerment with climate variability in consideration by developing an index capturing their agency of empowerment. The constructed index references the Abbreviated Women's Empowerment in Agriculture Index (A-WEAI) with an additional climate and adaptation domain. The climate and adaptation domain consist of three subindicators; awareness to climate change, access to extension services to adaptation to climate change and, utilization of climate mitigation and adaptation strategies. The sub-indicators were based of literature review. This study analyzed two districts in rural Nepal, low-land Chitwan (n=105) and high-land Kaski (n=104), as they lay in different ecological zones. This study found that the climate and adaptation domain was the second biggest contributor to disempowerment for women in both districts. Fewer women (28%) were empowered in the index with the climate and adaptation domain as compared to the normal A-WEAI index (34%). The difference in levels of empowerment between the indices was signicant at the 5% level (p=0.041). This shows how measuring women's empowerment in agriculture without considering climate change can overestimate their level of empowerment. This study calls for policy makers and researchers to consider climate variability when engaging in efforts to empower women in agriculture.

Keywords: Nepal; women's empowerment; climate change; gender; A-WEAI

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1. Introduction

Agriculture serves as one of the most effective means to alleviate extreme poverty and ensure food security for the growing population worldwide. Among the poorest communities, the growth of the agricultural sector is estimated to be two to four times more effective in increasing income compared to other sectors (World Bank, 2020). However, cultural norms and inequalities can cause production inefficiencies and hinder growth (Jayachandran, 2015). Many of these inequalities are related to gender including the norms, roles and relationships of and between groups of women and men (WHO, 2020) . In the agricultural context, gender roles determine the responsibilities of women and men. As the agricultural sector faces challenges related to climate change including changes in patterns of rainfall, temperature and other variables over varying timescales (IRI, 2020) and a depletion of natural resources (FAO, 2018), both men and women in rural communities must adapt to changing climatic conditions.

Although women account for 43% of agriculture labor in developing countries (FAO, 2011), they represent just 13% of agricultural landholders in the world (UNDP, 2020). This trend holds true in Nepal, a South Asian country where women account for 65% of the total agricultural labor (Raney, Anríquez, Croppenstedt, & Gerosa, 2011) and only 19% of landholders (Census Nepal, 2011). Further, approximately 74% of women are engaged in agricultural activities compared to 51% of men (National Planning Commission of Nepal, 2014).

The division of roles, responsibilities and decision-making powers for agricultural households determine the level of empowerment in Nepal. In the agricultural production process, men and women have distinct roles (FAO, 1999). Women are mainly responsible for the sowing of seeds, collection of manure from the livestock, applying compost to crops, weed control and crop harvesting, whereas ploughing and irrigation maintenance are male-dominated tasks (Brown,

2003). Although inheritance laws have changed, until 2002, land was mainly inherited through male lines (Laxaa, 2015). In the household, men tend to make key decisions about household finances while women are regarded as domestic managers, responsible for drawing water, fetching firewood, child rearing and household nutrition (Laxaa, 2015).

Women's empowerment in agriculture relates to climate change through two avenues**.** On the one hand, climate change can increase the workload for women. Over 50% of households in Nepal depend on surface and ground water for domestic use while 64% still rely on firewood for fuel (National Planning Commission of Nepal, 2011). As the availability of natural resources becomes limited, women often walk longer distances and spend greater amounts of time collecting resources and managing food sources (ADB, 2016). In turn, this may negatively affect their participation in gainful employment for income generation and involvement in community groups.

On the other hand, social and cultural systems determine women's dependency on their natural environment and dictate their capacity to adapt (ADB, 2016). As women tend to have limited access to productive resources, extension services, education, employment opportunities and decision-making (ibid), they are more vulnerable to climate shocks. In a study of 141 countries from 1981-2002, Neumayer and Plümper (2007) found that natural disasters lowered women's life expectancy more than men. However, the vulnerability gender gap decreased as the socio-economic status of women increased, which demonstrates that natural disasters can exacerbate existing patterns of gender inequality.

In Nepal, women's empowerment is an important topic in both scientific research and policy design and implementation . Previous studies of women's empowerment in Nepal have addressed the need to increase economic opportunities and resources, strengthen political power and raise the consciousness and self-confidence of women (Mahat, 2003). In the political sphere,

women-focused projects and national dialogues have targeted economic, legal and social empowerment of women as well as institutional strengthening (The Himalayan Times, 2019). Among these projects, the government of Nepal and the Asian Development Bank developed a project to promote gender equity, which focused on socio-economic conditions (Asian Development Bank, 2016). While the project focused on improving women's incomes and health status, it failed to address climate change and adaptation. As women in Nepal rely significantly on natural resources and agriculture, climate change is an important dimension of ensuring women's empowerment (UN Women, 2014).

Given the close links between women empowerment, agriculture and climate change, it is crucial to include climate dimensions in measurements of women's empowerment. This study addresses the research gap by developing a climate dimension for the women's empowerment in agriculture index and comparing empowerment in two diverse agro-ecological regions in Nepal. We hypothesize that accounting for climate change and adaptation will result in a higher share of disempowered women. In turn, we identify drivers of disempowerment of women and propose recommendations to improve women's empowerment for climate change adaptation in agriculture.

The remainder of this study is organized as follows. In Section 2, we present the methodological framework followed in this paper together with a description of the case study area and the data. The results are presented and discussed in Sections 3 and 4, respectively. We conclude in Section 5.

2. Research methodology

2.1 Case study districts

This study compared the districts of Chitwan (Terai lowlands, < 1000m) and Kaski (Annapurna mountains, >1,000m) in Nepal (Lillesø, Shrestha, & Dhakal, 2005). Chitwan, located in south-western Nepal, is characterized by a subtropical climate with cool dry winters and hot humid summers (Paudel, Acharya, Ghimire, Dahal, & Bista, 2014). Chitwan has a diverse economic profile with farming, livestock and tourism. The valley accounts for a large share of agricultural production in Nepal with over 150,000 metric tons of cereal production, of which 72% is paddy (MoAD, 2017) and approximately 34% of its area is utilized for agricultural activities (Central Bureau of Statistics, 2011).

The district of Kaski is located in the western development region of Nepal. The district experiences six different climate zones and a larger share of its area is at a higher altitude than Chitwan. Due to its high altitude and rough terrain, only 21% of Kaski terrain is utilized for agricultural activities (Central Bureau of Statistics, 2011). Kaski is the most urbanized district in Nepal with 64% of its population residing in urban municipalities (National Planning Commission of Nepal, 2014). Inhabitants engage in economic activities such as agriculture, tourism, industry, hydropower together with foreign employment (MoAD, 2018). Kaski's main food productions are cereals such as wheat, maize, millet and paddy, with over 147,000 metric tons annually (MoAD, 2017).

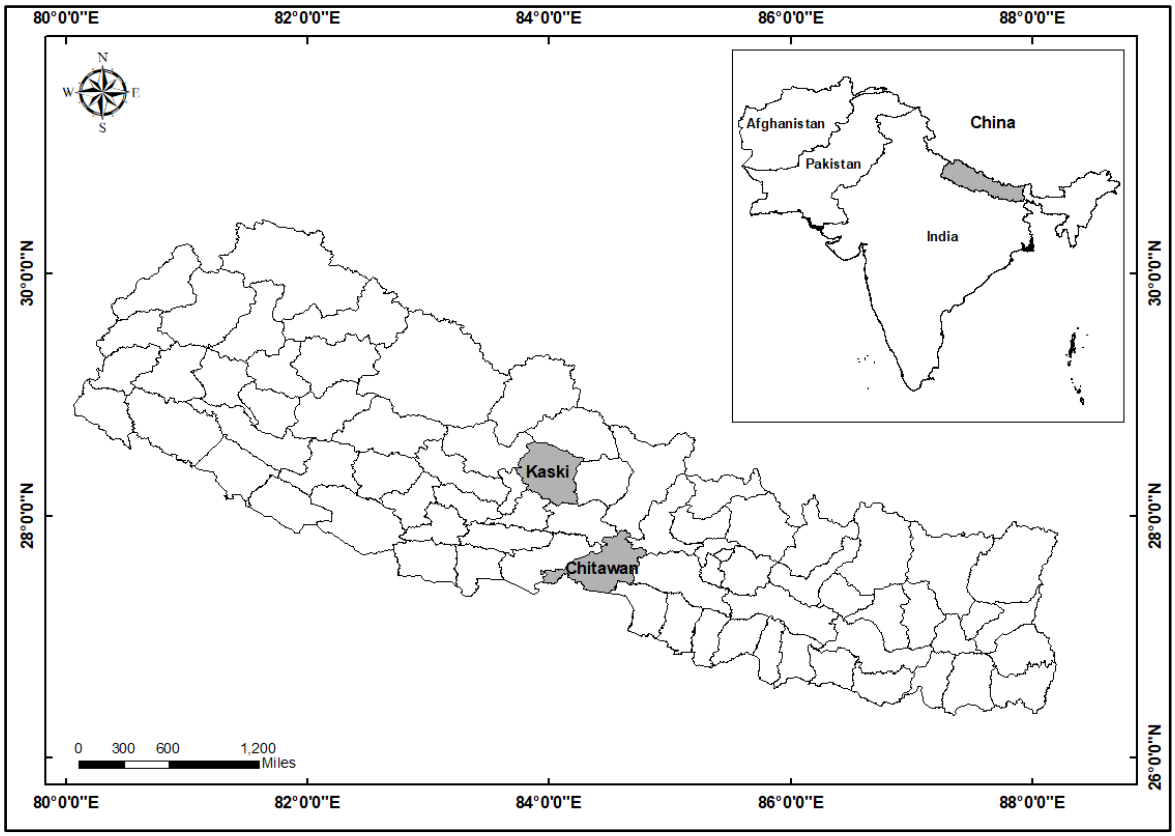

Figure 1. ***Districts of Chitwan and Kaski in Nepal***

Land ownership is an important indicator of women's empowerment. In terms of land resource ownership, there are no major differences between the regions. Overall, approximately 28% of the households in both districts reported the ownership of land or, property in the name of female members of the household (Census Nepal, 2011). However, there are differences in how the population in the districts depends on natural resources. Firewood is a major source of fuel in Nepal with over 49% and 33% of the households in Chitwan and Kaski are dependent on it, respectively (National Planning Commission of Nepal, 2011). At the same time, 65% and 8% of the censured households in Chitwan and Kaski depend on surface and ground water for domestic use (ibid). Water resources, fuel and energy are all impacted by climate shocks (Chaulagain, 2006) as increased temperatures can lead to water scarcity and flash floods can cause destruction of

woodland that act as source of energy (i.e. firewood). As women are responsible for securing and managing natural resources at the household level, they would be the most impacted by changes in availability and access to natural resources (Sujakhu et al., 2019).

A household's climate vulnerability in Nepal is heterogeneous, dependent on the altitude, geography and a community's resilience (Bista, 2018). In terms of climate vulnerability, Chitwan ranked "high" while Kaski is considered only "moderately vulnerable" (National Planning Commission of Nepal, 2014). The rankings were established based on each district's level of sensitivity, exposure and adaptation. Sensitivity was measured as an aggregate of human and ecological sensitivity. While both districts have the same ranking of sensitivity (high), Kaski had a "very high" adaptation ranking compared to "high" for Chitwan and a "moderate" exposure ranking compared to "very high" for Chitwan (MoE, 2010). As there are notable differences related to geography, ecological characteristics and climate vulnerability, the two districts enable this study to assess women's empowerment in agriculture under different climatic conditions.

2.2 Adaption of the index

Women's empowerment is the process of personal and social change through which women make meaningful choices and have control over their lives (O'Neil, Domingo, & Valters, 2014). Women's empowerment is based on three interrelated dimensions: access to resources, agency, and achievements (Kabeer, 1999). Resources (also referred to as 'pre-conditions') consist of materials as well as human and social resources, which help strengthen one's ability to make choices. The second dimension is agency (also referred to as 'process'), which captures the ability of someone to set their own goals and act upon them. It is also referred to as 'the power within' or 'decision-making power' (ibid). The last dimension is achievements (also referred to as 'outcomes') include the benefits one obtains from the first two dimensions coming together. This

can range from improved well-being to achieving equal representation of women in politics. The Women's Empowerment in Agriculture Index (WEAI) was developed to measure women's agency (i.e. process) using individual-level data collected from male and female-headed households (Alkire et al., 2013).

The WEAI is comprised of two sub-indexes. The first sub-index has five domains of empowerment: (1) decisions on agricultural production, (2) access to and decision-making power about productive resources, (3) control of the use of income, (4) leadership in the community, (5) time allocation (ibid). The second sub-index is comprised of the Gender Parity Index (GPI) (Alkire et al., 2013). Several institutions across the years have used the WEAI to develop ad-hoc indexes to cater for unique demands as they measure women empowerment efforts. One such significant modification to reduce complexity and ambiguity resulted in the Abbreviated Women's Empowerment in Agriculture Index (A-WEAI). The A-WEAI has three fewer indicators making it easier to administer and time saving (Malapit, Kovarik, Sproule, Meinzen-Dick, & Quisumbing, 2015). It is also possible to adapt the WEAI to meet different requirements (e.g. Women's Empowerment in Livestock Index (WELI) (Malapit et al., 2019)). This study adapted A-WEAI by incorporating a climate and adaptation domain, which measures the agency of the agricultural landholder under climate change. The following sub-indicators were included: (1) awareness of climate change, (2) access to extension services on adaptation to climate change and, (3) utilization of climate mitigation and adaptation strategies, as measures of a respondent's adaptability to climate change. There is evidence that women's empowerment levels can be improved by increasing women's awareness and access to information and knowledge i.e. agencies of empowerment, on aspects of climate change. Capacity building through extension services that provide knowledge and information on climate-smart agricultural technologies, practices and

services improve the resilience of agriculture-dependent households, communities and food systems to climate-related shocks and change (UNDP, 2016).

The total empowerment of an individual is established by summing up individual scores of the nine sub-indicators after applying their appropriate weights. The weights are calculated using the balanced weighted average of the nine sub-indicators. For each sub-indicator there were adequacy criteria as summarized in Appendix Table A-1. To be considered empowered in each domain, an individual needed a minimum score of 80%, as adopted from the A-WEAI manual (Malapit et al., 2015). This threshold is also applied to the total empowerment score based on the weighted average score across all domains. Table 1 summarizes the domains, sub-indicators and weights as adopted from the A-WEAI manual.

Table 1. The domains, sub-indicators and weights in the modified A-WEAI

Domain	Sub-indicator	Sub-indicator weight
Production	Input in productive decisions *Respondent has sole or joint decision-making powers over farm activities*	1/6
Resources	Ownership of Assets *Respondent owns land, solely or jointly* *Respondent owns major assets, solely or jointly*	2/18
	Access to and decisions to credit *Respondent has accessed credit and has decision-making powers over it*	1/18
Income	Control over use of income *Respondent has sole or joint decision-making powers over household expenditure*	1/6
Leadership	Group Membership *Respondent is a member of at least one community group*	1/6
Time	Workload *Respondent works less than 10.5 hrs. per day*	1/6
Climate and Adaptation	Awareness of Climate Change *Respondent has heard of and is aware of climate change*	1/18
	Access to Extension Services on Adaptation to Climate Change *Respondent has accessed extension services related to climate adaption strategies before or during the year data was collected*	1/18
	Utilization of Climate Mitigation and Adaptation Strategies *Respondent has employed a climate mitigation or adaptation strategy on his farm or livestock in recent years*	1/18

Two of the domains, production and income, captured the extent of participation and decision-making on-farm activities and household expenditure items (Appendix Table A-2.), respectively. For the resource domain, we included information about who accessed credit within the last twenty-four months as well as who was responsible for decision-making for the credit. The leadership domain measured the participation of respondents in community groups as listed in Appendix Table A-3. The time domain captured the 24-hour recall of how many hours a respondent worked in the past 24 hours.

The climate and adaptation domain consisted of three sub-indicators to capture agency over adaptability. The awareness to climate change, access to extension services on adaptation to climate change, and utilization of climate mitigation and adaptation strategies. The full list of strategies adopted by respondents is shown in Table A-3. . Finally, respondents were asked to recall any observed climatic events within the last 15-20 years as a measure of exposure to climate change. This study used the average number of reported climatic events for each district following Alam, Alam, and Mushtaq (2017).

i) Gender Parity Score

The second sub-index, the Gender Parity Score (GPI), measured the percentage of women that are equally empowered as the men in their households. We established the mean score of 6DE empowerment for male respondents and then used it as the cut-off for women parity. Any female respondent that had a 6DE score that is equal or higher of the mean male 6DE score was considered to have parity in the study.

$$Gender\ Parity = Female\ 6DE\ score\ \geq Mean\ male\ 6DE\ score \quad (1)$$

The empowerment gap was estimated by establishing the mean empowerment score for the female respondents that had not achieved gender parity and subtracting it from the mean 6DE score for the male respondents.

$$GPI = 1 - (percentage\ of\ women\ not\ achieving\ parity\ x\ empowerment\ gap) \quad (2)$$

The final A-WEAI is calculated on an aggregate level and is the weighted sum of the 6DE and GPI:

$$A - WEAI = 0.9\ x\ 6DE + 0.1\ x\ GPI \quad (3)$$

2.3 Data analysis

We estimated two versions of the index to compare the empowerment levels with and without the climate dimension. First, we investigated the dynamics of empowerment among the domains and sub-indicators. As the data was not normally distributed, non-parametric methods were used to test for significant differences between male and female respondents. All comparisons between groups, e.g. levels of empowerment/adequacy between respondents, used the Kruskal-Wallis test. This test is the non-parametric version of the one-way ANOVA test, which compares two or more groups of an independent variable on a continuous or ordinal dependent variable. Second, to compare the two versions of the index, we estimated the number of empowered women in each district and tested for significant differences using the McNemar significance test.

3. Results

Our final analysis included 105 observations from Chitwan and 104 observations from Kaski. Respondents from Kaski tended to be younger and more educated compared to their counterparts from Chitwan. The Brahaman/Chettri caste represented the majority of the respondents in both

districts and both districts reported a similar number of households with migrants. Table 2 shows a breakdown of the respondent demographics from both districts.

Table 2. Descriptive statistics

Variable		Kaski		Chitwan	
		Male	Female	Male	Female
Mean Age		47	49	56	54
Caste	Brahaman/Chhetri	86%	91%	88%	87%
	Janajati	14%	5%	8%	13%
	Dalit	0%	4%	4%	0%
Education	Primary (5 to 7 years)	18%	25%	6%	14%
	Secondary (8 years or more)	63%	65%	58%	59%
Marital status (married living with spouse)		98%	97%	99%	97%
Households with migrants		24%	38%	36%	37%
Observations		49	55	67	38

Table 3 presents observed rainfall patterns in Chitwan and Kaski districts. Average rainfall in the last 30 years was above 2,000 mm/year. Average rainy days were high in the Kasti district compared to Chitwan. The coefficient of variation in annual rainfall and annual dry spell length were significantly different between the districts. The coefficient of variation in annual rainfall was high in Chitwan, but the coefficient of variation in annual dry spell length was high in Kaski. Overall, the rainfall pattern in Chitwan is highly variable with low annual rainfall, low rainy days, high dry spell length, and a high coefficient of variation in annual rainfall compared to Kaski.

Table 3. Observed rainfall patterns in Chitwan and Kaski district (based on the last 30 years climate data analysis)

District	Average annual rainfall (mm)	Average rainy days in a year	Average dry spell length in a year	Coefficient of variation in annual rainfall	Coefficient of variation in annual rainy days	Coefficient of variation in annual dry spell length
Chitwan	2,016	89	66	21	10	28
Kaski	4,274	137	48	13	12	34

Note: high coefficient of variation indicates more uneven rainfall pattern and high risks

In Kaski, 59% of the respondents had observed an increase in the overall rainfall, intensity and frequency, more than any of the other climatic events. Whereas higher temperatures, heatwaves and hotter months than usual were the most observed climatic event in Chitwan as observed by 81% of the respondents. A shift in the season timings i.e. their start and end was the second most observed climate event for both Kaski and Chitwan. The types of observed climate change within the districts are summarized in Table 4.

Table 4. Types of climate change observed by households in Kaski and Chitwan

Type of variability observed	**Kaski**		**Chitwan**	
	Male	**Female**	**Male**	**Female**
Less rain during summer, monsoon and winter	6%	15%	31%	26%
More overall rainfall, high intensity of rainfall, more frequent floods (during monsoon)	63%	55%	36%	24%
Change in rain i.e. late start, early start, late stop, early stop and untimely rainfall	14%	13%	57%	55%
Higher temperatures, heat waves and hotter months than usual (in the summer), average temperature increase (overall)	4%	7%	88%	68%
Lower temperatures, cold waves, frost and colder months than usual (in the winter), average temperature decrease (overall)	27%	31%	69%	63%
Season change, shift in timings of seasons, uneven weather fluctuations (overall)	47%	55%	82%	63%
Water scarcity, increasing water shortages, water table level drop, prolonged drought and frequent droughts (summer)	8%	16%	43%	34%

A variety of mitigation and adaptation strategies are used in both districts. To mitigate and adapt to climate change, respondents from both districts used machinery tillage (100% in Chitwan and 77% in Kaski) to minimize the impact of increasing labor scarcity. Other widely utilized strategies were improved breeds for livestock (65% in Kaski and 97% in Chitwan) along with disease and pest control for crops (63% in Kaski and 92% in Chitwan). The adoption rates of various mitigation and adaptation strategies are summarized in

Table 5.

Table 5. Adoption rates of mitigation and adaptation strategies in Kaski and Chitwan

Climate Strategy	Kaski		Chitwan	
	Male	**Female**	**Male**	**Female**
Tractor use for tillage	76%	78%	100%	100%
Use of new seed variety	59%	67%	82%	87%
Improved breeds	76%	56%	97%	97%
Disease and pest management	55%	42%	93%	92%
Agro-Advisory	33%	35%	13%	8%
Crop nutrient management	31%	29%	0%	3%
Fodder and pasture management	45%	24%	88%	87%
Rainfall and temperature information	14%	18%	16%	11%
Mixed cropping	8%	9%	9%	16%
Raised bed planting	10%	7%	6%	3%

3.1 A-WEAI and key drivers of disempowerment of women

When comparing men and women, we found no significant differences between men and women across the nine sub-indicators in Kaski, except for land ownership. In Kaski, 91% of female respondents said they solely or jointly own land compared to 71% of the male respondents. In Chitwan, there was a greater difference between the male and female respondents in the input in productive decisions, access to credit, decision-making over household expenditure and awareness

to climate change. Male respondents had the upper hand when it came input in productive decisions and awareness to climate change at 99% and 88% as compared to 63% and 66% for female respondents. Female respondents were significantly better at accessing credit (63%), making decisions over household income (100%) and participating in community groups (95%). A comparison of the sub-indicators, their mean scores and total empowerment for males and females in both districts are in Table 2.

Table 6. Comparison and male and female empowerment between Kaski and Chitwan

Domain	Variable	Kaski			Chitwan		
		Mean		P-Value	Mean		P-Value
		Male	*Female*		*Male*	*Female*	
Production	Respondent has sole or joint decision-making powers over farm activities	0.57	0.53	0.65	0.99	0.63	0.00
	Respondent owns land, solely or jointly	0.71	0.91	0.01	0.97	0.90	0.11
Resources	Respondent owns assets, solely or jointly	1.00	1.00	NA	1.00	1.00	NA
	Access to credit (who accessed the loan)	0	0	NA	0.43	0.63	0.05
Income	Respondent has sole or joint decision-making powers over household expenditure	0	0	NA	0.85	1	0.01
Leadership	Membership (any group)	0.78	0.87	0.19	0.84	0.95	0.10
Time	Respondent works less than 10.5 hrs. per day	1.00	1.00	NA	1	1	NA
	Respondent has accessed extension services	0.33	0.35	NA	0.66	0.55	0.29
Climate	Respondent has used at least one climate coping and mitigation strategy on their farm	0.98	0.93	0.84	1	1	NA
	Respondent is aware of Climate Change	0	0	0.22	0.88	0.66	0.01
Total Empowerment Score (6DE)		0.57	0.58		0.89	0.87	

Achieved Empowerment (%)	0	0	75	68
Gender Parity Index (GPI)		0.96		0.95
Achieved Gender Parity (%)		44		53
A-WEAI Score		0.62		0.88

Across the levels of empowerment between men and women by domain, we found Chitwan had a higher level of empowerment (0.89 and 0.87), for male and female respondents respectively, as compared to Kaski (0.57 and 0.58). Kaski had no respondent, male or female, that met the adequacy cut-off for empowerment. Chitwan fared better with 75% of the male respondents and 68% of the female respondents meeting the adequacy cut-off and thus being empowered. The same was seen in gender parity where 53% of female respondents in Chitwan had parity with male respondents while in Kaski it was 44%. The gender parity score in Kaski was slightly higher (0.96) compared to Chitwan (0.95). The final women's empowerment score in Chitwan (0.88) was higher as compared to Kaski (0.62).

Regarding the biggest contributors to disempowerment in Kaski, control over income was the leading contributor (40%) followed by climate adaptability (23%) for the female respondents. While for the male respondents, control over income contributed most to their disempowerment (39%) also followed by climate (22%). Female respondents in Chitwan had input in productive decisions (46%) as their biggest contributor to disempowerment followed by climate adaptability (33%). Chitwan's male respondents had resources as their biggest contributor to disempowerment (28%) followed by group membership (24%). Climate was a significant contributor to disempowerment in both districts. For women in both districts, it was the second biggest contributor to disempowerment, 23% in Kaski and 33% in Chitwan (figure 2).

As the climate domain was a significant contributor to disempowerment, the study also found Chitwan respondents having observed twice the number of climatic events (3.8) as compared to Kaski respondents (1.8). The difference in observed frequency of the climatic events between the districts being significant at the 1% level.

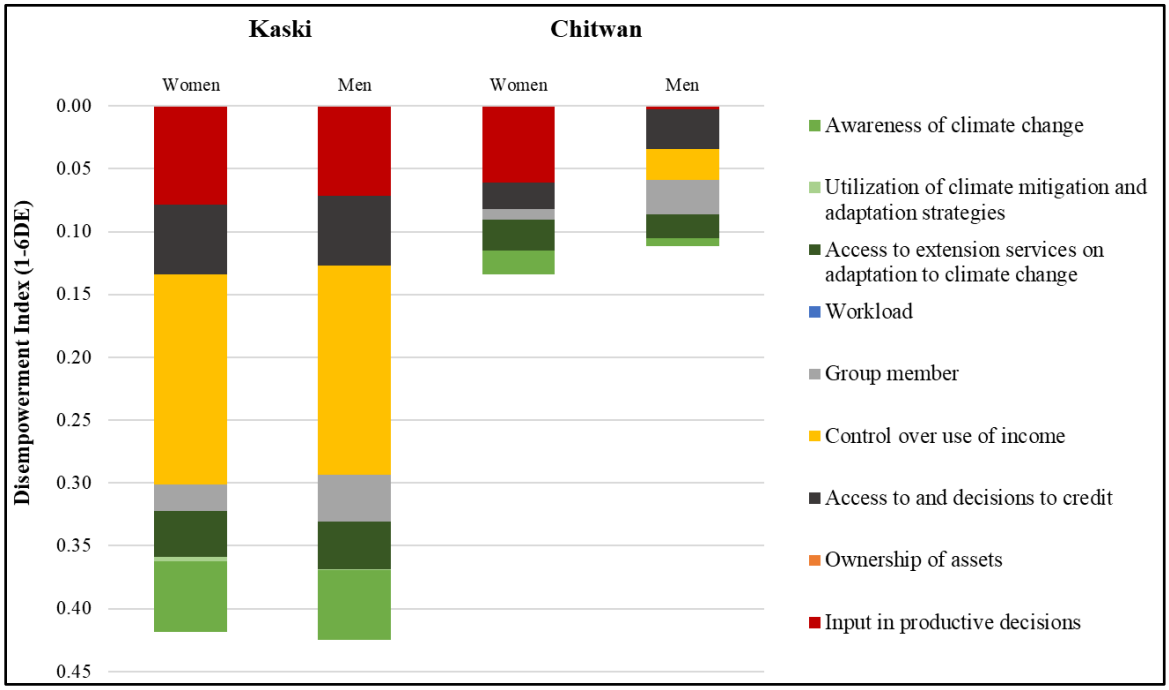

Figure 2. Contribution of each indicator to disempowerment in Kaski and Chitwan

3.2 Index comparison

Women had a lower domain empowerment score (0.721) in the AWEAI with a climate domain as compared to the AWEAI without a climate domain (0.754). This can be attributed to how the climate domain was a big contributor to disempowerment for respondents in this study. Only just 28% of women were empowered in the climate AWEAI while 34% ended up being empowered in the AWEAI without the climate domain. Overall, this led to a lower AWEAI score for women in the climate index (0.745) in comparison to the original AWEAI index where they scored (0.776).

On conducting a McNemar significance test between the indices, this study found that the difference in female empowerment between the indices was significant at the 5% level (*p-value = 0.041*).

Table 7. Comparison of A-WEAI with and without the climate domain

Indicator	**Nepal**			
	Climate_AWEAI		**Original_AWEAI**	
	Women	**Men**	**Women**	**Men**
DE score (1-M0)	0.721	0.778	0.754	0.798
Disempowerment score (1-DE)	0.279	0.222	0.246	0.202
N (number of observations)	93	116	93	116
% of individuals achieving empowerment (1-H)	0.280	0.431	0.344	0.474
% of individuals not achieving empowerment (H)	0.720	0.569	0.656	0.526
Mean DE score for not yet empowered individuals (1 - A)	0.387	0.390	0.375	0.384
Mean disempowerment score (1 - DE) for not yet empowered individuals (A)	0.613	0.610	0.625	0.616
GPI score (1 – HGPI x IGPI)	0.962		0.970	
% of women achieving gender parity (1 - HGPI)	0.355		0.344	
% of women not achieving gender parity (HGPI)	0.645		0.656	
Average empowerment gap (IGPI)	6%		5%	
A-WEAI score (0.9 x DE + 0.1 x GPI)	**0.745**		**0.776**	

4. Discussion

Overall, men were more empowered than women, particularly related to land ownership and climate. Women still displayed high levels of land ownership, with 9 out of 10 responding to owning land, solely of jointly, in both districts. As over 95% of all female respondents in both districts are married and are of the Brahaman/Chhetri caste (over 85%), it helps explain the high level of land ownership. According to Basnet (2011), most women in Nepal secure land ownership as wives and daughters-in-law. Kaski displayed a contrasting observation as women showed more land ownership (91%) as compared to men (71%). Though not clear, there are some reasons for this observation, one being out-migration. Kaski is a part of a region that collects the highest

remittances in Nepal (MoAD, 2018), as men are more likely to seek off-farm income to improve their livelihoods. Men are likely to sell off their farm land and remain with houses as they are engaged with off-farm income generating activities. Women on the other hand have limited mobility as they are engaged in productive and reproductive duties at the household level. Another reason being the lower land registration fees for women that were introduced by the Nepalese government in an effort to improve women's land ownership (Rijal, 2017). This has prompted an increased tendency to have land registered in the household female's name to take advantage of the low registration fees women pay (ibid).

4.1 Climate disempowerment

In both districts, the second biggest contributor to female disempowerment was the climate domain. As the majority of Kaski respondents reported experiencing increased intensity and frequency of rainfall, this exposure could lead to increased chances of floods. The perception of rainfall increase matches climate models which predict an overall increase in annual precipitation in Nepal by 2050 (Agrawala et al., 2003). In terms of gender implications, natural disasters tend to adversely affect women more than men. FAO (2018) estimated that women to be 14 times more likely to die from natural disasters like floods than men. Flood run-offs can wash over agricultural land leading to crop failure, livestock loss and even loss of entire fields (Nellemann, Verma, & Hislop, 2011). Women will be subjected to increased agricultural work to make up for crop loss FAO (2018) while also fetching and purifying water from water sources rendered unsafe from the influx of contaminants during floods (Nellemann et al., 2011).

4.1.1 Perception of climate change

The slight difference in intra-household perceptions to climate change has also been observed in other household survey studies in rural Kenya (Ngigi, Mueller, & Birner, 2017), Vietnam (McKinley, Adaro, Pede, Setiyono, & Thang, 2016) and Nepal (Bastakoti & Doneys, 2019). As women at the household level have both agricultural and domestic duties including maintaining natural resources, they tend to perceive climate change slightly different from men (ibid). Overall, Chitwan respondents observed rising temperatures and an increase in heat waves does follow the same trend seen in temperature models for Nepal (Agrawala et al., 2003). Warming in Nepal has been consistent and continuous at an annual rate of 0.06 ℃ between 1977-1994 (ibid). Increases in temperature can have adverse consequences to most crops and also lead to drought and drying up of water sources. The stress for resources can often lead to out-migration of male household members to search for other sources of income, leading to increased burden to the women left at home (UNDP, 2011). As women are also required to walk greater distances in search of water and fuel this limits their time that could have been spent on other income generating activities, access to extension services and participation in community decision-making groups (Nellemann et al., 2011). Climate change is therefore a direct threat to women's lives and impacts the agency women have over other dimensions of empowerment such at time, group membership and resources.

4.1.2 Awaraness of climate change

The climate domain also considered awareness of climate change. As awareness is closely linked to behavioral change, its absence can present a significant barrier to adaptation in developing countries. A survey of 5,060 households in Nepal in 2016 revealed that less than 50% of the respondents were aware of climate change, even though they might be aware of changing weather patterns (Tanner, Acharya, & Bahadur, 2018). Communities in mountainous areas had an even

lower awareness with 63% of households being unaware of climate change (ibid). This mirrors what this study found with awareness to climate change being significantly lower in the highlands of Kaski (0%) as compared to Chitwan (77%). The National Adaptation Programme of Action (NAPA) highlighted capacity building and raising awareness as key to improving adaptability to climate change at the national and local level (Khadka, Sapkota, Sharma, Ghimire, & Paudel, 2018). As both districts reported a low awareness of climate change, policymakers should focus on improving awareness.

The lack of climate change awareness could be addressed by improving formal education, extension programs and group activities. Halady and Rao (2010) suggested that identifying and prioritizing climate information that has an immediate impact on recipients, such as health and financial impacts, as it has shown to have a substantial uptake and transformative effect on recipients. Agricultural extension services work to provide technical advice, assistance and knowledge to farmers and supply inputs and services to support their agricultural production (FAO, 2017b). In the context to climate change, these services, inputs and advice relate to improving farmer's resilience to changing climate patterns. Nepal began using the agricultural extension in efforts to boost economic growth through farmers and agriculture since 1952 (FAO, 2019). However, there is minimal gender-responsive research and investment into less labor-intensive, time-saving technology and more gender-neutral extension services (FAO, 2019). Extension services coverage in Nepal is also very limited: one extension officer is expected to cover an average of 3,000 people and one extension center oversees 1,500 households (ibid).

4.1.3 Access to extension services related to climate adaptation

Access to extension services related to climate adaptation was low in Kaski (35% of female respondents) while in Chitwan, 55% of females had access. A similar observation by the ministry of agriculture and development in Nepal after it launched several agricultural programs such as,

Irrigation and Water Resources Management, Forest Cover Restoration, High Value Agriculture etc., on a district level to help build capacity for smallholder farmers. Out of the nine projects, the pilot climate resilience project saw the least female participation with women accounting for 13.4 % of the participants (FAO, 2019). The average participation of women in the other eight projects was at 49 % (ibid). A viable reason for low access to extension services might be due to the limited number of female extension workers in Nepal (FAO, 2010). In Nepal, only 11% of public employees working to provide agricultural services are women (MoAD, 2017).

The process of improving women's access to extension services can be achieved by increasing the number of female extension workers, implementing gender-sensitive practices and technologies (FAO, 2017a). Male extension workers usually do not cater towards gender sensitive service delivery skills that address the cultural practices that limit women's participation. Issues such as lack of mobility, limited technology that is women-friendly and, the domestic child rearing and providing nutrition duties that women are responsible for (MoAD, 2017). The dominance of male extension service workers also limits female participation in cultures that do not allow women to interact with men that are not family/in the same household. Addressing the shortage of female extension workers could promote innovation and change in a community (Anshida Beevi, Wason, Padaria, & Singh, 2018).

Overall, extension services need to assess and incorporate the different perceptions, needs and responsibilities that men and women have in the context of climate change during the intervention process. It is important to view women as positive agents of adaptation and mitigation and not just victims of climate change (Songani, 2016). Their knowledge and experience should be incorporated from the design and conception stage of intervention programs. Failure to do so can

exacerbate women's disempowerment, for example when the use of fertilizers can lead to increased time spent on weeding or harvesting process for women (Hadgu et al., 2019).

4.1.4 Utilization of climate mitigation and adaptation strategies

Gender-sensitive practices should also consider the cultural, social and resource limitations women have in their community (FAO, 2017a). In Ethiopia for example, reception to extension services was higher in regions where development agents conformed to social norms and local conditions (Cohen & Lemma, 2010). Male agents wearing the same clothes as local farmers while female agents would cover their heads as the local Muslim female majority do helped build trust and rapport (ibid). Further, extension programs can use female-friendly outreach strategies (Anshida Beevi et al., 2018). One of the challenges is the criteria to select and enroll farmers into extension services. Criteria such as land ownership, literacy level and, farmer's association membership are avenues, in which women are currently less empowered than men (ibid). Thus, if these criteria are used, decision-makers should be aware of this inequality.

Provision of gender-sensitive technology includes the designing of mechanized tools, improving access to resources, information and training in order for women to procure, access and utilize the technology (Jones, 2019). In Bolivia where women were not consulted with regards to post-harvest technology for sorting and handling potatoes (UNCTAD, 2020). This resulted in the introduction of mechanized equipment, which had considerable feedback from men during design phase, that was never adopted by the women. The physical requirements did not suit women thus the intervention team having observed this and understood the difficulties in adoption had to redesigned it to work based on a simpler, gravity-fed low bearing technique. This considerably improved the adoption of the technology amongst women during potatoes post-harvest. Another example is the introduction of fuel-efficient stoves to help women's domestic resource management duties. A project in Ethiopia introduced women to the design and construction of 50%

fuel efficient stoves that eventually had a triple effect within the target community (Hadgu, Bishaw, Iiyama, & Birhane, 2019). Reduced firewood consumption helped save vegetation cover, women spent less time collecting firewood for fuel and selling of the stoves helped generate some off-farm income. This allowed women more time to spend attending community groups and extension services, thus improving their empowerment in decision-making and participation in agricultural services. Policy and decision-makers should therefore ensure the active participation of women in the planning, designing and implementation of extension services. This will deliver equitable practices and technologies that improve agricultural productivity, income and livelihoods.

Respondents showed high adoption rates of mitigation and adaptation strategies, with over 90% of the respondents from both districts utilizing at least one mitigation and adaptation strategy. According to Abbasi and Nawaz (2020), adaptation strategies can be grouped into short run (characterized with autonomous actions on the back of local knowledge) e.g. addressing localized problem, and long run (which lead to transformative actions) e.g. large scale policy interventions. Respondents in study displayed adoption of autonomous, short run strategies to address localized context (Table 5). This state of autonomous adaptability to climate change has been cited in other studies as being prevalent in rural Nepal communities.

According to World Resources Institute (2013) many communities in Nepal, especially in the poorly-documented informal sector, have been responding and adapting to climate change autonomously. The measures taken individually or collectively by the communities are aimed at adopting new technologies and practices, accessing financial institutions for insurance and credits as well as diversification of their income and production activities (ibid).

This study found that in both districts, women adopted tractors, improved breeds and employing disease and pest management techniques. Other strategies such as crop insurance and

crop rotation were hardly adopted dues to limited availability and capacity. For example, Nepal currently does not have crop insurance in the traditional sense as it is perceived to be too complicated to design and implement (World Bank, 2009). However, there are currently two pilot schemes have been undertaken in two districts including Chitwan (ibid). There is a need for policy makers to further identify and address the barriers to adoption of adaptation strategies at the community level.

Our recommendations closely align with political efforts in Nepal. Since 2010, the government of Nepal has allocated considerable efforts to address climate change and gender issues from the national to local level. The government launched the National Adaptation Programme for Actions (NAPA) to identify the adaptation needs; develop and execute strategies and programmes to address these needs of at-risk communities (Abeysinghe, Dambacher, & Byrnes, 2017). NAPA is one of the few policies promoting the development and utilization of gender sensitive technologies for climate adaptation (Paudyal et al., 2019) and aims to improve information and communications on climate related risks, education on climate change and coping strategies as well as economic diversification within rural communities.

In 2012, the Nepal government adopted the nation's Climate Change Gender Action Plans (ccGAP), a gender centric plan to address agriculture and food security, forests, water, energy, health, and urbanization (IUCN, 2012). Nepal's ccGAP became one of the earliest policies to focus on gender dynamics related to agricultural production and climate related risks. The government of Nepal has also been proactively increasing its budget allocation towards climate change from 10.3% in the budget year 2013-14 to 30.8% in 2017-18 (Paudyal et al., 2019). However, its gender-neutral expenditure nature has been criticized as the adverse effects of climate change are not gender neutral (ibid). While these political steps signal change in a positive direction, we

recommend that efforts also focus on formal education, extension programs and groups to improve empowerment among rural women in Nepal.

5. Conclusion

Climate change and women's empowerment in agriculture are closely linked. Climate change can increase the workload of women in agricultural households and increase women's dependency on the natural environment, while disempowerment can limit women's adaptive capacity. As previous measurements of women's empowerment in agriculture (i.e. using the Abbreviated Women's Empowerment in Agriculture Index) have not considered these links, they may misrepresent female disempowerment. In this study, we developed a climate dimension to the women's empowerment in the agriculture index, compared two ecologically diverse regions and found that significantly fewer women were empowered when the climate dimension was included. The difference signals the importance of supporting climate responsive strategies (e.g., improvements to formal education, extension programs and groups) for women to policymakers.

In our climate dimension, we included three sub-indicators: awareness to climate change, access to extension services on climate change, and utilization of climate mitigation and adaptation strategies. Following previous literature about climate adaptation, we focused on awareness of climate change and access to extension services as both are closely linked to the adoption of new technologies and practices. Further, we investigated the specific climate mitigation and adaptation practices used by households to understand whether they address short or long run adaptation.

This study found that overall women were less empowered in Nepal compared to men across the six domains. In both districts of Kaski and Chitwan, the climate was the second biggest contributor to disempowerment for women at 23% and 33% respectively. Climate change has

shown to exacerbate women's disempowerment as it affects other dimensions of empowerment such as time, leadership and access to resources. From the three climate sub-indicators, awareness was the biggest contributor (13%) to disempowerment in Kaski while access to extension services was the major hindrance (18%) in Chitwan. Thus, improving women's access to formal education, agriculture extension and climate information services, and local community-based farmers and other groups will improve the overall empowerment levels of rural women in Nepal. At the same time, empowering women can also improve the adaptive response of rural communities facing climate change. When women are included in planning and decision-making processes, it leverages female experiences and knowledge of natural resource management.

As climate risks are not gender neutral, decision-makers should actively promote gender sensitive technologies (e.g., sowing and weeding machines, rice transplanting machine, bio-gas plants and postharvest management technologies) and extension outreach (e.g., female extension officers, selection criteria for extension, and technology demonstration trials with women farmers groups). While Nepal has adopted several policies and plans to address climate change and gender dynamics, policy makers should ensure they have monitoring and measuring tools to track the effectiveness of the policies and actions for gender inclusion and performance.

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Appendix A.

Table A-1. Adequacy criteria for sub-indicators of empowerment

Domain	Sub-indicator	Adequacy Criteria
Production	Input in production decisions	Respondent has sole or joint decision-making powers for at least half of the farm activities
Resources	Ownership of assets	Respondent owns land, solely or jointly
		Respondent owns at least one major asset, solely or jointly
	Access to and decisions on credit	Respondent has borrowed money at least once in the last 24 months and has decision-making powers of the loan.
Income	Control over use of income	Respondent has sole or joint decision-making powers for at least half of the household expenditure items
Leadership	Group membership	Respondent is a member of at least one community group
Time	Workload	Respondent has worked less than 10.5 hours per day in the past 24 hrs.
Climate	Awareness of climate change	Respondent has heard of climate change
	Access to extension services on adaptation to climate change	Respondent has accessed extension services related to climate adaptation strategies before or during the year data was collected
	Utilization of climate mitigation and adaptation strategies	Respondent has employed at least one climate mitigation or adaptation strategy on his farm or livestock

Table A-2. Household decision-making, farm activities and expenditure items

Farm activities	Household expenditure items
Land preparation	Food items (grains, vegetables, fruits etc.)
Planting	Fuel and lighting (Kerosene, electricity, coal etc.)
Sowing	Household items (soap, toiletries etc.)
Tilling	House rent
Weeding	New home/repairs of home
Harvesting	Transport
Post harvesting	Telephone/mobile
Selling of produce	Personal items (clothes, shoes etc.)
Selling of land	Household durables (jewelry, vehicles etc.)
Adoption of technology	Education of household member

Leasing of land	Household healthcare services (purchasing medicine, doctor fees etc.)
	Agriculture (purchasing equipment)
	Major events (wedding, festivals etc.)

Table A-3. Mitigation and Adaptation Strategies

Climate mitigation and adaptation strategies
Tractor use for tillage
Use of new seed variety
Improved breed
Disease and pest management
Agro-Advisory
Crop nutrient management
Fodder and pasture management
Rainfall and temperature information
Mixed cropping
Raised Bed planting
Crop Insurance
Laser land levelling
Zero Tillage
Direct seeded
Crop rotation
Incorporation of rice/wheat straws

Table A-3. Community Groups

Community groups
Input supply/Farmer Cooperative
Crop/seed producer and marketing group
Local administration
Farmer's association
Women's association
Youth association
Savings and credit group
Water user's association