



Gender Specific Differences of Smallholder Farm Households Perspective of Food-Energy-Land Nexus Frameworks in Ethiopia

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The water-energy-food security nexus concept is a widely recognized analytical approach to achieve sustainable development goals. However, to date, related thinking has mostly been applied at higher scales in a top-down manner, while bottom-up and local scale applications remain limited. This includes the gender dimension of the nexus, which is one of the sustainable development goals. Narrowing this gap, this paper describes and assesses the food-energy-land nexus from a smallholder farm household perspective in the context of rural Ethiopia through a gender-specific lens. To explore the differences between men and women perspective of the nexus, we adopted the Actors, Resources, Dynamics, and Interactions (ARDI) to co-develop a mental model of the nexus concept combined with statistical analysis. Using this approach, we examined the key direct actors and the linkages between major resources including the processes that affect the management by gender. The results indicate that there are four aspects that differentiate male and female perspectives with respect to the water-energy-food nexus. These differences include (1) access to external actors, (2) perceptions of target resources, (3) gender specific productive roles, and (4) decision making with respect to target resource management and utilization, which may affect the dynamics and governance of the water-energy-food nexus. With regards to factors associated with time spent for collecting water and fuel and crop production vary according to gender type. Overlooking these differences could make the nexus approach unrealistic to achieve gender equity while further aggravating the already burdening roles of women including children within households.

Keywords: ARDI method, gender roles, intra-household heterogeneity, labor availability, mental model, trade-offs

INTRODUCTION

The water-energy-food (WEF) nexus concept has become central to sustainable development (Allouche et al., 2015), for technical assessments to improve resource recovery and system efficiency (Hoff, 2011; Scott et al., 2015), for identifying trade-offs and optimizing synergies across nexus sectors (Bazilian et al., 2011; Howells et al., 2013), and for designing efforts to alleviate poverty and food insecurity (Hoff, 2011; Ringler et al., 2013; Guta et al., 2017). In recent years the WEF

nexus concept has received considerable attention in government agenda (Allouche et al., 2015), however, the current nexus concept frameworks are often focused on macro-level drivers of resource consumption patterns (Biggs et al., 2015) and a few focus on a micro-level scale (Endo et al., 2017). Moreover, international private sector actors were among the active participants in the formulation of the WEF nexus concept that perceived the nexus both as an opportunity (e.g., green economy) (Hoff, 2011) and a constraint to their respective business activities (e.g., resource scarcity). Promoting nexus approaches to sustainably manage the resources requires understanding of the nature of the relationships among food, water, and energy (in this case fuelwood) resources and the consequences of changes due to possible interventions (Bizikova et al., 2013) especially at the micro-scale. Security of WEF resources remains the core element of the nexus challenge (Hoff, 2011; Bizikova et al., 2013) and it goes beyond access to related resources, which includes the capacity to utilize these resources as well as the social dynamics and power relationships that affect the management of these resources (Biggs et al., 2015). Allouche et al. (2015) pointed out that the current nexus debates mask a larger debate on resource inequality and access, which contribute to social instability and insecurity. With regards to gender equity, to the best of our knowledge, no study has yet examined gender dimensions of the WEF nexus concept and gender specific perspectives of WEF nexus implications for rural landscapes; including gender specific resources, drivers influencing nexus dynamics, e.g., access to (external) actors promoting bio-energy alternatives, and their interlinkages. Reflecting gender perspectives of the nexus concept helps to identify specific local factors that may determine the degree of resource security and sustainable management. Thus, the objective of this paper is to explore the nexus concept through a gender lens among smallholder farmers in rural Ethiopia by co-developing a gender-specific WEF nexus framework. We apply a bottom-up approach to the gender perspective of nexus dynamics. We also explore the different factors affecting the male and female time allocation for utilizing nexus resources.

Gender-Specific WEF Nexus Perspective

Several depictions of nexus frameworks are offered in the literature. However, there are still many missing components of the nexus dimensions, such as agriculture related issues on land, labor and livelihoods (Wichelns, 2017). In developing countries, especially in Sub-Saharan Africa, resource access for the poor remains a practical and policy challenge. Unequitable access to basic resources (e.g., water and land) is especially prevalent among women. Gender equality and equity is one of the Sustainable Development Goals (i.e., Goal 5) and yet, very few studies have considered the potential for differential effects WEF nexus interventions with respect to gender (Djanibekov et al., 2016), while almost no in-depth efforts are featured in global discussions of linkages between gender and WEF nexus approaches or interventions. In reality, women in developing countries are often intensively involved in agriculture (FAO, 2011). In many countries of Sub-Saharan Africa, women are responsible for providing food for their households in addition to procuring fuelwood for cooking and drinking water (Arndt

et al., 2011). However, their contribution are often not formally recognized and face obstacles to engaging on equitable and fair terms (Malapit et al., 2020). Perhaps this could be one of the reasons why gender is a missing component of existing WEF frameworks. Hence, Kurian et al. (2019) suggested to consider the culturally mediated roles of gender in access to land, irrigation water, forests affecting labor market participation and wages with regards to governing the WEF nexus in agricultural households, which may systematically disadvantages women and girls by making them more experience poverty (Agarwal, 2001).

Socially constructed gender roles, responsibilities, and daily activities, including their access and control over resources, lead men and women to perceive and interact differently with natural resources and landscapes (Kiptot et al., 2014; Villamor et al., 2014). Therefore, examination of the extent to which daily experiences and routines of farm household members are influenced by gender may offer explanations for gender-related variability in the perception of the WEF nexus concept. In this study, we explore gender as one of many factors influencing perspectives of the WEF nexus concept at the local household level using a conceptual model of nexus systems (Villamor, 2014). Elucidating household level perspectives of the nexus concept helps to understand—and delineate—different conceptualizations related dynamics (Jones et al., 2011; Lynam and Brown, 2012). Through gender-specific mental models, men and women can simulate their interactions with these dynamics (according to their real life experiences, perceptions, and understanding of local systems) (Jones et al., 2011).

In this study, we applied the Actor, Resources, Dynamics, and Interactions (ARDI) method developed by Etienne et al. (2011). This method focuses on encouraging stakeholders to describe, explain, and predict the purpose, form, function, and state of a given system so as to elicit causal knowledge. This approach has mainly been applied to natural resource management (Balbi et al., 2010) and socio-ecological systems (Lynam et al., 2012). The approach has been successfully applied for contrasting between the scientists' group and the local stakeholders' nexus conceptual models of WEF (Villamor et al., 2020), which allowed to highlight the key differences of the nexus. Rather than adopting and readjusting existing WEF frameworks, we applied the ARDI method to co-conceptualize WEF nexus systems (as a complex systems thinking) according to gender types. We assumed that using a bottom-up approach with each gender group would not only highlight the specific gender differences of the nexus systems but also would accommodate to integrate their specific social practices, daily activities and experiences. As a basis for triangulation, we combined this method with an observational study to determine the different factors affecting the amount of time spent by male and female for specific nexus related activities.

METHODS

Study Area

The study area included two major regions in Ethiopia, Amhara and Oromia regional states (**Figure 1**). These regions constitute the majority of the upper Nile Basin and are critical to the management of the entire basin (Karlberg et al., 2015). Within

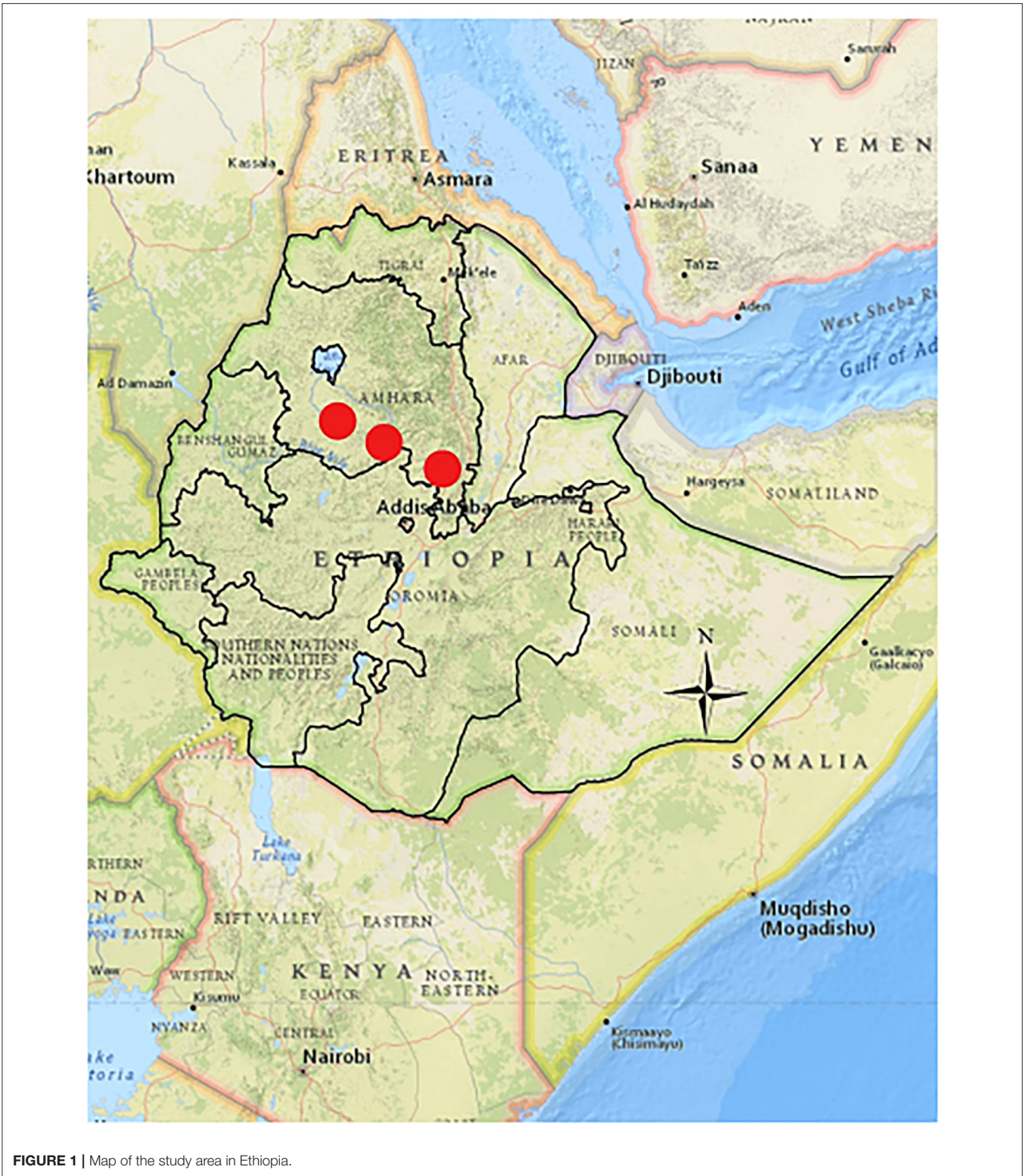


FIGURE 1 | Map of the study area in Ethiopia.

these regions, we selected three *kebeles* (the smallest official administrative units in Ethiopia), Gebezermariam and Bichena Debir in Amhara, and Sire Morose in Oromia. The study site

selection was mainly identified by the Woreda (equivalent of a district, composed of multiple *kebeles*) Administrative Offices based on the security concerns of the researchers and facilitators

at that time of field data collection at the same time, these kebeles were also included in the World Bank's Socio-Economic Survey (CSA-LSMS-WB, 2015) (see Data Collection and Analysis). The immediate landscape surrounding most of the *kebeles* in these regions include a mosaic of crop and pasture areas intermixed with small patches of woodlots. The area available for crop cultivation in Morose is relatively limited because most of the land is degraded. Only one *kebele* (Gebezemariam) has river access, which is a local source of irrigation water (i.e., modern irrigation systems). Other water needs are met by rainfall, springs, and pumped and manually dug wells. Most of the population engages in rain-fed agriculture, a minority has irrigated farmland. Springs used for irrigation only flow during the dry season (November to February) and dry up from February to May. According to the Woreda Administrative Office, the three *kebeles* host ~1,763 households, of which 20% (356) are female-headed households. Typical livestock includes cattle, horses, donkeys, sheep, goats, and domestic poultry. Mining of minerals and coal is an important economic activity in morose woreda, supporting ~235 people.

ARDI Approach

The ARDI approach, which is the conceptual framework of this study, is described in detail by Etienne et al. (2011). This approach frames the elicitation of individual knowledge that then leads to the emergence of collective learning. Sharing of representations of each stage leads to progressive emergence of a collective mental model. Among the many advantages of mental models are: they provide a collective representation of reality-based systems to improve decision-making processes (Dray et al., 2006; Elsayah et al., 2015); they can identify and inform strategies to overcome stakeholder knowledge limitations and misconceptions associated with a given resource (Morgan, 2002); and they facilitate the exploration of similarities and differences among different stakeholders' understanding of a particular issue in order to find ways to improve inter-stakeholder communication (Abel et al., 1998; Dah-gbeto and Villamor, 2016).

There are four different stages to this approach, which are briefly described below.

1. Identifying key actors (A): by listing stakeholders and their corresponding management entities and linkages between them. The participants (in this case male and female farmers) identify these stakeholders as either "direct" (whose practices have direct impacts on key resources) and "indirect" (whose actions have influence on the direct stakeholders to change their practices).
2. Identifying key resources (R): by listing the relevant resources (exclusively to products) of the study area according to the key stakeholders previously identified. For this study WEF resources were targeted.
3. Identifying key dynamics (D): by listing the main processes that drive resource dynamics in the study area. The processes may deal with ecological (e.g., water flow), economic (e.g., changing agricultural input prices), or social dynamics (e.g., collectivism or cultural identity).
4. Eliciting interactions (I): by collectively constructing an interaction diagram describing linkages among the identified stakeholders and resources. The participants also suggest a verb that characterizes the type of action that generates each linkage.

Once the listings of key actors, resources, and dynamics were prepared, the participants rank those according to their importance. The main output is a collective conceptual model of food-energy-land nexus.

Data Collection and Analysis

In fulfilling the ARDI components (or stages), we conducted a gender-segregated focus group discussion (FGD) based workshop and key stakeholder interviews at each study site. To select the participants for the FGD workshop, we first coordinated with the Woreda Administration Office of the selected *kebeles*. The representative from Woreda and agricultural development agents contacted local farmers to identify those willing to participate in the workshop activities. Initially, we conducted an exercise with a mixed-gender group; however, it became apparent that female participants would not speak openly in the company of men, so we decided to conduct gender segregated pretests before holding the FGD workshops. We conducted two pretests with male-only and female-only groups in the *kebele* Aleltu in Oromia on March 2016 to refine the central discussion questions for the FGD workshops. The pretest participants included extension officers, Woreda representatives, and local farmers identified by Woreda representatives as experts.

A total of six FGD workshops (one female-only group and one male-only group per study site) were conducted between April and June 2016. There were 48 willing participants (24 males and 24 females). Each group was composed of seven to nine participants identified by the Woreda and agricultural development representatives. The majority of the participants were married and their ages ranged between 35 and 60 years. The FGDs were facilitated by the researchers from the Center for Environment and Development Studies, Addis Ababa University, which speak the local languages of the two regions (i.e., Amharic and Afaan Oromo). Each FGD workshop lasted for ~4 h. During the FGD-workshops the central discussion questions were: How do (male and female) farmers manage their land for food and fuelwood energy production, and to conserve water, and What drives the change of the same food and energy resources, which were used to analyze the gender differences. Within the discussion of each question, follow-up questions were asked according to the ARDI method, including:

- Who are the main stakeholders who interact with farmers regarding land management (*actors*)?
- What are the primary resources of the managed landscape (*resources*)?
- What are the main processes that drive changes in resource production (*dynamics*)?
- How do farmers use the WEF nexus resources (*interactions*)?

The last question builds on the interactions between the users and resources and is crucial for synthesizing the response to the

first three questions, which contribute to the mental model of the local WEF system. We analyzed the results of six FGD workshops based on the integration of all actors, resources, dynamics and interactions organized into two graphical conceptual diagrams of the nexus system. Based on those diagrams, we differentiated elements by gender.

After identifying the key elements of the local nexus system from a gender perspective, we conducted two additional gender segregated workshops in July of 2017, in Aleltu to validate and verify the key results. There were seven participants in the male-only group and nine participants in the female-only group, which were also facilitated by the Center for Environment and Development Studies, and kebele and Woreda representatives. We further verified the general daily activities of both male and female farmers during the workshop.

Moreover, the results of the qualitative data analyses were compared with the descriptive statistics from the Ethiopia Socio-economic Survey conducted by the World Bank for 2013–2014 (CSA-LSMS-WB, 2015), which is derived from 3,744 households (Table 1 for descriptive statistics). That survey was financed and conducted by the World Bank to examine linkages between agricultural development and household income activities in the country. We ran a regression analysis of this dataset to account for the competition for household labor time and to determine the factors affecting the amount of time spent between gender on crop production, and collection of domestic energy and water. For regression analysis, we used the statistical software STATA 15.0.

RESULTS

In this section, we present the results of our study according to each of the research questions given in section Data collection and analysis. First, we describe the direct actors involved in the WEF nexus among rural male and female farmers. Then, we describe the role of WEF nexus resources in the livelihoods, as well as, the processes driving changes in WEF nexus and usage of WEF resources according to gender. Finally, we determine the factors affecting the differences between males and females, particularly in the allocation of their time for fuelwood and water collection and crop food production.

Direct (External) Actors

Gender specific perspectives of the direct actors involved in access to and the management of local nexus resources among farmers are summarized in Figure 2 whereas the brief description of the direct actors are presented in Table 2. The female-only groups identified a total of six direct actors; whereas, the male-only groups identified seven direct actors, of which one is specific to the energy sector. All identified sector actors are coordinated by the Administrative Office/Bureau. This suggests that the Administrative Office/Bureau serves as the mediator between sectorial actors and farmers. Cooperatives are perceived as direct non-governmental actors that provide access to credit and resources, such as seeds, fertilizers, and solar panels. From their perspective, all of the sector actors are in collaboration (as shown by arrows in Figure 2) except for the Mineral and Energy

Bureau, which coordinates only with the Agriculture Bureau and Administrative Office.

In terms of the direct actors with links with nexus resources, male farmers exhibited greater specific knowledge of external actors. Female farmers were more likely to identify the Health Bureau associated with the energy because it promotes improved cook stoves that reduce negative health impacts relative to traditional stoves. In addition, there is typically a more direct connection between female household heads and the Health Bureau relative to male household heads (Figure 2).

WEF Nexus Resources

Energy Use

Households mainly depend on bioenergy sources to meet their residential energy demand due to lack of access to a centralized electrical grid. Fuelwood derived from eucalyptus (*Eucalyptus globulus*) trees is the major source of household domestic energy, followed by dried cattle dung (hereafter “dung cake”) and crop residues (dried vegetative material from crops, such as maize and sorghum).

Fuelwood is collected from household farms or purchased from other farmers. On average, households spend around 3 months per year in the preparation and collection of fuelwood. This includes harvesting trees as well as splitting and stacking fuelwood to dry, which are responsibilities typically undertaken by adult male household members; whereas, women and children are responsible for transporting fresh cut fuelwood from harvest sites to households. Hired daily laborers, adult male relatives, or neighbors serve as substitutes, if there are no adult male household members. Households can generate between 300 and 750 kg of fuelwood from a single eucalyptus tree. The entire process of converting a single (mature) eucalyptus tree into fuelwood requires between 9 and 27 h. A daily laborer hired to perform these tasks is paid from 70 to 210 ETB per day (as of 2017)¹. Households are forbidden from collecting fuelwood from communal forests and subject to a fine for non-compliance with this prohibition.

Dung cake is the second most commonly used energy source for domestic residential needs. It is commonly used during *belg* from March to May (during which there is minor rain) and *kiremt*—the main rainy seasons from June to August seasons and typically prepared during the *tsede* from September to November, *bega* is the dry season from December to February. This is because the *tsede* and *bega* are mostly dry seasons; thus, it is convenient to prepare, dry, and pile dung cakes whereas *belg* and *kiremt* are rainy and cold seasons, which mean there is high demand for residential energy use. Women and children collect cattle dung from household farm fields and pastures. On average, a household spends half an hour each day or around 9 h per week during those months for dung collection. A grown woman can prepare ~100 dung cakes within 3 h. Dung cake is used for cooking “*wot*” (a traditional stew) and for baking *injera* (a dietary staple). In addition, dung is used by all farmers directly as an organic soil additive or else composted to improve soil

¹ 1 Ethiopian Birr = 0.036 United States dollar.

TABLE 1 | Descriptive statistics of rural households in Ethiopia (Source: CSA-LSMS-WB, 2015) (N = 3,744).

Variable	HH gender	N	Average	Std. Dev.	Min	Max
Annual mean precipitation (mm)	Total	3,682	1,100.42	410.62	144	2031
	Female	930	1,101.56	409.76	144	2031
	Male	2,752	1,111.05	409.98	144	2031
Annual mean temperature (°C + 10)	Total	3,682	193.40	35.42	106	294
	Female	930	193.21	35.30	106	294
	Male	2,752	192.96	35.48	106	294
Assets last year (USD \$/yr)	Total	3,682	132.26	236.94	1	9,367.86
	Female	930	95.18	133.12	1	2,482.76
	Male	2,752	145.12	261.68	1	9,367.86
Distance to market (km)	Total	3,682	68.32	51.78	0.50	283.30
	Female	930	68.22	51.66	0.50	283.30
	Male	2,752	68.24	52.12	0.50	283.30
Distance to nearest population (km)	Total	3,682	40.48	34.03	1.70	214.10
	Female	930	40.20	33.60	1.70	214.10
	Male	2,752	39.82	33.88	1.70	211.90
Distance to nearest major road (km)	Total	3,682	17.45	23.79	0	242
	Female	930	17.31	23.64	0	242
	Male	2,752	17.32	23.71	0	242
Household size	Total	3,740	4.99	2.39	1	16
	Female	1,785	5.04	2.38	1	16
	Male	2,715	5.04	2.39	1	16
Household in kind (BIRR)	Total	3,741	112.64	5558.39	0	336,000
	Female	1,786	194.29	7951.01	0	336,000
	Male	2,717	126.27	6446.13	0	336,000
Household wage (BIRR)	Total					
	Female	1,786	228.18	2743.32	0	105,000
	Male	2,717	173.45	2229.27	0	105,000
Head education ^a	Total	1,342	9.70	14.69	0	98
	Female	598	8.72	13.91	0	98
	Male	842	8.52	14.99	0	98
Labor availability	Total	3,744	2.59	1.42	0	10
	Female	974	1.97	1.42	0	10
	Male	2,770	2.82	1.36	0	10
Parcel certificate	Total	3,319	1.69	0.61	1	3
	Female	1,654	1.68	0.61	1	3
	Male	2,514	1.67	0.62	1	3
Land size (m ²)	Total	3,488	13,237	44,354.73	0	1,264,565
	Female	1,716	14,295	47,003.91	0	1,264,565
	Male	2,604	12,880	28,576.50	0	878,836
Number of females per hh (> 16 yr)	Total	3,774	1.48	0.871	0	9
	Female	974	1.56	0.882	1	9
	Male	2,770	1.46	0.866	0	7
Number of males per hh (> 16 yr)	Total	3,774	1.40	1.019	0	7
	Female	974	0.76	0.943	0	4
	Male	2,770	1.62	0.949	0	7
Sell harvest value (BIRR)	Total	2,799	1,197.56	4,717.06	0	125,000
	Female	1,451	1,074.42	4,007.98	0	69,860
	Male	2,716	1,180.71	4,241.99	0	83,200
Time spent by males on agriculture (hours)	Total	3,136	23.04	28.68	0	258
	Female	367	17.74	24.79	0	154
	Male	2,769	23.75	29.08	0	253

(Continued)

TABLE 1 | Continued

Time spent by females on agriculture (hour)	Total	3,573	11.71	19.82	0	220
	Female	974	11.90	19.35	0	133
	Male	2,599	11.64	19.99	0	220
Time spent harvesting by household (hour)	Total	3,039	439.54	664.13	0	11,004
	Female	652	270.55	450.10	0	5,772
	Male	2,387	485.71	704.54	0	11,004
Time spent by males on fuel collection (hour/day)	Total	3,133	0.16	0.74	0	15.58
	Female	599	0.46	0.98	0	9.00
	Male	2,769	0.16	0.76	0	15.50
Time spent by females on fuel collection (hour/day)	Total	3,572	0.44	0.98	0	10.33
	Female	287	1.34	1.42	0.02	10.33
	Male	109	0.06	0.41	0	3.00
Time spent by female on water collection (hour/day)	Total	2,222	0.73	0.82	0.02	10.00
	Female	560	0.68	0.89	0.02	10.00
	Male	1,662	0.74	0.80	0.02	8.00
Time spent by male on water collection (hour/day)	Total	423	0.72	0.98	0.02	10.00
	Female	63	0.73	0.69	0.03	3.00
	Male	360	0.72	1.02	0.02	10.00
Total livestock (TLU)	Total	2,995	4.92	5.29	0	85.13
	Female	622	3.66	3.97	0	28.94
	Male	2,373	5.26	5.54	0	85.13
Total chemical fertilizer purchased (kg)	Total	3,530	48.26	142.27	0	4000
	Female	869	26.85	64.84	0	600
	Male	2,661	55.25	159.01	0	4000

^aReference category illiterate.

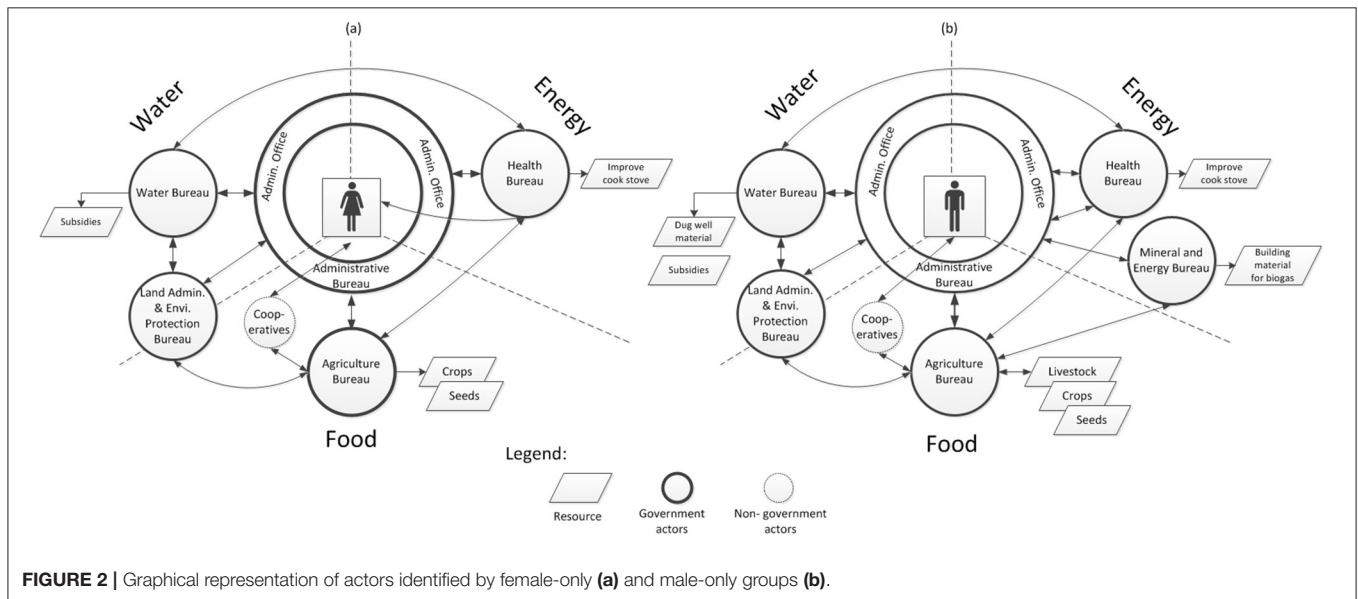


FIGURE 2 | Graphical representation of actors identified by female-only (a) and male-only groups (b).

fertility for household vegetable production. According to the workshop participants, the use of dung reduces fertilizer costs by 650 ETB ha⁻¹. Due to the scarcity of raw material (i.e., limited number of cattle), the amount of dung used for soil fertility treatment per household is minimal; hence, it is only applied for

household vegetable production. Even if sufficient raw material (cattle dung) is available, it is cumbersome to compost in large amounts because it requires substantial labor for preparation and transport from pasture areas. In addition, composting cattle dung requires ~50 l of water during the decomposition process.

TABLE 2 | Direct actors, resources, and interactions identified by the female-only and male-only groups in the study area (Source: Own data).

Key actor	Resource	Interaction	
		According to females	According to males
Agriculture Bureau	Training, improved seed, technology, equipment, improved poultry	Trains farmers on various agricultural practices; works with cooperatives and administration office; and assess the needs of farmers for agricultural inputs; submits requests to cooperatives	Trains farmers on various agricultural practices (e.g., land preparation, appropriate fertilizer application and post-harvest management); works with cooperative and administration office; and assess the needs of farmers for agricultural inputs
Land Administration and Environmental Protection Bureau	Land certification, conflict resolution, communal land management (knowledge)	Issues land certificates; resolves conflicts; and collaborates with Administration Bureau, Water Bureau and Agriculture Bureau	Issues land certificates; resolves conflicts; and collaborates with Administration Bureau and Judiciary agencies
Administration Office/Bureau	Rules and regulations	Coordinates all activities in the village; collaborates with Land and Environmental Protection Bureau, Administration Bureau and Agricultural and Health Bureau	Coordinates all activities in the village and collaborates with/ controls all actors in village
Water Bureau	Finance, technical support, potable water development, chemical (chlorine)	Financially covers 80% of the costs of construction of water systems and provides water treatment and maintenance services; works in collaboration with Health and Administration Bureaus, and Land Administration and Environmental Protection Bureau	Financially covers 80% of the costs of construction of water systems and provides water treatment and maintenance services; supplies building materials for dug well construction; and works in collaboration with Health and Administration Bureaus
Health Bureau	Information on sanitation, family planning (contraceptives) and improved cooking stoves	Creates awareness about family planning, sanitation and uses of improved cook stove; supplies information on contraceptive methods and trains farmers to improve their health (and livelihoods); and collaborates with Administration, Agriculture and Water Bureaus	Provides sanitation, hygiene and improved cook stove training and collaborates with Administration, Agriculture and Water Bureaus
Cooperatives	Improved seed, fertilizer, consumer goods (i.e., edible oil and sugar)	Supplies agricultural inputs and consumer goods; cooperates with Agriculture and Administration Bureaus, and Amhara Credit and Saving Association	Supplies agricultural inputs (e.g., such as fertilizer, improved seeds, pesticides and herbicide) and cooperates with Agriculture and Administration Bureaus
Mineral and Energy Bureau	Biogas establishment materials (i.e., cement and other equipment, and subsidy), minerals	–	Maps mineral resource sites of the village and submits to land administration and environmental protection; works with cooperatives, Administration, and Agricultural offices

During the winter, some households may collect dung cake from communal grazing land.

Crop residues (mainly from maize) are also used as fuel for domestic energy needs, especially in winter. Women and children are responsible for the collection and transport of crop residues from farm fields to households. In the study sites, farmers rarely use charcoal as a source of domestic energy needs. Workshop participants reported using kerosene for illumination purposes and estimated that mean monthly household spending on kerosene is ~24 ETB. Due to the high costs of renewable energy technology, such as solar panels, few households use them and if used, these energy sources are typically only for illumination purposes.

Biogas technology was initially introduced to the village (Sire Morose) by the Woreda Agricultural Office, but only eight of the households that participated in the workshop adopted the technology. Based on the information obtained from the study

participants, biogas is primarily used for illumination purposes and to a lesser degree for cooking. An initial cost of 1,400 ETB is required to install a biogas digester and the remaining costs can be covered by a government subsidy (e.g., from the Mineral and Energy Bureau).

The participants mentioned that several households in the study area had adopted improved cook stoves (or energy-efficient cook stoves) made from concrete or local earthen materials. According to workshop participants, improved cook stoves made from concrete are more efficient and release heat more slowly (over a longer period) than stoves made of local materials, but they are more expensive. Regardless, the performance of improved stoves of both construction types was considered together in the analyses relative to traditional cook stoves. Improved cook stoves cost ~140 ETB. Estimates of mean daily household energy consumption by cook stove technology are presented in **Table 3**. Overall household fuelwood

and dung cake consumption using improved stoves is roughly half that of traditional stoves. Household domestic energy consumption exhibits seasonal variability, with particularly greater consumption during colder months (June-August) as more energy is needed for heating.

The energy consumption estimates provided by men-only groups are far lower than estimates provided by their women counterparts. This difference is likely related to the fact that women are almost exclusively responsible for cooking responsibilities, suggesting that women are much more likely to have accurate knowledge on relevant energy consumption than men.

Food Security and Income

The main sources of household income are the sale of crops and livestock (and/or their derivatives), such as oxen or sheep. Females put relatively greater emphasis on crop production as a livelihood source. Other income sources include the sale of eucalyptus wood and vegetables.

The workshop participants identified different local crops produced for both subsistence and income generation (Table 4). The most productive local crops are teff and maize, which are considered staple food items and important income sources. Currently people in the study area prefer to sell teff at local markets rather than consume it because it has the highest commercial value relative to other crops. Vegetables produced for both subsistence and commercial purposes include onion, cabbage, pepper, pea, potato, and sugarcane. Participants observed that farmers with access to irrigation for growing vegetables have greater income relative to villagers who rely on rain-fed agriculture. Households generate additional income from artisanal non-farm activities, such as pottery making, textile weaving, metal work, and mining of minerals.

Although men reported a similar reliance on agriculture as a primary livelihood means with women, they specifically mention the importance of eucalyptus trees. Due to generally inadequate soil productivity for crop production, households often set aside farmland for commercial eucalyptus production. Income generated from the sale of wood is often used to cover costs of fertilizers, school expenses, cropland rent, and other household expenses. Eucalyptus trees are harvested 3–5 years after planting. Participants indicated that eucalyptus production alleviates harvest pressure on native tree species. Eucalyptus is preferred for production purposes because the species cultivated locally is fast growing and serves multiple purposes, such as home construction, fuelwood and fencing material. Participants also identified negative impacts of eucalyptus production on the local environment, particularly on soil and water resources, and thus eucalyptus is usually planted on marginal land like slopes and gullies. The land adjacent to eucalyptus groves is typically used for livestock grazing rather than crop cultivation.

Dominant crops produced in the study sites include cereals (wheat, barley, teff, and maize), pulses (bean, pea, and grass pea), and oil seeds. Male farmers identified maize as the most productive crop, followed by teff. Current market prices for teff range from 1,520 to 4,010 ETB per quintal. Workshop participants reported that vegetable production has been

increasing over the 4 previous years because of the expansion of irrigation and greater access to improved vegetable seeds.

Water Resources

As noted earlier, most farmers in the study area engage in rain-fed agriculture. Local water sources include the river, springs, wells, and manually dug wells. Small-scale irrigation systems are uncommon in the study area. Only one kebele has access to a river, which connects the irrigation system used for subsistence fruit and vegetable production. However, the participants did not discuss water distribution for unknown reasons, which is considered as a limitation of this study. Instead, this study explored the gender aspect of water resources in the study area by assessing the amount of time spent on water collection, which is discussed in the Interaction section.

Dynamics of the Local WEF Nexus System Social

Both male and female farmers are subject to similar social, ecological, and economic processes that drive local WEF nexus dynamics. According to the participants, rapid population growth is considered the most prevalent problem in Ethiopia because of increasing pressure on limited land and other natural resources, according to all participants. The resulting shortage of arable land contributes to emigration from rural areas, mostly of rural youths (Headey et al., 2014; Hermans-Neumann et al., 2017). The major migrant destinations are urban areas of Oromia (Dello-Bale and Wollega) and Amhara (Hawi and Armacho), as well as Addis Ababa and neighboring towns. Most migrants seek work opportunities as day laborers. Youth unemployment rates are high due to insufficient land resources for agricultural production and insufficient non-agricultural employment opportunities (Denu et al., 2005). Workshop participants reported that the prevalence of sharecropping and land rental are increasing in the study *kebeles*. Children are sometimes hired as labor for herding cattle on neighboring farms. According to participants, the annual average wage payment for a child working as a herder is about 2,500 ETB. In addition, some individuals engage in non-farm activities within and/or outside of the *kebeles*.

Ecological

Soil degradation and, particularly, soil productivity, decline due to soil erosion and deforestation. Such erosion and deforestation were identified as major ecological factors affecting WEF system dynamics in the study sites. Participants reported that these processes have reduced the availability of biomass energy resources. Soil productivity is also decreasing due to overgrazing and increased use of cattle dung and crop residues for meeting domestic energy needs, reducing their availability for application as an organic fertilizer. Furthermore, mean household livestock numbers have been reduced due to pasture and associated fodder shortages. Workshop participants also mentioned weather variability as a common problem, including temporal rainfall patterns and temperature increases.

TABLE 3 | Estimated daily household energy consumption by stove type (Source: Own data).

No.	Energy source	Consumption using a traditional stove (kg/day)	Consumption using an improved stove (kg/day)	Price (USD \$/kg)*	Season
1	Fuelwood	15–30	7.5–15	0.06–0.12	All
2	Dung cake	10	5	0.26	Summer (<i>Kiremt</i>)
3	Crop residue	44	22	Not estimated	Winter (<i>Bega</i>)
4	Charcoal	0.6	0.6	0.06–0.21	All

*At the time of writing.

TABLE 4 | Characteristics of major crops identified by both men and women (Source: Own data).

Crop type	Sowing period	Harvesting period	Yield per hectare (quintal)*	Market price per quintal (USD \$)
Maize	Mar 28–May 18	Oct 24–Nov 24	8	22
Teff	Jul 22–Aug 13	Oct 28–Jan 8	13–17	56–76
Wheat	–	Jan 8–Feb 8	8	32
Barley	Jun 24–May 24	Sept 11–Oct 7	12	31
Bean	Jun 24–Jul 20	Nov 8–Dec 8	8	88
Pea	May 18–Jun 24	Sept 11–Oct 8	8	88
Lentil	Aug 30–Sept 25	Jan 8–Feb 8	7	110

*1 quintal = 100 kg.

Economic

Farmers reported that both income and expenses have been increasing in recent years. Overall, they identified a decline in poverty over the last 10 years. Participants observed that more farmers have access to improved agricultural technologies, such as improved seeds, fertilizers, appropriate agronomic practices, and pesticides. According to farmers, their mean household income has increased in recent years, due to improved farm productivity, income diversification via increasing common sources, such as greater tree production, and increased livestock finishing prior to slaughter.

Technical support from extension agents and different actors has helped farmers increase productivity on smaller areas of land. Farmers reported that expenditures on fertilizers, improved seeds, pesticides, school expenses, and purchased food items (e.g., cooking oil, sugar, etc.) exhibit a steadily increasing trend.

Local municipalities pay limited compensation to farmers evicted from land leased to commercial interests. Current lease rates for commercial operations are ~807 ETB m⁻² as mentioned by some participants in Oromia.

Interactions

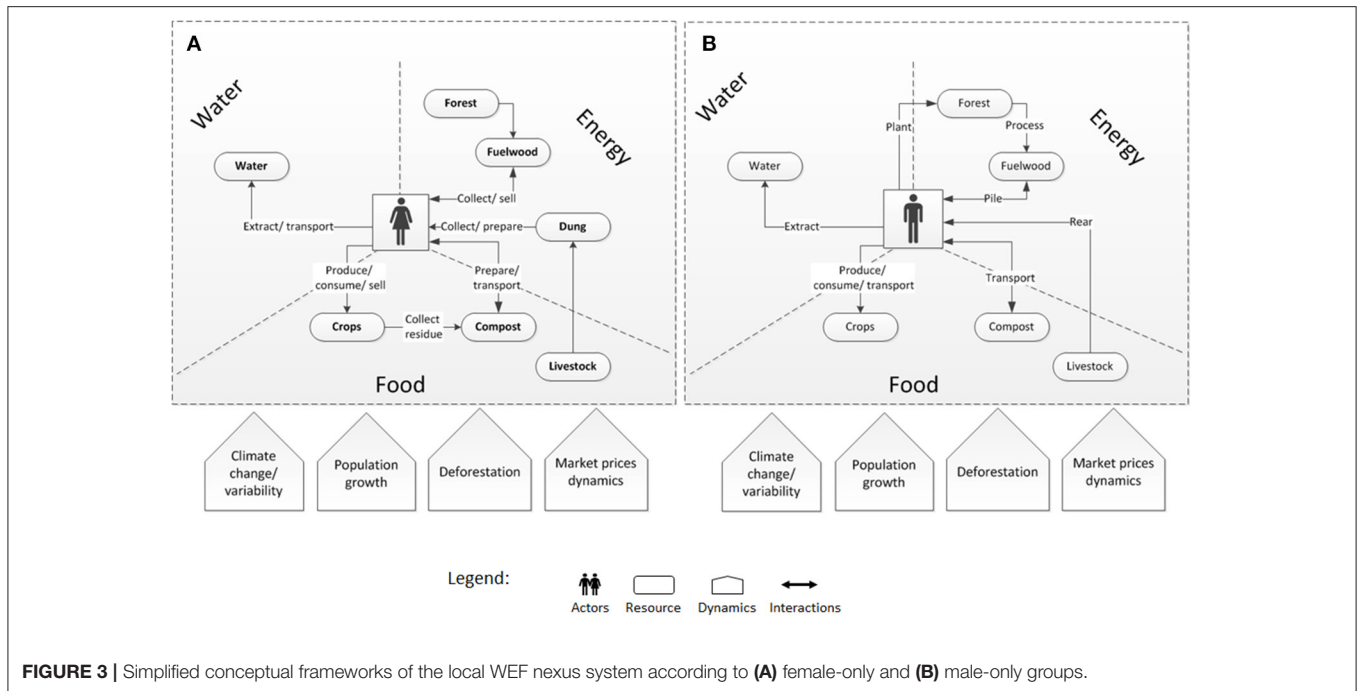
Synthesizing the key elements (i.e., resources, dynamics, and interactions as represented by actions) identified by participating farmers resulted in the conceptual model of the local WEF system according to gender (**Figure 3**). Although the mental models of both male and female farmers identify similar resources and

drivers of change, there is some differentiation in terms of actions performed with the target resources and their uses.

Some actions reported by workshop participants have temporal characteristics. For this reason, we further explore their activities during the workshops. Gender-specific tasks are particularly apparent on a daily basis. Daily activities in relation to the access to, and management of, resources nexus by gender are presented in **Figure 4**. Both males and females share several productive roles, such as chores related to feeding and caring for cattle. Several gender specific productive roles mentioned earlier were confirmed by workshop participants, such as the differentiation of tasks related to fuelwood procurement mentioned earlier (**Figure 3**), and female and/or children specific tasks related to water (for cooking and drinking) and dung cake acquisition. Activities, such as caring for cattle, transporting fuelwood, and collecting crop residues and dung are often shared with household children during the holidays and on Sundays. Based on daily activity cycles presented in the figure, the specific roles of females in crop production are not obvious, but may be flexible relative to other domestic roles.

Gender-Specific Time Allocated for Nexus Activity

We used the seemingly unrelated regression model to account for the activities labor time competition (**Table 5**). The chi² statistics reported at the bottom of the table show that the explanatory variable is jointly significant ($p > 0.01$) in all equations. Both asset and household size were positive determinants for both male and female labor time use for agriculture and statistically



significant in all cases at 1% except female time use for agriculture at 5%. Male labor time used for fuel collection was significantly lower than counterpart households who had none of their parcel certified and statistically significant at 1%. On the contrary, female labor was higher for household who had certified parcel compared to who no parcel certified. The higher the household wage the higher the female time used for fuel collection. An increase in total livestock owned associated with an increase in time by males and females used for agricultural activities is statistically significant at 1 and 5%, respectively. Sales value of household production positively and significantly at 1% associated with male time use for fuel and water collection but negatively to agricultural production. In all cases, the estimated coefficients were very low. The education level of head of household correlated negatively with time used for agriculture for both male and female and significant at 1 and 5%, respectively. Female time use for water collection also decreased with an increased education level of the head. Increase in distance from road associated with a decrease in time used by males for agriculture production and fuel collection and statistically significant at 5 and 1%, respectively. Male time use for agriculture and female time use for water collection increased with an increase in distance to population center and statistically significant at 5 and 1%, respectively. The estimated result shows that the mean annual temperature associated with an increase in time used fuel collection and decrease in time use for agriculture by both male and female and statistically significant in all cases at 1% except for female time use for agriculture at 5%. Male time use for water collection and agriculture and female time use for water and fuelwood collection were all negatively to mean precipitation and statistically significant at 1% except for female time use for fuel at 5%.

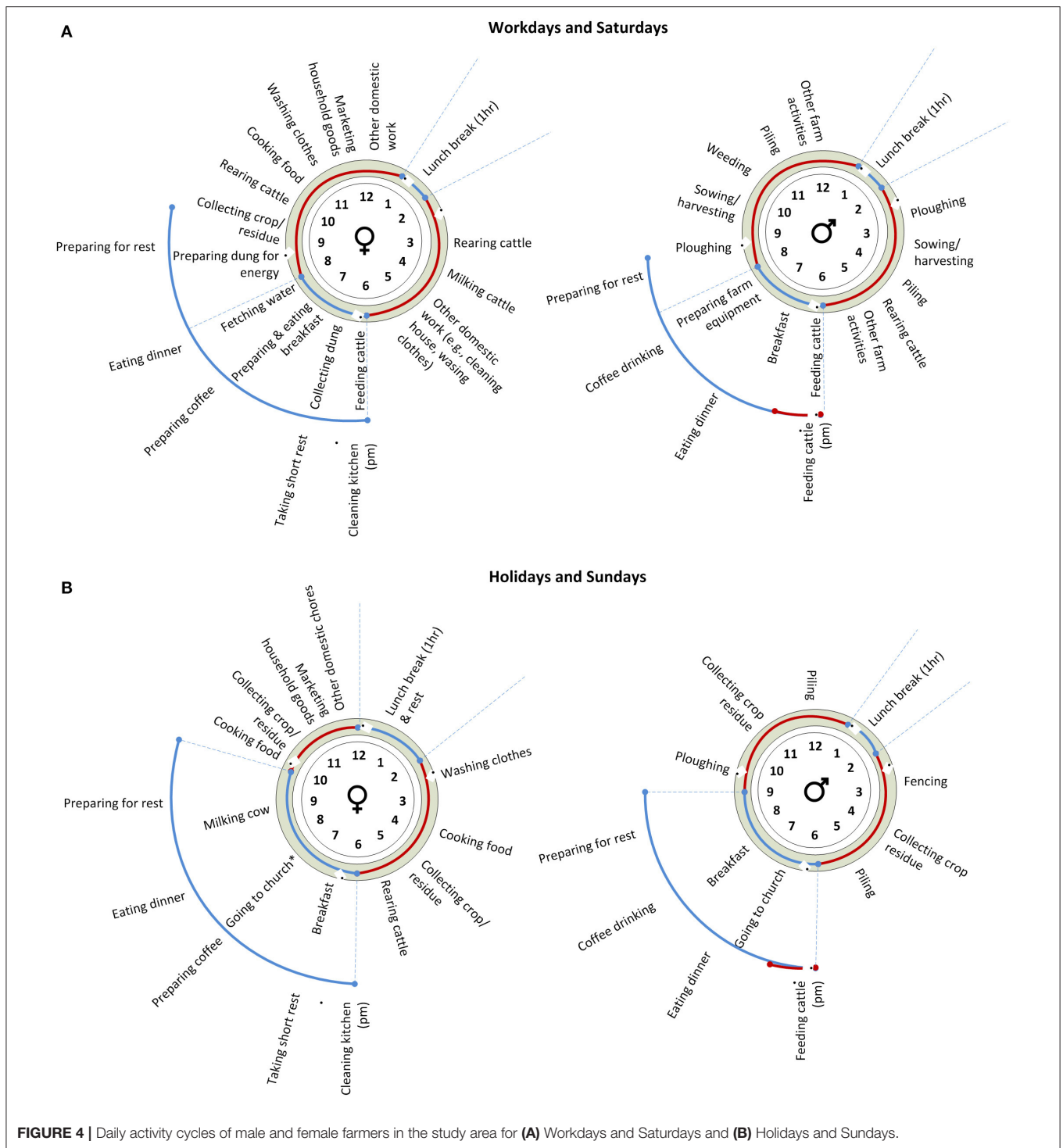
DISCUSSION

Gender-Specific Differences

Conceptualizing the WEF nexus at the local level and according to gender types using ARDI approach allowed to identify the areas of gender differences:

Access to External Actors That Shapes the Dynamics of the WEF Nexus

Our findings show that male and female farmers have differential access to external actors. For example, males reported access to a broader spectrum of actors involved in elements of the WEF nexus (particularly with respect to energy, minerals, and irrigation) compared to females. This was reflected by relatively greater awareness of energy alternatives (i.e., biogas, electricity grids) among male-only groups. There is a general observation that in Sub-Saharan Africa, women lack access to financial markets and services (Fletschner and Kenney, 2014). In our findings, females are more likely to interact with trading actors, probably due to increased demand and prices for teff that farmers are more likely to sell their teff than normally use it for household subsistence purposes. As mentioned earlier, female participants also exhibited greater knowledge of the use of improved cooking stoves and related energy consumption, which link them to the health sector that promotes improved cooking stoves. Both male- and female-only groups underscored the role of government actors in affecting WEF dynamics. According to Hoff (2011) the nexus concept is concerned with addressing externalities across multiple sectors, with a focus on system efficiency rather than the productivity of isolated sectors. Our results confirm the state-driven and centralized governance structure in Ethiopia that extends to the village level.



Since the local administration offices coordinate with actors in other sectors, this governance structure may promote resource efficiency technologies at the local level. However, as observed during the fieldwork, the administration offices direct natural resource management outreach to male farmers (i.e., household heads). According to one female workshop participant, “my

husband is the one talking to the administration representative and frequently with extension agents; anyway, it is his job because he is the head of the household, and that’s what the head of the household should do.” Gender-oriented outreach presents a significant challenge when the head of the household is female.

TABLE 5 | Seemingly unrelated regression result of labor hour allocated to different activities by gender groups.

Explanatory variables	Male			Female		
	Water	Fuel	Agro	Water	Fuel	Agro
Household size	0.00179 (0.00513)	-0.00731 (0.0101)	1.406*** (0.342)	0.0116 (0.00890)	0.0178 (0.0125)	0.908*** (0.273)
Household assets	-0.000963 (0.000762)	0.00197 (0.00151)	0.273*** (0.0507)	0.00130 (0.00132)	-0.00198 (0.00185)	0.107** (0.0405)
Parcel certificate ^a	0.00744 (0.0216)	-0.112** (0.0426)	-1.203 (1.435)	0.0286 (0.0374)	0.203*** (0.0523)	-0.496 (1.146)
Household wage	-0.000002 (0.000004)	0.0000001 (0.00001)	0.000004 (0.000241)	0.000004 (0.00001)	0.00002* (0.00001)	0.00003 (0.0002)
Household in kind	-0.0001 (0.000398)	-0.0004 (0.000787)	-0.0180 (0.0265)	0.0001 (0.000691)	0.00116 (0.000967)	0.0248 (0.0212)
Total livestock	-0.00120 (0.00212)	-0.00508 (0.00419)	0.740*** (0.141)	-0.00518 (0.00368)	-0.00778 (0.00515)	0.276* (0.113)
Land size	0.0000004 (0.0000003)	0.0000003 (0.000001)	-0.00001 (0.00002)	-0.0000003 (0.000001)	0.0000001 (0.000001)	-6.77e-08 (0.00002)
Sell harvest value	0.0000100*** (0.000002)	0.00003*** (0.000005)	-0.000407* (0.000163)	0.000001 (0.000004)	-0.00001 (0.00001)	-0.0002 (0.0001)
Head education ^b	-0.0320 (0.0216)	-0.0188 (0.0427)	-6.907*** (1.439)	-0.0960* (0.0375)	-0.00941 (0.0525)	-3.213** (1.149)
Distance to road	-0.00150* (0.000673)	0.000801 (0.00133)	-0.198*** (0.0448)	-0.00224 (0.00117)	-0.000874 (0.00163)	0.0209 (0.0358)
Distance to pop center	0.000312 (0.000470)	-0.00135 (0.000928)	0.0959** (0.0313)	0.00183* (0.000815)	0.00118 (0.00114)	-0.0316 (0.0250)
Distance market	0.000169 (0.000229)	0.000549 (0.000452)	-0.00512 (0.0152)	-0.000423 (0.000397)	-0.000897 (0.000555)	-0.00279 (0.0122)
Mean ann. temperature	-0.000196 (0.000366)	0.00327*** (0.000723)	-0.0695** (0.0244)	0.000261 (0.000635)	0.00176* (0.000889)	-0.0759*** (0.0195)
Mean ann. precipitation	-0.0001*** (0.00003)	0.00003 (0.0001)	-0.01*** (0.002)	-0.0003*** (0.0001)	-0.0002** (0.0001)	0.001 (0.002)
_cons	0.264** (0.0884)	-0.374* (0.174)	45.44*** (5.881)	0.699*** (0.153)	0.297 (0.214)	23.36*** (4.698)
N	1,678					
R ²	0.030	0.034	0.1	0.035	0.043	0.042
Chi ²	51.33 ($p > 0.000$)	65.64 ($p > 0.000$)	181.28 ($p > 0.000$)	60.69 ($p > 0.000$)	74.94 ($p > 0.000$)	73.73 ($p > 0.000$)

Standard errors in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

^aReference category no certificate.

^bReference category illiterate.

Gender-Specific Resources

Our study shows that there are WEF resources specific to gender types. Men explicitly regard livestock as a resource (for livelihood and recognition), whereas females were more likely to identify products derived from livestock, such as cattle dung and milk as (energy and food) resources (Figure 3). These perceptions are associated with gender-specific tasks and/or the degree of direct benefit from resources. This finding particularly on men corroborate with the research findings of Baker et al. (2015) in Ethiopia that men are engaged in income generating activities involving livestock and eucalyptus. The said study further assessed the gender-specific perception of water resources through mapping, and found that women mapped the landscape in detail where sacred sites (e.g., holy water) were included. In contrast, men are focusing more on degraded land as an

important ecological factor affecting WEF system (Sonneveld and Keyzer, 2003; Baker et al., 2015) and reducing the biomass energy production.

Decision to Utilize Resources

In rural Ethiopia, while men dominate most household decisions, decisions of whether to use cattle dung for domestic energy or for compost are commonly made by household females. Contrarily, decisions regarding livestock and eucalyptus production are mainly made by household males. Other factors may affect decision making, for example whether to sell teff may be highly dependent on market value. Studies of factors that influence decision making regarding (biomass) energy use have identified some of these alternative influences. For example, household consumption of biomass energy sources may change due to

ownership of an improved stove (Mekonnen et al., 2015), which was also reflected by reductions in energy resource consumption among households in our study area. Other influences include the distance to biomass energy resource collection areas, livestock (particularly oxen) ownership, certain demographic characteristics (Mekonnen et al., 2015), and off-farm wages (Djanibekov et al., 2016).

Moreover, their decision how to manage the resources are also affected by the social, ecological, and economic dynamics that were identified. For example, as much as one would like to use cattle dung as fertilizer, they are limited due to the availability of chemical fertilizer in the study area.

Gender-Specific Productive Roles

Productive roles are activities that generate income and have either an actual or potential value; reproductive roles are activities related to biological reproduction and the maintenance of home and family members; and community managing labor are activities at the community level that ensure the allocation, provision, and management of items consumed collectively, such as water, health care, and education (Moser, 1993). Time allocation to daily tasks among women appears to be more flexible in that they participate in all three spheres (Figure 4) across time. In general, the role of females is dominant in the reproductive sphere, while time and efforts are largely concentrated in the productive sphere among men. On the other hand, factors associated with time spent for each activity vary between genders (Table 5).

These may be important factors that influence how household decisions are made (especially if interventions are introduced), how such decisions may affect a household's biophysical environment, the feedback effects on future decisions (Villamor et al., 2014; Elsayah et al., 2015; Hermans-Neumann et al., 2017), and the sustainability of nexus resources. On the other hand, male and female farmers share similar perception of the dynamics or processes that drive the management of nexus resources.

Insights Into the WEF Security Nexus and Policy Implications

The WEF nexus approach is an expression of trade-offs (Kurian, 2017). Often trade-offs relate to stakeholder perspectives (and response to a given situation) along with the concept of resource efficiencies (Villamor et al., 2017). In this case, trade-offs may emanate from these gender-specific differences. For example, males may tend to reduce WEF nexus trade-offs at the *kebele* level because they have access to a broader spectrum of actors involved in WEF resources relative to females. This might also suggest that males have more opportunities to access higher level and more influential WEF actors (e.g., extension advisors, inputs suppliers and investors). On the other hand, because of gender-specific roles and decisions, male and female farmers may focus their attention on only one or two nexus resources. For instance, females may focus more on dung cake as an energy source, whereas males may focus more on fuelwood. On the other hand, a male farmer may use majority of his time on raising livestock, while a female farmer may use more of her time on crop and dung cake production. Areas where there appear to

be trade-offs between allocation of time spent for WEF nexus resources are presented in Figure 4 and Table 5. For example, the time spent on fuelwood collection by male members within the household is negatively associated with the harvesting of crops; whereas male household members' time spent on crop production depends on the amount of time spent by women on collecting water and fuel (Figure 4). Thus, working together collaboratively with all household members to define the role and activity of household members can reduce trade-offs and foster synergies on WEF nexus resources at both the household and *kebele* levels (Djanibekov and Gaur, 2018).

On the other hand, the labor transition within the household (from primary to secondary sectors) is one of the nexus system criticalities identified by Smajgl et al. (2016). Accordingly, the more household members who engage in secondary and tertiary sectors, the more that energy (i.e., electricity) demand is likely to grow. Whether this system criticality applies or not in the context of Ethiopia, remains unanswered and requires further analysis (considering that migration is one of the socio-economic dynamics raised by the respondents). Furthermore, these results link to an important question of whether the introduction of technology to improve energy efficiency or bioenergy will translate into greater leisure time or availability for off-farm activities for women and men. This is a key question that can address gender inequality and can enhance the quality of life and self-development in rural areas, which requires further analysis.

Despite Ethiopia's national government's efforts, such as the Growth and Transformation Plan in 2010 and the Climate-Resilient Green Economy strategy in 2012 (which established a national pathway for agricultural and rural development), heavy reliance on fuelwood, dung cakes, and crop residues is prevalent in rural areas. There is also a tendency for farmers to intensify crop production, e.g., teff, in response to high market value. Indeed, the nexus framework and interventions discussed at the global scale may not apply to *in situ* context. Thus, the political economy of the nexus needs to be given attention (Stein et al., 2014), especially in rural contexts and consideration of gender-specific perceptions of nexus components. Ringler et al. (2013) suggested that the development and dissemination of technologies for improving resource-use efficiency, e.g., integrated soil fertility management, should be targeted in these respects (Bryan et al., 2013).

According to Foran (2015), there are two approaches to understand the nexus. The first approach is the systems' complexity of the nexus, which is based on the system dynamics concept that seek answers to questions, such as "How do efforts to increase variables of interest in domain (a) (e.g., fuelwood) affect other variables of interest in domains, (b) (e.g., food production), (c) (e.g., irrigation water)?" The second approach is the critical social science of the nexus, which involves the power relations that seek answers to the questions, such as "How has the resource nexus in particular place emerged, historically? Which social groups are enriched (impoverished) by a particular resource nexus?" Both approaches have specific characteristics, properties and limitations. For example, the first approach is

limited by its relatively unsophisticated social and political analysis; whereas, the second approach is limited by its relatively unsophisticated system dynamics analysis (Foran et al., 2014). In this study, we explored gender and nexus using the first approach. Through the ARDI method, we were successfully identified the differentiation of the gender perspectives, such as the key actors affecting the nexus management as well as their resources and related time allocation. However, there are several important questions that this study opens up for future research, such as (1) the in-depth understanding of gender-specific power relations in governing WEF resources, such as how gender decision making is different for women in married households (e.g., in dual-headed households) vs. female-headed households; (2) gender differences in access to irrigation water both small- and large-scales farmings (which in turn affect the maintenance of bio-digesters) and other energy efficient technologies; and (3) the impact of gendered institutions on farm households (e.g., women's associations), including financing schemes.

Feminization of agriculture is becoming a global phenomenon. One of the reasons identified in this study is the outmigration pattern of male population from rural to urban areas in search of better opportunities. Women in developing countries are involved in the full range of agricultural production and associated value chains (FAO, 2011). Although, these trends have created new economic opportunities for both men and women in rural areas, they can also create new dependencies and vulnerabilities (i.e., by burdening the roles of both women and children), which require further in depth study. We also suggest to further explore the nexus-at-home framework of Foden et al. (2019) in the context of rural agricultural-based households.

CONCLUSIONS

This study explores the gender perspective of smallholder farmers on the food-energy-land nexus in the Ethiopian highland by combining the focus group discussions and statistical analysis of secondary data. Male and female farmers have particularly developed perceptions of energy-food-land linkages because they continue to rely heavily on fuelwood and agricultural by-products (dried cattle dung and crop residues) for their domestic energy needs. Although they share similar understanding of the dynamics and processes affecting the nexus, dissimilarities emerge in terms of external actors; access to nexus resources; and their interactions. These are likely to influence the success of government policies (e.g., modern bioenergy) related the nexus as well as achieving sustainable development goals particularly gender equity. These include gender-specific productive roles, and decision making regarding resource utilization (including time allocation). From our study, the specific roles, including decisions, of females and males within the households in relation to WEF resources are difficult to isolate, because they depend

upon one another. Thus, these variables should be considered for the promotion of energy supply innovations for replacing traditional biomass use at the local level as well as possible implication due to economic development within nearby towns that would lead to outmigration of males. Our results provide insights into how linkages between men and women farmers and institutions may be relevant for the management of important WEF nexus resources.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved. We conducted this study in rural Ethiopia. We obtained a letter from the center for environment and development studies of Addis Ababa University addressed to woredas where the study took place and got full acceptance from woreda administrations and participants in the focus group discussion. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

GV, DG, and AM conceptualized and designed the paper, reviewed, and commented on various versions of the manuscript. GV and DG carried out the implementation of ARDI method, performed the analysis, and wrote the manuscript. All authors read and approved the final manuscript.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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