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*Small-Scale Irrigation and Women's
Empowerment: Lessons from an Irrigation
Intervention in Northern Ghana*

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EXECUTIVE SUMMARY

Gender equality and women's empowerment are inextricably linked with the achievement of other development goals including improving food security and nutrition, promoting sustainable agriculture, and addressing climate change. While considerable progress has been made towards achieving these goals many gender gaps remain. These gaps are notable in the agriculture sector, where women comprise a significant share of the agricultural labor force, yet have less access to productive resources, technologies, and services like information and financial services; less decision-making authority; and fewer opportunities given a considerable work burden with domestic and productive responsibilities. To address these gaps, strengthening women's economic empowerment is becoming a key feature of development interventions. However, the impact of development interventions on women's empowerment outcomes can vary dramatically across contexts, even when they specifically aim to facilitate women's empowerment. Thus, programs should be designed in ways that are responsive to gender dynamics and address key areas of women's disempowerment in a particular context.

Small-scale irrigation is an important agricultural practice that is expanding throughout sub-Saharan Africa with

increasing attention and investment by governments, donors, the private sector, and NGOs. Small-scale irrigation offers considerable benefits including significant gains in the productivity and profitability of smallholder production, improved food security and nutrition, and resilience to climate shocks and stressors. Women's empowerment influences the extent to which small-scale irrigation contributes to these outcomes by shaping production decisions, income allocation, and water management. Small-scale irrigation may also influence women's empowerment directly to the extent that women are able to adopt and use irrigation technologies and control the benefits. Yet, women face substantial challenges in adopting and utilizing small-scale irrigation technologies in ways that meet their needs. Furthermore, if not carefully planned and targeted, irrigation may lead to negative outcomes for women, such as an increase in their time burden.

With a multitude of technologies and systems for small-scale irrigation, questions remain about which technologies or approaches are appropriate where and for whom. There is little awareness among representatives of agricultural ministries, irrigation and water engineers, agricultural experts, and service providers of the need to consider gender dimensions in the design of irrigation technologies, systems, and interventions. Even when awareness exists, limited insight into *how* to effectively integrate gender abounds.

This dissertation uses a mixed-methods approach to explore issues related to women's empowerment and small-scale irrigation from several different angles: conceptually, based on a literature review, qualitatively and quantitatively, based on a case study in Northern Ghana, and qualitatively, as part of a larger effort of development organizations to promote adaptation to climate change. The analysis relies on a conceptual framework that illustrates the linkages between small-scale irrigation and the domains of women's empowerment as well as the broader opportunity structure shaping these relationships. It then uses qualitative and quantitative data from the case study area to identify what aspects of women's empowerment are salient in this context and how the irrigation intervention influences outcomes for women. Finally, the dissertation draws lessons from a capacity needs assessment of development organizations to identify areas for strengthening the delivery of gender-sensitive programs.

Thus, the main research questions addressed by this dissertation are:

- 1) What are the linkages between small-scale irrigation technologies/systems and dimensions of women's empowerment?
- 2) What aspects of women's empowerment emerge as the most salient in the context of Northern Ghana where small scale irrigation is practiced

and modern technologies (motor pumps) are being introduced?

- 3) How does the introduction of small-scale irrigation technologies (specifically motor pumps) affect indicators of women's empowerment?
- 4) What are the gender-related capacity needs of development organizations working to promote climate change adaptation (of which small-scale irrigation is an important practice)?

A conceptual framework is developed in Chapter 2 and applied to the case study literature to explore the gendered patterns of adoption and use of small-scale irrigation, the distribution of costs and benefits, and how these influence other development outcomes. The chapter organizes the literature by the type of small-scale irrigation system (household, group-based, and communal schemes), to illustrate how the relationships between aspects of women's empowerment and small-scale irrigation depend on the type of system as well as the larger context determining women's roles in farming and livelihood systems. The results shows that women's access to resources tends to be constrained across all types of small-scale irrigation systems, although the resources required may vary. For household-level systems, women's intra-household bargaining power is needed to influence irrigation decisions, such as how irrigation technologies are used, and to access other complementary resources.

For communal schemes, women's agency in community spaces is required to successfully influence decisions regarding the design, operation, and governance of the schemes. Much less research is available on the gender dimensions of group-based approaches to small-scale irrigation. Studies that do exist suggest that successfully reaching women requires more targeted, project-based approaches that address the specific constraints women face in a given context.

Chapter 3 applies the conceptual framework developed in Chapter 2 to a case study in Northern Ghana, where motor pumps were distributed to small groups of farmers in communities and where many women and men were already engaged in small-scale irrigation activities using manual methods. Using qualitative research methods, the chapter identifies the resources and aspects of women's agency needed for women to participate in and benefit from small-scale irrigation. The findings show that women have more limited access to some key resources needed for engaging in small-scale irrigation, particularly less access to land near the water source, limited labor needed to dig wells or construct mud fencing around irrigated plots, and less access complementary inputs and other productive assets. Moreover, women's agency is required to negotiate for land, participate in irrigation decisions, and control income earned through the sale of irrigated crops. At the same time, irrigation affects aspects of women's agency in both positive and negative

ways. For example, the motor pump intervention induced some households to change the allocation of labor for irrigation towards men, which limited women's influence over irrigation activities and decisions but freed their time to engage in other livelihood activities that they preferred.

An impact evaluation of the extent to which the motor pump intervention increased women's empowerment in Chapter 4 revealed some evidence of a positive impact—the motor pump intervention increased women's control over assets and income but did not affect aggregate empowerment scores or other aspects of women's empowerment. Qualitative findings from Chapter 3 suggest that the positive impacts among women in households that received the motor pumps may have been indirect benefits of the intervention. That is, increased control over assets and income by women may have been the result of a shift in women's time allocation to other activities that provided direct benefits and an overall increase in household well-being. Additionally, evidence suggests that the intervention created negative spillover effects in the form of tensions within those households that did not receive the motor pumps, which negatively affected women.

Chapter 4 demonstrates that programs aimed at increasing the productivity, profitability, and sustainability of agriculture through the dissemination of improved agricultural technologies and practices, like small-scale

irrigation, must consider underlying structural inequalities and gender dynamics if they are to also increase women's empowerment. Yet the results of a knowledge, attitudes and practices survey and key informant interviews with representatives of organizations working to promote climate change adaptation throughout sub-Saharan Africa, presented in Chapter 5, shows that the ability of these organizations to deliver gender-responsive programs remains limited. This chapter identified several key capacity constraints that vary across organization types (government agencies, local NGOs, and international NGOs) including the ability to integrate gender-sensitive research, including the use of sex-disaggregated data, into operations to ensure that programs are designed and implemented in ways that address the differential needs of men and women. Lack of staff capacity and limited availability of locale-specific research and sex-disaggregated data and insufficient financial resources were reported as key constraints.

The findings in this dissertation suggest that there are many factors to consider in the design and dissemination of small-scale irrigation technologies to ensure that these are equitably distributed and that both men and women have the opportunity to engage in and benefit from irrigation. These include gendered preferences for the type of irrigation technology or system, the underlying socio-political environment shaping the barriers that men and women face, and implementation approaches.

Moving beyond simply reaching women (that is, counting their participation in program activities) to benefitting and empowering women (increasing their well-being outcomes and expanding their ability to make strategic life decisions) requires knowledge of the local context and dedicated attention toward ensuring that outcomes for women are achieved, even if this means expanding activities and opportunities outside of agriculture. Thus, greater efforts are also needed to build the capacity of implementing organizations to deliver gender-responsive programs. Creating platforms, like stakeholder consultation processes or dialogues, for setting goals and sharing information, approaches, and lessons learned is one way to build this capacity. Integrating gender-sensitive research tools into strategy development, project design, implementation, and monitoring and evaluation of implementing agencies would also support the development of more gender-responsive irrigation interventions and would contribute to fill remaining research gaps on the gendered implications of alternative agricultural technologies and practices. While this dissertation provides some evidence on the impacts of motor pumps for small-scale irrigation on women's empowerment, this is only one of many types of irrigation technologies and approaches. More research is needed on the implications for women's empowerment of alternative irrigation technologies, systems, and dissemination

tactics, including group-based and service-based approaches.

ZUSAMMENFASSUNG

Die Gleichstellung der Geschlechter und die Stärkung der Rolle von Frauen sind untrennbar mit der Erreichung anderer Entwicklungsziele verbunden, darunter die Verbesserung der Ernährungssicherheit und eine bessere Ernährung, die Förderung einer nachhaltigen Landwirtschaft und die Bekämpfung des Klimawandels. Obwohl bei der Erreichung dieser Ziele erhebliche Fortschritte erzielt wurden, bestehen nach wie vor viele geschlechtsspezifische Unterschiede. Diese Unterschiede fallen vor allem im Agrarsektor ins Gewicht, da Frauen zwar einen erheblichen Anteil der landwirtschaftlichen Arbeitskräfte ausmachen, jedoch weniger Zugang zu produktiven Ressourcen, Technologien und Dienstleistungen wie Informationen und Finanzdienstleistungen haben; sowie geringere Entscheidungsbefugnisse; und weniger Chancen aufgrund ihrer und weniger Möglichkeiten aufgrund ihrer erheblichen häuslichen und produktiven Arbeitsbelastung haben. Die Stärkung der wirtschaftlichen Teilhabe von Frauen wird dadurch zu einem Schlüsselmerkmal von Entwicklungsinterventionen um diese Lücken zu schließen. Die Auswirkungen von Entwicklungsinterventionen auf die Ergebnisse der Stärkung der Rolle von Frauen können jedoch je nach Kontext dramatisch variieren, selbst wenn sie speziell darauf abzielen, die Stärkung von Frauen zu ermöglichen.

Daher sollten Programme so gestaltet werden, dass sie der Geschlechterdynamik Rechnung tragen und Schlüsselbereiche der Entmachtung von Frauen dem Kontext entsprechend angehen.

Die Kleinbewässerungslandwirtschaft ist eine wichtige landwirtschaftliche Praxis, die zunehmende Aufmerksamkeit und Investitionen von Regierungen, Gebern, dem Privatsektor und NGOs in ganz Subsahara-Afrika erhält. Die Kleinbewässerung bietet erhebliche Vorteile, darunter beträchtliche Produktivitäts- und Rentabilitätssteigerungen der kleinbäuerlichen Produktion, verbesserte Ernährungssicherheit und bessere Ernährung sowie Widerstandsfähigkeit gegenüber Klimaschocks und anderen Stressfaktoren. Die Stärkung der Rolle der Frauen beeinflusst das Ausmaß, in dem Kleinbewässerung zu diesen Ergebnissen beiträgt, indem sie Produktionsentscheidungen, Einkommensverteilung und Wassermanagement beeinflusst. Bewässerung in kleinem Maßstab kann sich auch direkt auf die Stärkung der Rolle der Frauen auswirken, insofern Frauen in der Lage sind, Bewässerungstechnologien anzueignen und zu nutzen und die Erlöse zu kontrollieren. Frauen stehen jedoch bei der Einführung und Nutzung von Bewässerungstechnologien, die ihren Bedürfnissen entsprechen, vor großen Herausforderungen. Darüber hinaus kann die Bewässerung, wenn sie nicht sorgfältig geplant und zielgerichtet ist, zu negativen Folgen für

Frauen führen, wie z. B. zu einer Zunahme ihrer Zeitbelastung.

Bei einer Vielzahl von Technologien und Systemen zur kleinräumigen Bewässerung bleibt die Frage offen, welche Technologien oder Ansätze wo und für wen geeignet sind. Bei Vertretern von Agrarministerien, Bewässerungs- und Wasseringenieuren, Agrarexperten und Dienstleistern besteht wenig Bewusstsein für die Notwendigkeit, Gender-Dimensionen bei der Gestaltung von Bewässerungstechnologien, -systemen und -interventionen zu berücksichtigen. Selbst wenn ein Bewusstsein vorhanden ist, bleibt oft unklar *wie* man Gender effektiver integrieren kann.

Diese Dissertation verwendet einen Mixed-Methods-Ansatz, um Fragen im Zusammenhang mit der Stärkung von Frauen und Kleinbewässerung aus verschiedenen Blickwinkeln zu untersuchen: konzeptionell basierend auf einer Literaturrecherche, qualitativ und quantitativ basierend auf einer Fallstudie in Nordghana und qualitativ als Teil eines größeren Programms von Entwicklungsorganisationen die Anpassung an den Klimawandel zu fördern. Die Analyse stützt sich auf einen konzeptionellen Rahmen, der die Verbindungen zwischen kleinräumiger Bewässerung und den Ansatzpunkten für die Stärkung der Frauen sowie die breitere Chancenstruktur, die diese Beziehungen prägt, veranschaulicht. Anschließend werden qualitative und

quantitative Daten aus dem Fallstudienstandort verwendet, um zu ermitteln, welche Aspekte der Stärkung der Rolle von Frauen in diesem Zusammenhang hervorstechen sowie die spezifischen Auswirkungen der Bewässerungsintervention auf die Frauen. Schließlich zieht die Dissertation Lehren aus einer Analyse des Kapazitätsbedarfs von Entwicklungsorganisationen, um Bereiche zu identifizieren, in denen die Umsetzung geschlechtersensibler Programme gestärkt werden kann.

Die zentralen Forschungsfragen dieser Dissertation lauten daher:

- 1) Welche Verbindungen bestehen zwischen Kleinbewässerungstechnologien/-systemen und den Ansatzpunkten für die Stärkung der Rolle von Frauen?
- 2) Welche Aspekte der Stärkung von Frauen kristallisieren sich im Kontext Nordghanas heraus, wo die Kleinbewässerung praktiziert wird und moderne Technologien (Motorpumpen) eingeführt werden?
- 3) Wie wirkt sich die Einführung von Kleinbewässerungstechnologien (insbesondere Motorpumpen) auf Indikatoren für die Stärkung der Rolle von Frauen aus?
- 4) Welchen geschlechtsspezifischen Kapazitätsbedarf haben Entwicklungsorganisationen, die sich für die Anpassung an den Klimawandel einsetzen (wobei die

Kleinbewässerungslandwirtschaft eine wichtige Maßnahme darstellt)?

In Kapitel 2 wird ein konzeptioneller Rahmen entwickelt und auf die Fallstudienliteratur angewendet, um die geschlechtsspezifischen Muster der Einführung und Nutzung von Kleinbewässerung, und die Verteilung von Kosten und Nutzen zu untersuchen, sowie deren Auswirkungen auf andere Entwicklungsergebnisse. Das Kapitel organisiert die Literatur nach der Art der Kleinbewässerung (Haushalts-, gruppenbasierte und kommunale Systeme), um zu veranschaulichen, wie die Beziehungen zwischen Aspekten der Stärkung der Rolle von Frauen und kleinräumigen Bewässerungssystemen von der Art des Systems abhängt, sowie von einem umfassenderen Kontext, der die Rolle von Frauen in der Landwirtschaft und in den Lebensunterhaltungssystemen bestimmt. Die Ergebnisse zeigen, dass der Zugang von Frauen zu Ressourcen bei allen Arten von Kleinbewässerungssystemen generell eingeschränkt ist, mit Variationen was die benötigten Ressourcen angeht. Für Systeme auf Haushaltsebene benötigen die Frauen Verhandlungsmacht, um Bewässerungsentscheidungen zu beeinflussen, beispielsweise wie Bewässerungstechnologien eingesetzt werden, und um Zugang zu anderen komplementären Ressourcen zu erhalten. Bei kommunalen Programmen ist die Mitwirkung von Frauen in gemeinschaftlich genutzten Bereichen erforderlich, um Entscheidungen über die

Gestaltung, den Betrieb und die Verwaltung der Programme erfolgreich zu beeinflussen. Zu den geschlechtsspezifischen Dimensionen gruppenbasierter Ansätze zur Kleinbewässerung gibt es wenig Forschung. Vorhandene Studien legen nahe, dass ein erfolgreiches Erreichen von Frauen gezieltere, projektbasierte Ansätze erfordert, die sich mit den spezifischen Zwängen von Frauen in einem bestimmten Kontext befassen.

Kapitel 3 wendet den in Kapitel 2 entwickelten konzeptionellen Rahmen auf eine Fallstudie in Nordghana an, wo Motorpumpen an kleine Gruppen von Bauern in Gemeinden verteilt wurden und wo viele Frauen und Männer bereits mit manuellen Methoden in der Kleinbewässerungslandwirtschaft vertraut waren. Unter Verwendung qualitativer Forschungsmethoden identifiziert das Kapitel die Ressourcen und Aspekte der Agency von Frauen, die erforderlich sind, damit Frauen an der Kleinbewässerung teilnehmen und davon profitieren können. Die Ergebnisse zeigen, dass Frauen weniger Zugang zu einigen Schlüsselressourcen haben, die für die Kleinbewässerung benötigt werden, insbesondere weniger Zugang zu Land in der Nähe der Wasserquelle, begrenzte Arbeitskräfte zum Graben von Brunnen oder zum Bau von Lehmzäunen für bewässerte Grundstücke sowie weniger Zugang zu ergänzenden Inputs und anderen produktiven Vermögenswerten. Darüber hinaus brauchen Frauen Handlungsfähigkeit, um über Land zu verhandeln, an

Bewässerungsentscheidungen teilzunehmen und die Einnahmen aus dem Verkauf von bewässerten Pflanzen zu kontrollieren. Gleichzeitig wirkt sich die Bewässerung sowohl positiv als auch negativ auf Aspekte der Handlungsfähigkeit von Frauen aus. Zum Beispiel veranlasste die Motorpumpenintervention einige Haushalte dazu, mehr männliche Arbeitskräfte einzusetzen, was den Einfluss der Frauen auf Bewässerungsaktivitäten und -entscheidungen einschränkte, ihnen jedoch Zeit für andere, von ihnen bevorzugte, Aktivitäten zur Sicherung des Lebensunterhalts gab.

Eine Wirkungsbewertung des Ausmaßes, in dem die Motorpumpen-Intervention die Selbstbestimmung von Frauen in Kapitel 4 steigerte, ergab einige Hinweise auf eine positive Wirkung – die Motorpumpen-Intervention erhöhte die Kontrolle der Frauen über Vermögen und Einkommen, hatte jedoch keinen Einfluss auf die Gesamtbewertung oder andere Ansatzpunkte der Selbstbestimmung von Frauen. Qualitative Ergebnisse aus Kapitel 3 legen nahe, dass die positiven Auswirkungen auf Frauen in Haushalten, die die Motorpumpen erhielten, indirekte Vorteile der Intervention waren. Das heißt, die stärkere Kontrolle über Vermögen und Einkommen durch Frauen könnte das Ergebnis einer Verlagerung der Zeitaufteilung der Frauen auf andere Aktivitäten gewesen sein, die direkte Vorteile und eine allgemeine Steigerung des Wohlergehens der Haushalte mit sich brachten. Darüber hinaus gibt es

Hinweise darauf, dass die Intervention negative Spillovereffekte hatte, in dem sie zu Spannungen in den Haushalten führte, die die Motorpumpen nicht erhielten, was sich negativ auf die Frauen auswirkte.

Kapitel 4 zeigt, dass Programme, die darauf abzielen, die Produktivität, Rentabilität und Nachhaltigkeit der Landwirtschaft durch die Verbreitung verbesserter landwirtschaftlicher Technologien und Praktiken, wie etwa der Kleinbewässerung, zu steigern, zugrunde liegende strukturelle Ungleichheiten und Geschlechterdynamiken berücksichtigen müssen, wenn sie zusätzlich die Handlungsfähigkeit von Frauen stärken sollen. Die in Kapitel 5 vorgestellten Ergebnisse einer Umfrage zu Wissen, Einstellungen und Praktiken sowie Interviews mit wichtigen Vertretern von Organisationen, die sich für die Anpassung an den Klimawandel in ganz Subsahara-Afrika einsetzen, zeigen jedoch, dass die Fähigkeit dieser Organisationen, geschlechtergerechte Programme anzubieten, nach wie vor begrenzt ist. Das Kapitel identifiziert mehrere wichtige Kapazitätsbeschränkungen, die je nach Organisationstyp (Regierungsbehörden, lokale NGOs und internationale NGOs) variieren. Defizite stehen unter anderem bei der Integration von geschlechtersensiblen Forschung, inklusive der Verwendung von nach Geschlecht aufgeschlüsselten Daten, in Programme, um sicherzustellen, dass diese den unterschiedlichen Bedürfnissen von Männern und Frauen Rechnung tragen.

Als Haupthindernisse wurden mangelnde Personalkapazität und begrenzte Verfügbarkeit gebietsspezifischer Forschung und nach Geschlecht aufgeschlüsselter Daten sowie unzureichende Finanzmittel genannt.

Die Ergebnisse dieser Dissertation legen nahe, dass bei der Gestaltung und Verbreitung von Kleinbewässerungstechnologien viele Faktoren zu berücksichtigen sind, um sicherzustellen, dass diese gerecht verteilt werden und sowohl Männer als auch Frauen die Möglichkeit haben, sich an der Bewässerung zu beteiligen und davon zu profitieren. Dazu gehören geschlechtsspezifische Präferenzen für die Art der Bewässerungstechnologie oder des Bewässerungssystems, das zugrundeliegende gesellschaftspolitische Umfeld, das die Barrieren beeinflusst, mit denen Männer und Frauen konfrontiert sind, sowie geschlechtsspezifische Umsetzungsansätze.

Um über das bloße Erreichen von Frauen (das heißt ihre Teilnahme an Programmaktivitäten) hinaus zu gehen, um Frauen zu fördern und ihre Selbstbestimmung (das heißt ihr Wohlbefinden zu steigern und ihre Fähigkeit, strategische Lebensentscheidungen zu treffen) zu stärken, sind Kenntnisse des lokalen Kontexts und besondere Aufmerksamkeit erforderlich, um sicherzustellen, dass die Ergebnisse für Frauen erreicht werden, auch wenn dies eine Erweiterung der Aktivitäten und Möglichkeiten

außerhalb der Landwirtschaft bedeutet. Dafür sind auch größere Anstrengungen erforderlich, um die Kapazitäten der Durchführungsorganisationen für die Bereitstellung geschlechtergerechter Programme aufzubauen. Die Schaffung von Plattformen wie Prozessen zur Konsultation von Interessenvertretern oder Dialogen, um Ziele zu setzen und Informationen, Ansätze und gewonnene Erkenntnisse auszutauschen, ist eine Möglichkeit, diese Kapazitäten aufzubauen. Die Integration geschlechtersensibler Forschungsinstrumente in die Strategieentwicklung, Projektgestaltung, Umsetzung sowie Überwachung und Bewertung der Durchführungsstellen würde auch die Entwicklung geschlechtergerechterer Bewässerungsinterventionen unterstützen und dazu beitragen, verbleibende Forschungslücken zu den geschlechterspezifischen Auswirkungen alternativer Agrartechnologien und Praktiken zu schließen. Während diese Dissertation einige Forschungsergebnisse für die Auswirkungen von Motorpumpen in der Kleinbewässerung auf die Selbstbestimmung von Frauen generiert hat, ist dies nur eine von vielen Bewässerungstechnologien und -ansätzen. Es bedarf weiterer Forschung was die Auswirkungen alternativer Bewässerungstechnologien, -systeme und ihrer Verbreitung, einschließlich gruppenbasierter und dienstleistungsbasierter Ansätze, auf die Agency von Frauen angeht.

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1. INTRODUCTION

The Sustainable Development Goals (SDGs) offer a roadmap for the global community to address multiple, cross-sectoral development goals simultaneously. These goals are all interconnected and there are tradeoffs and synergies among them (Nilsson, Griggs, and Visbeck 2016). Thus, meeting the SDGs requires new research, policies, and interventions, and research that consider the synergies and trade-offs among development objectives and apply cross-sector solutions to address complex challenges (UN 2018). Achieving gender equality and empowering women and girls (SDG5) is inextricable linked with the achievement of other development goals including ending hunger, improving food security and nutrition, and promoting sustainable agriculture (SDG2); reduced inequalities (SDG10); and combatting climate change (SDG13). This dissertation highlights the linkages between these intersecting development goals by exploring the potential for small-scale, farmer-led irrigation to provide a pathway for women's empowerment in Northern Ghana. It focuses on the impacts of a small-scale irrigation intervention whereby motor pumps were provided to a random selection of farmer groups composed of both men and women farmers in the Upper East Region of Ghana. These findings are placed in an institutional context in which multiple development organizations, with limited capacity to

implement gender-sensitive interventions, are promoting climate change adaptation, including small-scale irrigation as an important adaptation strategy.

1.1 Background: Women's Empowerment and Gender Equality in Agriculture

While gender equality and women's empowerment are considered fundamental to achieving many development goals, 25 years after the Beijing Platform for Action, where world leaders called for global changes to guarantee equal rights, expand livelihood opportunities, and increase participation in decision-making for women and girls, there remain considerable gender gaps in almost every aspect of society (FAO, IFAD, WFP 2020). These gaps are prominent in the agriculture sector, where women comprise a significant share of the agricultural labor force, yet have less access to productive resources, technologies, and services like information and financial services; less decision-making authority; and fewer opportunities given a considerable work burden with domestic and productive responsibilities (FAO 2011; Doss 2001; Doss and Morris 2001; Peterman et al. 2011; Quisumbing 2003; Udry 1996).

Assets function as a store of wealth and productive assets, such as farm equipment or tools, can be used to generate food and income (Meinzen-Dick et al. 2011; Johnson et al. 2016). The distribution of assets within a household

and in the community also influences bargaining power of individuals (Quisumbing and Maluccio 2003; Meinzen-Dick et al. 2011; Doss 2013; Johnson et al. 2016). There is extensive literature documenting gender disparities in access to and control over assets, like land and other productive assets, which shows that women tend to have fewer or lower-value assets, less access to capital and labor, and use fewer agricultural inputs on plots that they manage (Deere and Doss 2006; Doss and Morris 2001; Ortiz-Ospina and Roser 2018; Peterman, Behrman, and Quisumbing 2014; Perez et al. 2014; Peterman et al. 2011).

Women are also at a disadvantage in terms of intangible assets, such as human capital. Even though more women are becoming educated today compared to 50 years ago, the gender gap in education persists, especially in rural areas (FAO 2011; Evans, Akmal, and Jakiela 2020). Women also tend to have less access to agricultural and climate information and extension services that would build their knowledge and skills, improve agricultural production outcomes, and facilitate adoption of new technologies and climate-smart practices (Quaye et al. 2019; Bernier et al. 2015; Jost et al. 2015; Katungi, Edmeades, and Smale 2008; Lahai, Goldey, and Jones 1999; Tall et al. 2014). There is also a considerable gender gap in access to financial services, such as having a bank account or access to credit, and building financial capital is also more difficult for women given that they have

fewer economic opportunities and are more likely to work in informal, low-wage employment (FAO 2011; Morsy 2020; Hasler and Lusardi 2017, Fletschner and Kenney 2014; ILO 2021).

Men and women often have different preferences regarding how to use resources, what risks to take, and how to allocate income, which are often tied to the different livelihood roles men and women play (Quisumbing 2003; Villamor et al. 2014; Bernier et al. 2015; Ravera et al. 2016). They even have differences in opinion of what constitutes joint decision-making (Anderson, Reynolds, and Gugerty 2017; Acosta et al. 2020; Alwang, Larochelle, and Barrera 2017). Yet women tend to have less bargaining power and limited influence over important household decisions, including how their own personal earned income is spent, and whether to take a loan or sell assets (Ortiz-Ospina and Roser 2018; Pradhan, Meinzen-Dick, and Theis 2018). Women also tend to be excluded from decisions made at the community level in local groups or decision-making bodies, such as water user associations (Pandolfelli, Meinzen-Dick, and Dohrn 2007).

Women also shoulder a larger work burden with both domestic and productive responsibilities, including ensuring the supply of fuel and water for their households; caring for children, the sick, and the elderly; preparing food and other housework; and contributing labor to

agricultural activities that men lead (Kes and Swaminathan 2006). Women's time poverty limits their ability to engage in and lead income-earning activities in agriculture (Blackden and Wodon 2007; Buvinic and Rao Gupta 1997), take on leadership roles in community groups (Lyon, Mutersbaugh, and Worthen 2017) and negatively impacts their nutritional status (Komatsu, Malapit, and Balagamwala 2019) and the amount of time they spend caring for children (Komatsu, Malapit, and Theis 2018). Adoption of mechanized and labor-saving technologies can reduce the burden of agricultural production and free women's time, minimize the energy cost of agricultural production, and reduce drudgery (Pingali 2007; Singh, Mathur, and Rathore 2007; Bains, Kaur, and Mann 2002). Yet women often have trouble accessing and benefiting from labor-saving technologies and mechanization services, such as small-scale irrigation technologies (Theis et al. 2019; Theis et al. 2018).

There is considerable evidence of a gender gap in crop yields between plots that women and men manage, because of the inequalities discussed above (Burke and Jayne 2021; Nchanji et al. 2021; Mugisha et al. 2019; Ali et al. 2016; Croppenstedt, Goldstein, and Rosas 2013; FAO 2011; Peterman et al. 2011). Reducing the gender gap in agriculture by addressing these areas of disadvantage would have huge benefits including, boosting productivity on plots that women manage, thereby increasing food availability, and reducing hunger.

FAO (2011) estimates that closing the input gap on the agricultural land managed by women could increase yields by between 20–30 percent, increasing the agricultural output of developing countries by between 2.5-4 percent.

The literature points to many other benefits of women’s empowerment in agriculture. A review of empirical studies of the economic benefits of women’s empowerment found evidence to support the linkages between women’s empowerment, particularly their control over productive assets, and economic benefits like increased farm productivity, labor productivity, and incomes (Anderson et al. 2021). Several studies have demonstrated that women’s empowerment is a vehicle for achieving other development outcomes, like health, nutrition, and education (Malapit et al. 2015; Malapit and Quisumbing 2015; Sraboni et al. 2014; Yimer and Tadesse 2015).

The Covid-19 pandemic has increased the urgency to address gender gaps in agriculture and other areas of society. Covid-19 has also exposed gender disparities in how men and women experience the combined health and economic shocks of the pandemic, with considerable variation across countries. While men are at a higher risk of severe illness due to both biological and lifestyle factors (i.e. smoking and alcohol consumption) (Koo et al. 2021), women are more likely to shoulder a larger care

burden. Both men and women in rural areas have been hit hard by income losses, savings and asset depletion, indebtedness, and food insecurity because of the pandemic (Alvi et al. 2022). The extent to which families rely on men's or women's savings and assets to cope with the pandemic will have lasting implications for the gender asset gap and the resilience capacities of men and women to address future shocks and stressors. The World Economic Forum (2021) estimates that the time needed to close the global gender gap increased from 99.5 years to 135.6 years because of Covid-19.

The global community increasingly recognizes the need for more transformative changes in agriculture to tackle structural inequalities and achieve inclusive and sustainable food systems. In recognition of the fact that women are key users of development interventions and have important contributions to make, women's economic empowerment is becoming a key feature of development interventions. Today close to 90 percent of social safety net, livelihood and employment, and financial inclusion programs have a gender focus (Andrews et al. 2021). A review of the impact of these programs found that they strengthened women's economic opportunities and income, increased asset ownership, and led to subtle shifts in gender norms, such as increased mobility (ibid).

Yet even when women's empowerment is a program objective, this outcome can be difficult to achieve

(Johnson et al. 2016). The impacts of women's empowerment programs can vary dramatically across contexts, given the specific set of challenges women face in a particular context. Impacts may be more muted in contexts where social norms are more restrictive of women (Kabeer et al. 2012) and, in some cases, programs can have negative unintended consequences, such as an increase in domestic violence (Holmes and Jones 2013, Buller et al. 2018). Programs should be designed in ways that address areas of women's disempowerment in a given context and take into consideration other intersecting identities that affect outcomes, in order to boost program effectiveness and minimize unintentional consequences, such as exacerbated time poverty, reinforced traditional gender roles, and gender-based violence (Andrews et al. 2021). It's important that these strategies go beyond simply targeting or "reaching" women, to ensure that women also benefit, and increase their ability to make strategic life choices (Johnson et al. 2018; Quisumbing, Meinzen-Dick, and Malapit 2019).

1.2 Benefits of Small-Scale Irrigation

Accessing water for domestic and productive purposes is one of the main challenges facing rural agricultural households in sub-Saharan Africa. Water is essential for every aspect of the life and is especially important for the livelihoods of smallholder producers. Irrigation plays an important role in global food security, helping to produce

40 percent of crops worldwide on just 20 percent of the world's cultivated area (Batchelor and Schnetzer 2018). Yet most agricultural production in sub-Saharan Africa relies on rainfall that is variable and becoming increasingly uncertain under climate change. Only 6 percent of cultivated area on the continent is irrigated, compared to 14 and 37 percent in Latin America and Asia, respectively (Malabo Montpellier Panel 2018).

Thus, the potential for expanding irrigated production in the region is high and investments are accelerating (Malabo Montpellier Panel 2018; Giordano et al. 2012). Irrigation investments have historically targeted large-scale irrigation schemes, but more recent evidence suggests that the greatest gains in terms of productivity, profitability, and environmental sustainability will come from investments in small-scale irrigation (Xie et al. 2021; Xie et al. 2018; Xie et al. 2014; Giordano et al. 2012; You et al. 2011). Small-scale irrigation is defined as irrigation that is adopted, managed, and financed by farmers individually or in small groups and implemented on small areas of land to produce both high value and staple crops (Lefore et al. 2019; de Fraiture and Giordano 2014). Small-scale irrigation currently comprises the largest share of irrigated land in many countries across sub-Saharan Africa (Malabo Montpellier Panel 2018).

Numerous studies have documented the productivity and income gains from small-scale irrigation (Passarelli et al.

2018; Xie et al. 2014; Burney and Naylor 2012). These immediate benefits lead to more indirect benefits of improved nutrition and health through several pathways (see Figure 1.1, Bryan, Chase, and Schulte 2019; Passarelli et al. 2018). For example, irrigation can facilitate crop diversification and the production of more nutritious foods, like fruits and vegetables, for household consumption leading to improved nutrition and health outcomes (Bryan, Chase, and Schulte 2019; Alaofè et al. 2016; Olney et al. 2015; Kabunga, Ghosh and Griffiths 2014). Irrigation also increases the availability of nutritious foods for consumers in local marketplaces, particularly during the dry season (Burney et al. 2013; De Fraiture and Giordano 2014)

Because small-scale irrigation increases income from the sale of irrigated crops, this can lead to other well-being outcomes through increased spending on food, health care, and education (Passarelli et al. 2018; Alaofè et al. 2016; Burney and Naylor 2012). Other economic benefits of irrigation include increased employment opportunities and lower poverty (Adam et al., 2016; Dinye and Ayitio, 2013). Irrigation can also improve the Water, Sanitation, and Hygiene (WASH) environment to the extent that water is used for multiple purposes and is managed effectively to minimize health risks associated with poor water quality or vector borne diseases (Bryan, Chase, and Schulte 2019).

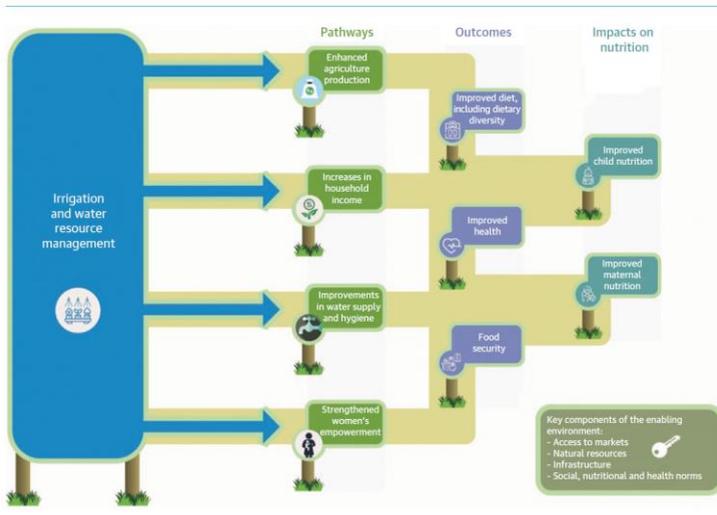


Figure 1.1: Pathways from Irrigation to Nutrition and Health Outcomes

Source: Bryan, Chase, and Schulte 2019

The expansion of irrigation also provides other benefits in terms of increase resilience of food systems to climate shocks and stressors. This is because climate change largely affects agricultural production through changes in water availability due to changing rainfall patterns; more frequent extreme events like droughts and floods; and higher rates of evapotranspiration, which increase the water demand of crops and the need for irrigation (Jiménez Cisneros et al. 2014) and smallholder producers without irrigation will be particularly negatively affected given that their livelihood depends on favorable weather conditions. Climate change will also affect the yields of

key staple crops on which poor producers and consumers in developing countries rely (Wiebe et al. 2015), leading to higher food prices and reduced affordability of food, lower calorie availability, deterioration of diet quality, and increases in childhood malnutrition in Sub-Saharan Africa (Fanzo et al. 2018; Ringler et al. 2010; Springmann et al. 2016). As a result, climate change will slow progress towards eradicating hunger—an additional 80 million people may be at risk of hunger because of the effects of climate change with impacts concentrated in the global South and sub-Saharan Africa in particular (IFPRI 2019).

Irrigation is a key adaptation strategy to mitigate these risks (De Pinto et al. 2019; Batchelor and Schnetzer 2018). Supplemental irrigation can stabilize yields loss under climate change and water stress, thereby potentially reducing the need for food imports, emergency relief, and insurance payouts following climate shocks (Xie et al. 2018; Nangia and Oweis 2016; Fox and Rockstrom 2003). Small-scale irrigation is profitable for small producers in Sub-Saharan Africa under both a drier and a wetter climate future as well as under alternative crop price and irrigation cost trajectories (Xie et al. 2014). Irrigation can also contribute to climate change mitigation if irrigation technologies reduce the use of non-renewable energy and if irrigation is implemented in a sustainable way that improves the quality of natural resources and increases the resilience of ecosystems that support agricultural

production (Batchelor and Schnetzer 2018; Tompkins and Adger 2004).

1.3 Potential for Women’s Empowerment to Maximize the Benefits of Small-Scale Irrigation

As shown in Figure 1.1, women’s empowerment is a potential pathway to achieve improved well-being outcomes of irrigation. Moreover, all the pathways shown in the figure—production, income, and water supply—are all strongly influenced by gender (Bryan, Chase, and Schulte 2019; Lefore et al. 2019; Domenech 2015). Paying careful attention to gender differences in access to as well as needs and preferences for water technologies and their uses, is essential ensure that irrigation interventions provide the greatest benefits in terms of health and nutrition, while minimizing risks.

For example, when women are involved in agricultural decisions households may be more likely to produce a more diverse set of crops as shown by a study from Bangladesh (De Pinto et al. 2020). Several other studies suggest that women tend to prefer irrigation technologies that serve multiple purposes and can be used close to the homestead to grow nutritious crops for household consumption, while men tend to prefer to use irrigation to grow cash crops. (Theis et al., 2018; Nigussie et al., 2017; Carr 2008). Multiple use systems may lead to benefits such as better health outcomes from an improved WASH

environment and more time devoted to childcare (Theis et al. 2018; Pickering and Davis 2012; van Koppen et al. 2009). Similarly, women may have different preferences for how to spend income from the sale of irrigated crops. Several studies have shown that women prioritize expenditures on food, health care, and education when they control income decisions (Gillespie, Harris and Kadiyala 2012; Meinzen-Dick et al. 2012).

Small-scale irrigation may also influence women's empowerment directly to the extent that women are able to adopt and use irrigation technologies and control the benefits (Theis et al. 2018). At the same time, if not carefully planned and targeted, irrigation may lead to negative outcomes for women by increasing their time burden or increasing the gender gap in decision-making authority and asset ownership (Steiner-Asiedu et al. 2012; Riley and Krogman 1993). There are several examples of irrigation projects targeted towards women, such as irrigated home gardens, which show direct benefits for women participants, including an increase in assets and income controlled by women (Burney et al. 2010; Iannotti, Cunningham, and Ruel 2009; Olney et al. 2015; Olney et al. 2009; van den Bold, Quisumbing, and Gillespie 2013). This dissertation explores the relationship between women's empowerment and small-scale irrigation further around an irrigation intervention in Northern Ghana.

1.4 Objectives and Research Questions

As the previous sections have shown, the objectives of promoting gender equality and women's empowerment, improving food security and the livelihoods of poor producers in developing countries through the expansion of small-scale irrigation, and adapting to the negative impacts of climate change are intertwined and mutually reinforcing. Considering these objectives simultaneously can lead to the design and implementation of policies and programs that maximize benefits of investments in these areas. This dissertation explores the linkages further as applied to a case study in Northern Ghana.

The first objective of this dissertation is to develop a conceptual framework to illustrate the linkages between various types of small-scale irrigation and women's empowerment. Most of the literature on gender and small-scale irrigation centers on irrigation schemes and the extent to which women participate in or are excluded from such schemes. Chapter 2 contributes to the literature by focusing on small-scale, farmer-led irrigation and intra-household dynamics around access, use and benefits from small-scale irrigation.

Second, this dissertation aims to examine the context of women's empowerment in Northern Ghana and which dimensions of empowerment might be influenced by small-scale irrigation. Chapter 3 explores how dimensions of empowerment determine the extent to which women

may adopt and benefit from small-scale irrigation. It seeks to answer the following questions using qualitative data collected from men and women farmers and traders in the Upper East Region of Ghana. How do local definitions of empowerment and the aspirational goals of women converge with researchers understanding and measurement of empowerment? What dimensions of empowerment are influenced by the diffusion of small-scale irrigation technologies and how?

Third, this dissertation aims to quantitatively assess the impacts of a small-scale irrigation intervention on indicators of women's empowerment using the Women's Empowerment in Agriculture Index (WEAI). Literature exploring the impact of irrigation on women's empowerment is largely qualitative or focused on home garden interventions that target women. This dissertation expands this work by providing new empirical evidence on the impact of motor pump intervention on women's empowerment.

Finally, given the central role of NGOs, government agencies, private sector actors, and other implementing partners to lead efforts to scale small-scale irrigation as part of a larger effort to promote adaptation to climate change, this dissertation aims to assess the capacity of these stakeholders to implement gender-sensitive interventions.

Thus, the analyses in this dissertation are guided by 4 main research questions:

- 5) What are the linkages between small-scale irrigation technologies/systems and dimensions of women's empowerment?
- 6) What aspects of women's empowerment emerge as the most salient in the context of Northern Ghana where small scale irrigation is practiced and modern technologies (motor pumps) are being introduced?
- 7) How does the introduction of small-scale irrigation technologies (specifically motor pumps) affect indicators of women's empowerment?
- 8) What are the gender-related capacity needs of development organizations working to promote climate change adaptation (of which small-scale irrigation is an important practice)?

1.5 Policy Relevance

Investments are shifting towards small-scale irrigation, particularly in sub-Saharan Africa where large untapped potential remains. Much of the expansion of irrigation technologies at the household level occurs autonomously and is demand driven, while at the same time, organizations like NGOs and private companies are working to scale technologies for small-scale irrigation,

and governments are crafting policies and regulations to ensure the supply and manufacturing of technologies and speed dissemination. The ways in which different countries are promoting the expansion of small-scale irrigation varies from largely government-led efforts as in the case of Ethiopia (Bryan et al. 2020) to more hands-off approaches in which private sectors partners are expected to lead as in Ghana (Minh et al. 2020, Atuobi-Yeboah, Aberman, and Ringler 2020).

Furthermore, with a multitude of technologies and systems for small-scale irrigation, questions remain about which technologies or approaches are appropriate where and for whom. While policy documents and agricultural program designs often reference the need for social inclusion, increasing gender equality in interventions for small-scale irrigation remains an elusive goal. Most agricultural sector development policies and programs now have specific objectives and priorities related to addressing gender, yet implementation remains lacking, and gender is not adequately mainstreamed throughout all agricultural activities (Ampaire et al. 2020). There is little appreciation among representatives of agricultural ministries, irrigation and water engineers, agricultural experts, and service providers of the need to consider the gender dimensions of irrigation in the design of irrigation technologies, systems, and interventions. Thus, these stakeholders have little information and knowledge about gendered preferences for and outcomes of small-scale

irrigation (Theis et al. 2016). In contexts where the diffusion of small-scale irrigation technologies is left up to the private sector, as in Ghana, there is little oversight to ensure that these technologies and the benefits of these technologies are being distributed in an equitable manner.

While not yet mainstreamed in the irrigation sub-sector, many donors, policymakers, and practitioners are paying greater attention to the importance of women's empowerment, and gender equality and inclusion in agriculture with the recognition that agricultural development that excludes women is not only unjust, but also of limited effectiveness given women's unique roles in and contributions to their households, communities, and societies. Thus, many implementing partners are now looking for research and information on how to integrate gender effectively into their programs. This dissertation aims to contribute to this body of knowledge by evaluating the impacts of a small-scale irrigation intervention that provided motor pumps to farmers in Northern Ghana and by identifying the capacity needs of implementing partners with respect to gender.

Even among organizations that want to implement gender-sensitive irrigation interventions, the capacity to do so remains low, as this requires understanding the local social context in which the intervention will take place. Tools, such as the Women's Empowerment in Agriculture Index (WEAI), are emerging to diagnose the main

contributors to women's disempowerment in a given context and to understand local definitions of and aspirations for empowerment. Similarly, capacity needs assessment can uncover entry points for strengthening the capacity of development organizations to implement gender-sensitive programs.

1.6 Structure of the Study

This dissertation explores issues related to women's empowerment and small-scale irrigation from several different angles: conceptually based on literature review, as applied to a case study in Northern Ghana, and as part of a larger effort of development organizations to promote adaptation to climate change. This research relies on mixed methods for data collection and analysis including literature review, qualitative data collection and analysis, econometric analysis of intrahousehold survey data collection and analysis of data collected through a knowledge, attitudes and practices (KAP) survey with development organizations. Chapter 2 describes the conceptual framework used for this research and explores how the dimensions of women's empowerment (resources, agency, and achievements) vary across different contexts (opportunity structure) and for different types of small-scale irrigation systems (communal, household, and group-based). Chapter 3 applies the conceptual framework to a case study in the Upper East Region of Ghana, where a small-scale irrigation

intervention took place, through which groups of farmers received motor pumps for small-scale, household-level irrigation. This chapter draws on qualitative data collected from several communities in the region to explore local definitions and processes of empowerment and ongoing social change, focusing on the particular dimensions that relate to small-scale irrigation. Chapter 4 uses household and intra-household data to assess the impact of the same small-scale irrigation intervention on indicators of women's empowerment using the Women's Empowerment in Agriculture Index (WEAI) and discusses the implications for the design and approaches used by interventions to expand the diffusion of technologies for small-scale irrigation. Chapter 5 takes a step back to examine the capacities of development organizations to deliver gender-sensitive programming focusing on climate change adaptation programs more broadly, of which small-scale irrigation is often an important component. Chapter 6 links the findings across these chapters together and discusses the policy implications of this research and remaining research gaps.

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2. WOMEN AND SMALL-SCALE IRRIGATION: A REVIEW OF THE FACTORS INFLUENCING GENDERED PATTERNS OF PARTICIPATION AND BENEFITS

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ABSTRACT

Small-scale irrigation is expanding rapidly in parts of the world, especially sub-Saharan Africa, offering smallholder farmers an opportunity to improve their livelihoods, diets, and resilience to climate change among other benefits. Growing research focuses on the potential for small-scale irrigation to offer a pathway for women's empowerment, yet the factors conditioning the relationship between small-scale irrigation and women's empowerment are not well understood. The evidence tends to be scattered across context-specific case studies that focus on targeted outcomes, without distinguishing between technology types, scales, or approaches to irrigation systems or technologies. This paper synthesizes the issues related to gender and small-scale irrigation

using a conceptual framework that highlights the linkages between elements of women's empowerment and small-scale irrigation. Because gendered dynamics with small-scale irrigation play out differently depending on the scale of irrigation and the technologies used, this paper applies the framework to examine case studies across a typology of small-scale irrigation systems. The case studies cover a range of farming and livelihood systems in which women's roles and gender relations vary, highlighting the importance of the opportunity structure or context in which irrigation takes place. This paper then draws lessons on the various ways in which small-scale irrigation, gender relations, and women's empowerment interact and highlights areas where research gaps remain.

2.1 Introduction

Small-scale irrigation has gained attention of policy makers and development institutions as an important practice for increasing yields and profits of smallholder producers in developing countries (Xie et al. 2014, Giordano and de Fraiture 2014, Burney, Naylor, and Postel 2013; You et al. 2011) and for mitigating the risks of climate change (Nangia and Oweis 2016; Malabo Montpellier Panel 2018). Already widely adopted across much of South Asia (Barker and Molle 2004), recent research documents an increase in the practice throughout sub-Saharan Africa (SSA) (Woodhouse et al. 2017, Beekman, Veldwisch, and Bolding 2014). In addition, research points to the potential for further expansion in the region to increase the profitability of agriculture under climate change, while also improving food security and nutrition outcomes (Xie et al. 2018, Passarelli et al. 2018, Xie et al. 2014, Giordano and de Fraiture 2014, Burney, Naylor, and Postel 2013; You et al. 2011). Small-scale irrigation can be defined as irrigation that farmers control themselves for cultivating small plots of land, using technologies and systems which they operate and maintain at the household level or in small groups or communities. While small-scale irrigation is expanding and offers potential for improved livelihoods and economic growth generally, the sub-sector requires greater scrutiny to begin to assess the gendered patterns of participation and benefits.

New research suggests that small-scale irrigation may contribute to a wider set of development goals beyond just increasing crop productivity and incomes. These include expanding employment opportunities, increasing climate resilience of farming, improving food security and nutrition, as well as providing opportunities for women's empowerment (Bryan and Mekonnen 2021; Passarelli et al. 2018; Adam et al. 2016; Alaofè et al. 2016; Burney and Naylor 2012). The evidence tends to be scattered across context-specific case studies that focus on targeted outcomes, without distinguishing between technology types, scales, or approaches to irrigation systems or technologies. The outcomes of small-scale irrigation interventions often depend on these and other factors—including characteristics of the social, economic, and agro-ecological context. The literature reflects the complex linkages and multiple factors between irrigation and development outcomes, which makes analysis of gender particularly challenging.

Early research on women in irrigated agriculture focused largely on gendered access to and roles in large public irrigation schemes. This research demonstrated how gender relations influenced irrigation investments and the development of formal and informal irrigation institutions that in turn, often constrained opportunities for women to participate in and benefit from the schemes (Padmaja et al. 2019, Lefore, Weight, and Mukhamedova. 2017, Nkhoma and Kayira 2016). More recently, studies are

examining gender dynamics and small-scale irrigation with important contributions from the CGIAR. This literature examines how gender relations at the household level influence adoption and use patterns, and the distribution of costs and benefits across different members of the household, which has broader implications as an increasing number of households adopt technologies for small-scale irrigation throughout SSA and other parts of the world. Gender dynamics at the household level are still strongly influenced by the socio-economic context that defines gender roles in farming.

While this paper focuses primarily on gender, other intersectional characteristics of men and women farmers within the same context, such as their wealth, cast, age, education, marital status and other identities, also shape the distribution of resources and livelihood roles thereby conditioning opportunities for uptake of irrigation and outcomes. For example, in parts of South Asia, including Bangladesh, India, and Pakistan, landless women and women from poorer households tend to be more involved in agriculture—either by working as wage laborers or on family plots—while women from wealthier households tend to be less engaged in agricultural work (Shah and Memon. 2014). Even among women working in agriculture, caste plays a strong role in the extent to which women can participate in water management decisions at the community level (Ahmed 2014). We acknowledge these intersectional factors, but do not include these in this

analysis. This paper synthesizes the issues related to gender and small-scale irrigation, including gendered patterns of adoption and use, the distribution of costs and benefits, and the influence of these patterns on development outcomes. These issues play out differently across different small-scale irrigation systems (from household to communal schemes), with different irrigation technologies, and across different farming and livelihood systems in which women's roles and gender relations vary widely. Much of the research to date focuses on individual case studies where specific irrigation interventions or technologies or schemes are examined. This paper draws lessons from case studies from a range of contexts in which different irrigation systems and technologies are applied to begin to better understand the various ways in which small-scale irrigation, gender relations, and women's empowerment interact. With an overview of the existing research, we then highlight areas where research gaps remain.

2.2 Conceptual Framework

The literature on gender and small-scale irrigation consists mostly of disparate case studies of different small-scale irrigation interventions from different local contexts, as noted above. Each covers different aspects of women's empowerment, such as women's ability to adopt small-scale irrigation and/or the benefits they may receive in terms of control over income, decision-making, among

others. Women's empowerment is a complex process that plays out differently in different contexts, which means that not all aspects are necessarily considered across the various case studies on the gendered dimensions of small-scale irrigation. Thus, we develop a conceptual framework to provide a conceptual picture of the key elements and connections between small-scale irrigation and women's empowerment. We then use this framework to systematically examine the patterns across cases in terms of the relationship between small-scale irrigation and the various elements of women's empowerment. This approach also helps to highlight evidence gaps and enables us to draw lessons for future investments and intervention approaches.

Women's empowerment is multi-dimensional and is often conceived as both an outcome (having greater access to and control over resources and decision-making ability) and a process of change (the process of expanding people's freedom to act and capacity to make choices) (Alsop et al. 2006, Datta and Kornberg 2002, Stern et al. 2005, Nussbaum 2000, and Kabeer 1999, 2001). Power relations at multiple scales are fundamental to understanding empowerment. Empowerment often includes a relational increase in the forms of power, including: "power to" (the ability and freedom to make decisions that achieve goals), "power with" (achieving shared interests through collective action), "power within" (an individual's sense of freedom from restriction,

self-respect, and self-efficacy), and “power over” (control over others, regarded as a negative form of coercive power) (Rowlands 1997, Mosedale 2005, Datta and Kornberg 2002, and Deshmukh-Ranadive 2005). Other frameworks of empowerment describe the opportunity structure (broader social and political context in which actors pursue their interests), agency (individual and collective ability to utilize assets and capacities to make choices), and the interaction between these as determinants of empowerment (Alsop et al. 2006, Narayan 2005, and Petesch et al. 2005). While these concepts can be applied across a variety of contexts and settings, frameworks should allow flexibility to integrate emic understandings of empowerment (Meinzen-Dick et al 2019, Mason 2005, and Narayan 2005).

The framework used for this study acknowledges and builds on the existing approaches and allows for an iterative process of women’s empowerment. This framework enables us to consider the process and entry points through which women improve their ability to make strategic life choices (agency) by utilizing resources (e.g. assets and capacities), leading to improvements in well-being outcomes (achievements), such as food and nutrition security, and/or economic and social status (Bryan and Garner 2020; Meinzen-Dick et al. 2019; Kabeer 1999). Agency is defined here as an individual’s ability and freedom to make decisions that achieve goals (instrumental agency), their ability to achieve shared

interests through collective action (collective agency), their internal sense of freedom from restriction, self-respect, and self-efficacy (intrinsic agency). Resources expand the range of opportunities for women to make strategic life choices. Similarly, women need agency to be able to access and control resources. This is illustrated by the two-way arrow between resources and agency. This interaction then produces achievements (or lack of achievements) including changes in well-being outcomes for better or worse. This process is iterative, whereby well-being outcomes influence women's access to and control over resources and their level of agency, as shown by the arrows feeding back into these components. The opportunity structure influences all of these components, such as the distribution of resources, the ways in which women exercise agency, and the well-being outcomes they are able to achieve.

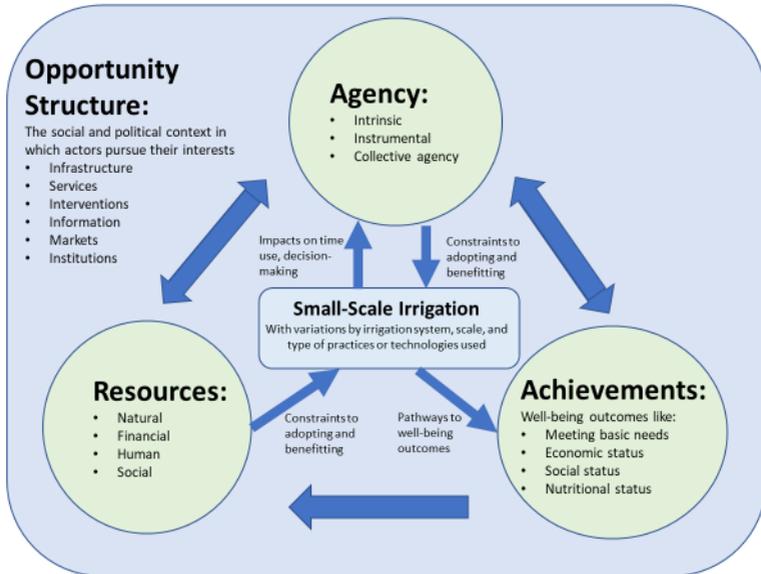


Figure 2.1: Framework for Small-Scale Irrigation and Women’s Empowerment

Source: Bryan and Garner 2020 (Adapted from Meinzen-Dick et al. 2019 and Kabeer 1999).

This framework builds on previous approaches in that it places small-scale irrigation into the interaction with and between the components of women’s empowerment (resources, agency, and achievements). Small-scale irrigation is shown to have a two-way relationship with the dimensions of empowerment, whereby empowerment influences uptake of irrigation and irrigation also affects changes in empowerment (Figure 2.1). That is, women’s ability to adopt and use small-scale irrigation depends on:

- 1) their access to productive resources, like land, water

and other agricultural inputs, 2) their ability to exercise various types of agency (intrinsic, instrumental and collective), and 3) the institutional environment (or opportunity structure) that governs their behavior within different gendered farming and livelihood systems (Bryan and Garner 2020). Once adopted, small-scale irrigation can increase well-being achievements through several pathways, such as changes in income, changes in food security, and changes in women's empowerment. The opportunity structure, defined as the social, political and institutional context in which different actors pursue their interests (Alsop et al. 2006, Narayan 2005, and Petesch et al. 2005), determines the ways in which these relationships play out in a local context by influencing the distribution of resources, the ways in which women can exercise agency, and the well-being outcomes they are able to achieve through irrigation.

The opportunity structure shapes the degree and nature in which women participate in and benefit from small-scale irrigation. It consists of the formal and informal rules in society that govern human interaction and power dynamics, including policies, laws, and investments, organizations and program interventions, infrastructure, services, and informal social and cultural norms of behavior. In other words, the opportunity structure goes beyond institutions to consider the broader context in which farming systems are based, which shapes the

gender dimensions of these systems in terms of resources, agency, and achievements.

An important part of the opportunity structure is the socio-cultural norms that define men's and women's roles within gendered farming systems. Van Koppen and Hussain (2007) describe two basic types of gendered farming systems—dual-farming vs. male-dominated farming systems—that shape women's water needs and interests as well as the extent and nature in which women participate in and benefit from irrigation. In male-dominated farming systems, women's role in agriculture is not widely recognized or appreciated in society and women tend to be excluded from production and irrigation decisions, face social taboos that prevent them from engaging in irrigation activities, and subject to men's control over the factors of production, including women's own labor (Van Koppen and Hussain 2007). In dual-farming systems, women have somewhat greater ability to adopt and benefit from small-scale irrigation; the potential productivity increases and livelihood improvements from addressing gender gaps in production (i.e. in access to inputs, resources, information, technologies, services, and markets) are great (ibid). Even within these two basic types of gendered farming systems, there is variation in the roles men and women play and in the constraints women face related to factors that shape the specific opportunity structure.

Similarly, social norms also influence the extent to which women can exercise agency to participate in and benefit from small-scale irrigation. In many contexts, women lack decision-making authority within the household and community spaces to successfully negotiate for resources and provide input into farming decisions, including the development of irrigation schemes or arrangements and the adoption and use of irrigation technologies in ways that benefit them. For example, women often have less influence over decisions related to the use of irrigated crops or the spending of income from the sale of irrigated crops (Theis et al. 2018). Women may also have more limited mobility or ability to participate in group-based activities, which can further limit their ability to adopt and benefit from small-scale irrigation.

The opportunity structure also shapes access to essential resources for irrigation, such as land and water. Access to water for irrigation is often conditioned on access to land, and when women do not inherit land, their ability to participate in and benefit from irrigation activities depends on men granting them access to irrigable land (Bryan and Garner 2020, Imburgia 2019). In patrilineal societies, women have more difficulty in gaining access to land, whereas in matrilineal societies women can benefit from greater access to and control over land. That said, inheritance norms vary by community within the same country and society. In places where joint rights to land are recognized, women's knowledge of their rights

matters, as demonstrated by a study from Ethiopia (Kumar and Quisumbing 2015). In Pakistan, women's inheritance rights are not always recognized which leads to men's de facto control over land (and water) (Shah and Memon 2014). Even in matrilineal societies where women's rights to land are nominally stronger, patriarchal dominance remains the norm, whereby men may still control decisions about land use, farming, the allocation of labor, and income (Djurfeldt et al. 2018).

The gender-sensitivity of policies, investments, and interventions for small-scale irrigation also influences the extent to which women participate in and benefit from various systems for small-scale irrigation. For example, investments in water infrastructure at multiple scales, such as dams, irrigation schemes, and tubewells, may change land and water use patterns and use rights in ways that may negatively affect women by not meeting their specific land and water needs or by negatively affecting their labor burden (Mitra and Rao 2019, Nkhoma and Kayira 2016). That is, policies, investments, and interventions are important components of the opportunity structure that shape the design and development of systems for small-scale irrigation and also determine the types of technology and finance available to farmers.

The institutional structures associated with investments in irrigation infrastructure and the spread of irrigation

technologies also influence whether or not women and other resource-poor farmers have or can obtain secure rights to land, water, and irrigation infrastructure (Meinzen-Dick 2014). Notably, women and other marginalized farmers' meaningful participation in the development and operation of irrigation interventions and in community groups for water management conditions the ability to advocate for rights to participate in and benefit from irrigation and other water uses (Meinzen-Dick 2014). However, women's ability to negotiate for their interests and preferences in the policy and community spaces is often limited—male engineers and farmers tend to dominate the design of schemes and other irrigation infrastructure and local, typically male, leaders set rules for participation and the distribution of resources (Udas 2014). For example, women working in the irrigation authority in Pakistan face significant constraints, including lack of access to their own separate toilets and harassment by male colleagues, which prevent women's meaningful participation in policy and planning decisions regarding water management (Shah and Memon 2014). At community level, local leadership may prevent women from participating in or speaking at irrigation scheme or water user group meetings, which reduces the influence of women farmers in local level governance (Lefore, Weight, and Mukhamedova 2017).

The way in which interventions are designed and implemented also influences the extent to which women

can participate in and benefit from small-scale irrigation. More inclusive interventions take into consideration and aim to address the specific constraints and opportunities that women face in a particular context, such as lack of access to information about irrigation (Theis et al. 2018). On the other hand, gender-blind irrigation interventions can unintentionally introduce or exacerbate gender inequalities (Mitra and Rao 2019, Lefore, Weight, and Mukhamedova 2017, Nkhoma and Kayira 2016, van Koppen 2002). The gender sensitivity of irrigation and natural resource management programs depends, in part, on the perceptions about, as well as support and resources for, gender equity from decision makers from the national to local level, including men and women policymakers, irrigation engineers, project implementers, technocrats, among others (Dittoh, Snyder and Lefore 2015).

Even when the constraints that women face are taken into consideration in policy and program design, gender-sensitive policies may not be funded adequately or implemented at the local level. In this regard, the institutions and bodies that determine and allocate budgets are part of the opportunity structure. For example, in Malawi, national policy dictates that women should be included in the executive committees of water user associations (WUAs) and that 30 percent of plots in formal schemes should be allocated to women (Lefore, Weight, and Mukhamedova 2017). However, these quotas did little to increase women's meaningful participation in

water management decisions at the local level, particularly in leadership roles within WUAs and women, particularly in patrilineal areas, still had difficulty accessing land and other resources, like inputs, to participate in and benefit from the scheme. A study in Ghana also suggested that a strong national narrative and official policy in support of gender equity did not translate to gender-sensitive programs and projects, because national agencies failed to allocate funding (Dittoh, Snyder and Lefore 2015).

While the opportunity structure often limits women's access to resources and agency, women that are able to adopt small-scale irrigation may benefit from a reduced work burden, greater participation in decision-making, increased control over income or productive resources, and expanded opportunities for community leadership and engagement. The extent to which women benefit directly from irrigation depends greatly on the context as well as the irrigation systems and technologies that are put in place and available to farmers. When women can adopt and benefit from irrigation practices and technologies, this can enable them to achieve the goals that they define for themselves. Often these goals go beyond aspirations for women's own lives to include well-being goals for other family or community members—such as putting children through school, ensuring the family's food security and nutrition, or helping others in the community (Bryan and Garner 2020, Meinzen-Dick et al. 2019).

2.3 Application of the Framework to Case Studies by Type of Irrigation

By applying the framework to multiple case studies covering different contexts, and different systems and technologies for small-scale irrigation, this review explores how these dimensions influence the relationship with resources, agency, and achievements (or benefits). The use of the framework for analysis enables us to highlight how the opportunity structure influences women's ability to participate in and benefit from small-scale irrigation within various types of schemes or system, and across different technologies. Women's ability to adopt small-scale irrigation also depends on the type and scale of the irrigation system and technologies selected for small-scale irrigation. The characteristics of different systems and technologies determine which resources and what type of agency are needed for women to successfully adopt and benefit from irrigation. Note that the typology of small-scale irrigation systems used in this paper focuses on the scale of operation of the system (communal, household, or group), which follows the common typology used by governments, policymakers or investors. Alternative typologies of small-scale irrigation systems could be based on other characteristics of irrigation that also have implications for gender dynamics and women's empowerment, including governance arrangements, ownership or management of the systems, or source of investment.

Table 2.1: Types of Irrigation by Scale

Type	Description
Communal schemes	Systems that largely draw water from surface water bodies (and in fewer cases, lift from deep groundwater), and distribute it through built infrastructure, such as gravity canals, to numerous smallholder farmers within an area. The system command area may be large, but individual farmer plots are often small-scale. Distribution of water tends to be uneven, whereby farmers located closer to the water source have easier access (amount and schedule) to sufficient water, while those located towards the tail end of the scheme infrastructure may not receive equal or adequate shares of water. Public institutions with support from international finance institutions often provide funding for and own infrastructure, whereas members of the scheme may own or rent land within the command area and be expected to pay for operation and maintenance costs. Scheme decisions (governance) related to water management are expected to be collective by water users within the scheme.
Household-level	Systems at household level or individual level involve smallholder farmers utilizing practices (such as water harvesting) or affordable technologies (such as motorized or manual pumps) to lift water. Farmers typically access and lift water from hand-dug wells or boreholes, or access surface water bodies, distributing water on field by furrow, hose, sprinkler, drip or manual method. Farmers control the timing and application of water to relatively small, individually owned or rented plots. Investment is predominantly made by individual farmers with own funds or informal or small-scale finance. Decisions on investments, technologies, practices, or water resources are typically

	autonomous and lack formal consultation or coordination with other members of the community or watershed.
Group-based	Group-based systems involve groups of smallholder farmers sharing low-cost infrastructure, and/or irrigation technologies, jointly farming small-scale irrigated plots or contiguous plots, and/or sharing or renting irrigation technologies. Water sources are both surface and shallow groundwater and field distribution often furrow, hose, sprinkler, drip, or manual method, such as buckets or watering can. Group-based systems pool the costs and resources associated with investment, which are sometimes farmers' own investments, but often promoted through development interventions (e.g. irrigated home garden projects with groups of women). Group-based systems often fall outside formal governance structures for water resources.

Source: Authors

2.3.1 Communal Schemes for Small-Scale Irrigation

The resources and agency that women need to participate in different irrigation systems varies by the scale of the system. As the scale of an irrigation scheme increases, more finance, infrastructure, and resources (including labor) are needed. Similarly, as the scale of irrigation activities increases, stronger property rights and specialized institutional arrangements—i.e. those requiring greater levels of collective action and coordination— are needed for sustainable, efficient and inclusive management of irrigation (Meinzen-Dick 2014).

In larger, communal schemes, the scale of irrigation increases and the bargaining spaces (or “domains of interaction”) move beyond the home to include community and policy spaces, which in turns requires distinct forms of agency in order for women to have the ability to negotiate for their needs and interests (Meinzen-Dick and Zwarteveen 1998). In addition, the benefits that women derive from larger irrigation systems may also vary from other types of systems. A research and monitoring and evaluation tool, called the Gender in Irrigation Learning and Improvement Tool (GILIT), was designed to enable projects to assess gender and access to resources, participation in management decisions, and the distribution of benefits within irrigation schemes and tested in Malawi, Uzbekistan, and India (Lefore, Weight, and Mukhamedova 2017, Padmaja et al. 2019). This subsection reviews the results of these studies and others that look at issues of resources, agency, and benefits of communal irrigation schemes.

Resources

Collective irrigation schemes involving numerous smallholder farmers require considerable investment in irrigation infrastructure, including the initial cost of infrastructure construction and continuous costs of operation, maintenance, and repair. The resources invested in communal irrigation schemes are often significant (Inocencio et al 2007), yet land and water resources within these schemes are often unevenly

distributed to farmers in a community and within the scheme, particularly women farmers. For example, a study of the Bakolori Irrigation Scheme in Zamfara, Nigeria showed that women were rarely allocated land of their own and that when some women did access land in the scheme it was the poorest quality land, located far from the water source (Abubakar, Danjuma, and Mustapha. 2017). Even in contexts where women have land rights, such as in the Lake Chalwa Basin in Malawi, the development of irrigation schemes disrupted matrilineal power structures through which women had strong land and water rights—men were favored within the scheme and allocated plots near the water source (Nkhoma and Kayira 2016). In Uzbekistan, women farmers were excluded from formal irrigation schemes and the water user associations, despite the disproportionate role women farmers play in irrigated food production for national nutritional security (Lefore, Weight, and Mukhamedova 2017).

Labor is another critical resource for engaging in irrigated production. The labor requirements of communal schemes are often higher than household or group systems, because scheme investors and managers expect small farmers to contribute to construction, operation, and maintenance of the schemes, and in some countries, building feeder roads to link the scheme to the road network. However, across several cases, women are more constrained than men in providing labor in these schemes

due to a heavy work burden and the time required to manage plots within the schemes (e.g. land preparation for efficient water distribution); and social norms often discourage women from performing required heavy labor tasks, such as canal cleaning, or performing tasks at night (Chancellor and O’Neill 1999a, Matshalaga 1999, Awulachew et al. 2005). Examining two different case studies of communal schemes—one in Argentina and one in Ethiopia—Imburgia (2019) finds that the technical properties of irrigation systems largely determine the corresponding physical work demand and that the manual labor input required for water distribution creates a barrier for women. In Nepal, farmers’ labor contribution for maintenance of a system was not linked to the size of their irrigated land so the cost-benefit ratio for women who tended to farm smaller plots was much higher (Udas 2014). In Egypt, social perceptions about women’s physical inability to perform irrigation activities, such as canal cleaning, often prevented them from renting irrigable land, participating in irrigation, and providing wage labor for irrigation (Najjar, Baruah, and El Garhi 2019).

Agency

Irrigation schemes that serve multiple farms require coordinating institutions, rules, and property rights to land, infrastructure, and water (Meinzen-Dick 2014). Women’s ability to participate in and benefit from communal schemes, therefore, depends on their success

in negotiating for their interests at the community level (in addition to the household level) (Meinzen-Dick and Zwarteveen 1998). Women and men often have different preferences for how irrigation schemes are designed and operated and what crops are grown with irrigation (Chancellor and O'Neill 1999a, Matshalaga 1999). Yet women tend to be at a disadvantage in shaping decisions about the design, operation, and management of irrigation schemes, given more limited levels of collective and instrumental agency (Lefore, Weight, and Mukhamedova 2017, Chancellor, Hasnip, and O'Neill 1999, Chancellor and O'Neill 1999a, Matshalaga 1999; Meinzen-Dick and Zwarteveen 1998). Formal and informal membership criteria for participating in water management organizations, such as land ownership and organizing processes that target male heads of household, tend to exclude women (Imburgia 2019, Lefore, Weight, and Mukhamedova 2017, Aarnoudse, Closas and Lefore 2017, Meinzen-Dick and Zwarteveen 1998). For example, in Uzbekistan, women are largely excluded from water user groups and water management decisions as they are less likely to be landowners (Lefore, Weight, and Mukhamedova 2017). A study from South Africa showed, however, that where women have active groups, their ability to negotiate collectively for their interests in the rehabilitation of a water scheme was greater than in communities without active women's groups (Chancellor and O'Neill 1999a).

Other constraints also prevent women from participating in water user and other decision-making groups. For example, women were never consulted in scheme planning or management for the agricultural watershed project in the Bundelkhand region in Central India, where social norms prohibit women from attending meetings and speaking in front of men (Padmaja et al. 2019). Similarly, women's already heavy labor burden can prevent them from participating meaningfully in water user groups, particularly if the meetings are not conveniently located or are poorly timed (Meinzen-Dick and Zwarteveen 1998).

Women's lack of agency, especially their limited participation in water user groups and particularly, their participation as executives in water user groups and water management decisions means that they have less input in the allocation of resources within the scheme (including land and water resources) and less access to information that is shared during these meetings, such as information about the timing of irrigation turns (Padmaja et al. 2019, Lefore, Weight, and Mukhamedova 2017).

Benefits

Moreover, the benefits that women can acquire from participation in the scheme are more limited than men given the constraints to influencing the design, management, and operation of the scheme in a way that meets their needs and preferences. For one, women tend

to prefer schemes are designed for multiple purposes, serving women's needs for both domestic and productive uses of water (Lefore, Weight and Mukhamedova 2017, Shah and Memon 2014). Developing multiple-use irrigation systems that also alleviate women's domestic labor burden is particularly important in male-dominated farming systems where women's ability to participate in and benefit from irrigation is minimal (van Koppen and Hussain 2007).

Moreover, women's lack of instrumental agency also limits their ability to participate in and benefit from communal schemes. Women are at a disadvantage when they do not participate in scheme management, for instance, if the scheme managers schedule women's irrigation turns at night (Imburgia, 2019, Najjar, Baruah, and El Garhi 2019, van Koppen and Hussain 2007, Awulachew et al. 2005). Participating in communal schemes also requires a certain level of mobility to operate and maintain the system, which is another limiting factor for women in many contexts (Najjar, Baruah, and El Garhi 2019, Ashrafi and Rahman 2014, van Koppen and Hussain 2007).

Because women are constrained in providing labor to operate and maintain the schemes, they may not be able to receive adequate shares of water and, therefore, do not gain the full benefits of irrigated production. Conversely, women often withdraw participation in the schemes when

they provide labor input but don't directly receive the benefits from their participation (Lefore, Weight, and Mukhamedova 2017). A study from Malawi showed that women's lack of access to resources and agency, namely inputs, credit, and labor as well as greater market constraints and limited control over income decisions within the household, also led to lower benefits from participation in the irrigation scheme (ibid).

Women also may benefit less than men from communal schemes due to more strict rules about what the water may be used for. When women contribute less to the design of the schemes and setting rules for their operation, they may not have access to water to meet their domestic needs, or homestead gardens used for household vegetable production. Moreover, there may be restrictions about which crops can be grown with the irrigation water—decisions are often taken by public agencies or water user group executives that generally do not reflect women's crop preferences. For example, in Zimbabwe, farmers participating in irrigation schemes were not able to choose which crops they grew and monocropping across the scheme reduced the price that farmers received for their output (Matshalaga 1999). Women were at a disadvantage because they mainly produced less valuable crops for home consumption and had less influence in marketing committees (ibid). Especially where women play a large role in farming, their limited ability to participate in and

benefit from irrigation reduces the productivity of the entire scheme (van Koppen and Hussain 2007).

2.3.2 Household-Level Irrigation

Recent research highlights the ongoing expansion and potential for small-scale irrigation at the household level to contribute to national irrigation development plans and to improvements in the livelihoods and food security situation of smallholder farmers (Namara et al. 2014, Woodhouse, et al. 2017, Xie et al. 2014, 2018). While much of the research on gender and irrigation has focused on communal schemes, recent research explores gender and irrigation dynamics within household-level systems. Within these systems, women's ability to participate in and benefit from small-scale irrigation depends more on the distribution of household resources, such as agricultural plots, and intra-household bargaining processes (Bryan and Garner 2020, Theis et al. 2018, Nigussie et al. 2017). Decisions about intra-household resource allocation and gender roles in agriculture, including irrigation activities, are still strongly influenced by the opportunity structure, notably factors such as inheritance laws, social norms, and institutions.

Numerous studies have examined the constraints to adopting small-scale irrigation at the household level. Constraints that are highlighted include poorly developed supply chains for irrigation technologies, lack of access to

credit, high operational and maintenance costs of irrigation technologies or schemes, high output price risks for irrigated crops, lack of market access for irrigated crops, and lack of institutional support (e.g. access to information, extension, training, and other services) (Giordano and de Fraiture 2014; Namara et al. 2014). Other household characteristics are also cited as determinants of adoption of small-scale irrigation, such as age and education of the household head, access to family labor, access to off farm income, proximity to urban areas, and landholding size (Namara et al. 2014, Haile et al. under review), as well as lack of information about the price of pumps and how to use and maintain them (Colenbrander and van Koppen 2012).

Yet men and women within the same households do not face the same set of constraints and opportunities for adopting small-scale irrigation practices and technologies. While the above-mentioned determinants and constraints apply largely to both men and women farmers, these constraints tend to be more pronounced for women in many contexts, and women and other resource-poor farmers typically face additional hurdles to adopting small-scale irrigation, such as less access to land and to water for irrigation, less access to financial capital, restrictive social norms, lack of access to knowledge and training, and heavier work burdens at home (Bryan and Garner 2020, Imburgia 2019, Abubakar et al. 2017, Nigussie et al. 2017, Giordano and de Fraiture 2014;

Colenbrander and Van Koppen 2012, van Koppen, Hope, and Colenbrander 2012).

Resources

As with communal schemes, women face considerable resource constraints in adopting practices and technologies for small-scale irrigation. In particular, access to irrigable land is a critical constraint for many women to engage in household-level irrigation (Dittoh, Snyder and Lefore 2015). This is especially true in patrilineal societies where women only access land through their husbands (Bryan and Garner 2020, Imburgia 2019, van Koppen and Hussain 2007), but may also apply to matrilineal societies where women must access land through uncles or other male relatives.

While labor input to maintain and operate communal infrastructure is not relevant to household-level irrigation systems, adoption and profitability of irrigation at household level is linked to labor. Household-level irrigation often increases the labor requirements of agriculture, due to the expansion of the production calendar into the dry season, the increase in time spent weeding and preparing land, the need to build fences around irrigated dry season plots, and managing livestock in ways that keep them from invading irrigated areas, in addition to the time it takes to water crops using various methods. The labor requirements of household-level irrigation also vary by water source and type of

technology used. For example, in Northern Ghana, hand dug wells in the riverbed required considerable investment of labor at the start of each dry season, while households located near small reservoirs had an easier time accessing water for irrigation (Bryan and Garner 2020). Women were perceived to be unable to dig the hand dug wells and were, therefore, more easily excluded from engaging in irrigation in communities where that was the only source of water (ibid). Decisions about irrigation technologies may also be influenced by labor availability. In Ethiopia, households with more adult women who could provide labor for irrigation were less likely to invest in labor-saving technologies, such as pumps for water lifting and conveyance (Hagos et al. 2017).

Women also tend to have less access to information about household irrigation technologies, like pumps, and less access to financing to purchase them. For example, in Zambia, women have less access to formal financial services to purchase pumps (Colenbrander and van Koppen 2012). In Ethiopia, women were more constrained in accessing information about irrigation technologies, because women lacked cell phones and contact with extension agents and projects, and were therefore, not invited to meetings (Nigussie et al. 2017). Women in Malawi also had lower access to the technologies through which information about irrigated agronomy was shared, such as radios, or lacked access to

radios at times when agricultural programs were aired; extension field days were also held far from the household and women lacked time and means to participate (Lefore, Weight, and Mukhamedova 2017).

Women also tend to have less access to and control over productive assets and other agricultural inputs that are needed to successfully adopt and sustain irrigated production activities (Peterman, Behrman, and Quisumbing 2011, Doss 2001, Doss and Morris 2001). Access to technologies for small-scale irrigation is one of the largest impediments to the expansion of small-scale irrigation at the household level in many parts of the world, particularly, sub-Saharan Africa. Many of the most profitable technologies require prohibitive cash outlay for smallholder producers and, therefore, pump owners tend to be wealthier men farmers (de Fraiture and Giordano 2014, Namara et al. 2014). Even in South Asia where small-scale irrigation technologies, like motorized pumps, expanded rapidly, irrigation equipment tends to be purchased and owned by larger farmers (de Fraiture and Giordano 2014). Women farmers tend to be even less likely to adopt new, mechanized irrigation technologies, like motorized pumps, but often provide the labor for manual watering with buckets (de Fraiture and Giordano 2014). Which technologies are available in local markets or promoted by government or NGO interventions also affects adoption patterns. Evidence shows that men and women prefer different technologies, but these preferred

technologies face different supply chain constraints. If only men's preferences are considered in the design of irrigation technologies, and in establishing national importation and distribution regimes, then the options that are available in the marketplace may be less appealing to women. Furthermore, many private companies do not target women in their marketing and distribution strategies for pumps.

One approach to household level irrigation is rental, which is a growing business model in many countries. For example, in Ghana, given that pumps are unaffordable for most smallholder farmers, only a few farmers own motorized pumps and rental arrangements are becoming common in some regions (Namara et al. 2014). Accessing the credit needed to rent irrigation equipment may be much more feasible for women who find purchasing a pump cost prohibitive. Even then, renting pumps is difficult for some farmers with lack of access to financial services. Farmers often have limited money at the start of the season to rent pumps or purchase fuel (ibid). To address that challenge, women farmers in Ghana interplant a continuous harvest crop, such as leafy greens, to cover rental or running costs throughout the dry season (Balana et al 2017). Similarly, it matters to what extent women can participate in and benefit from rental services. A study from Bangladesh shows that women were less likely to receive mechanization services or act as service providers, although they did play important

administrative roles and did express interest in opportunities to become more engaged (Theis et al. 2019).

Agency

Women's ability to adopt and benefit from small-scale irrigation at the household level also depends on their agency—especially their ability to bargain for practices, technologies, and uses of irrigation that meet their needs and preferences. Despite having different preferences for technologies women tend to be less involved in the selection and adoption of technologies and equipment for irrigation as well as decisions about how irrigation is applied (Theis et al 2018, Namara et al 2014, Njuki et al. 2014, Nigussie et al. 2017). For example, in Tanzania, while some men and women decided jointly to purchase a pump, when they disagreed, the men made the final decision and, in some cases, men purchased pumps without consulting their wives (Njuki et al. 2014). Sales data from both countries indicated that women purchased less than 10 percent of treadle pumps sold (ibid).

Gendered patterns of uptake of particular technologies and the ways these technologies are applied reflect preferences within a given institutional environment in which gender norms and roles may limit the ways women can benefit from engaging in irrigated production. In particular, women's preferences for different technologies for small-scale irrigation are strongly influenced by several factors, including whether the technology is

considered appropriate for women to use, how much control women have over the technology, how and where the technology is applied, and what benefits women derive from using the technology in terms of time savings, control over output, or other benefits (Theis et al. 2018, Njuki et al. 2014). For example, a study in Ethiopia found that women preferred solar pumps because they were installed near the homestead where they could be used for domestic purposes and watering livestock (Nigussie et al. 2017). Women's intrinsic agency, their ability to use small-scale irrigation in pursuit of their own goals and interests is critical in determining the degree to which they participate in and benefit directly from irrigation activities.

While not as essential as with communal irrigation schemes, women's collective agency can facilitate their participation in household-level irrigation by increasing women's access to information, resources such as credit, and even labor sharing arrangements. Furthermore, as more people autonomously adopt irrigation at the household level using individual wells or tapping into surface water bodies, the impact on other users in the watershed increases—women's collective agency becomes more important as farmers develop rules for managing water more sustainably, to ensure that these rules are equitable (Meinzen-Dick 2014).

Benefits

Because women' often have less decision-making authority over which practices and technologies for small-scale irrigation are adopted and how they are used and applied, their ability benefit directly from use of the technology, for example, in terms of control over the produce and income from irrigated production, tends to be more limited (Theis et al. 2018). In some cases, such as in Tanzania, women may contribute to irrigated production decisions and activities but when it comes time to sell the crops, husbands dominate marketing, sales, and control over income (ibid). However, when women are able to engage in irrigation in ways that they prefer, such as on plots or crops that they control, there is some evidence that they can benefit directly and even increase their own agency through greater control over the output and income from the crops that they produce (Bryan and Garner 2020, Nigussie et al. 2017, Njuki et al. 2014, Van Koppen, Hope, and Colenbrander 2012). In some cases, women are more likely to participate in agricultural decisions and control output from irrigated production compared to rainfed production (Van Koppen, Hope, and Colenbrander 2012). Some of the factors that influence the extent to which women benefit from small-scale irrigation are: whether women have control over decisions related to how the technology is used, the labor implications of the technology, whether the irrigation water can be used for multiple purposes, the location of

the irrigated plot and whether it is managed by women, and the types of crops grown on the plot.

The evidence suggests that men dominate irrigation with mechanized technologies because of social norms about ownership of agricultural machinery, and because the potential to reap greater benefits from irrigation increases with relatively newer technology (Bryan and Garner 2020; Theis et al 2017). For example, in Northern Ghana, even when women were in small groups that received access to a motor pump, pumps were considered major assets and, therefore, owned by their husbands, who then tended to take over irrigation activities (Bryan and Garner et al. 2020; Theis et al 2018). In Kenya and Tanzania, among households that adopted a treadle pump, men continued to make most of the major decisions on crop choices and income use (Njuki et al. 2014). Similarly, in Kenya women reported that men had control over the pumps and rarely lent them to women (Njuki et al. 2014). In some contexts, women have less control over manually-operated pumps because it is considered culturally inappropriate for women to operate these technologies (Njuki et al. 2014, Chancellor and O'Neill 1999b).

Women, therefore, express preference for technologies that they are better able to control in terms of how it is applied and the benefits from its use (Nigussie et al. 2017). For example, women farmers in Ethiopia

perceived an increase in their control over income relative to men when they used tractor with drip and rope and washer, while use of a diesel pump was less likely to change women's participation in expenditure decisions given that they are mainly used on plots planted with cash crops that men control (ibid).

Women also prefer technologies that can be applied to plots or crops that they control, such as those located near the home, or garden plots that they manage. Women in Ethiopia and Benin, for example, expressed preference for solar pumps installed near the household given that the capacity of the pumps is well suited for small household garden plots over which they have greater control (Theis et al. 2018, Nigussie et al. 2017, Burney et al. 2010). Women in Lesotho found it more difficult to engage in irrigated production on plots located far from the household because it made childcare more difficult (Riley and Krogman 1993). Even male-dominated farming systems, where women face constraints to engaging in irrigated cash crop production, women often maintain home gardens or plots where they cultivate staple crops mainly for home consumption. For example, in India, women benefitted most from adopting drip kits on home garden plots that produced food for household consumption but also provided women with a means to earn additional income (Namara, Uphadya, and Nagar 2005).

Women are aware of the risk that men will take over production activities that they control if the crops become commercialized or too profitable. For example, in the Gambia, the introduction of irrigation led male community leaders to take over production of rice, a crop previously controlled women (von Braun and Webb 1989). In these cases, women may mediate their goals to focus more on meeting household food security objectives while taking advantage of opportunities to earn small amounts of income. For example, in Kenya, women's ability to manage income from irrigated crops depended mainly on the type of crop, the quantities in which it was sold and whether it was for cash only or cash and food (Njukie et al. 2014). In general, women tend to have more control over produce and income from food crops, such as leafy green vegetables, while men have more control over cash crops, such as tomatoes (Nigussie et al. 2017, Njukie et al. 2014). In both Ghana and Ethiopia, women were able to control income over crops continuously harvested and garnered smaller amounts of cash over time, whereas men controlled the income from 'lumpy' harvest crops that led to larger amounts of cash in a single sale (Theis et al. 2018). Because women are typically responsible for sourcing and preparing foods for their families, irrigated home gardens also offer benefits in terms of increasing the availability of nutritious foods for the family. A study of home garden production in Burkina Faso found that irrigation programs increased the production of fruits and

vegetables, increased food security, and improved nutrition (Olney et al. 2015).

Small-scale irrigation technologies also have implications for the level of labor input required—more manual irrigation technologies, like watering with buckets or manually-operated pumps, do not save much time and may in fact increase women’s time in agricultural production. More mechanized irrigation technologies, like motorized or solar pumps, save time and have the capacity to irrigate even greater areas of land. Studies suggest that both men and women farmer prefer irrigation technologies that relieve their labor burden. For example, a study from Ghana found that there was considerable disadoption of treadle pumps that were promoted by NGOs due to high labor requirements, drudgery, and the limitations in terms of irrigable area (Namara et al. 2014).

Given the labor implications of irrigation using different small-scale technologies, it matters who provides the labor for irrigated production using these different methods. In general, women tend to engage more in irrigation using manual watering methods, such as buckets, while men dominate irrigation with motorized, labor-saving pumps (Theis et al. 2018, Nigussie et al. 2017, De Fraiture and Giordano 2014, Van Koppen, Hope, and Colenbrander 2012). This suggests that irrigation tends to be a more labor-intensive task for

women, given relatively higher constraints to more mechanized technologies.

Because women also have heavy domestic workloads, with responsibilities for managing other uses of water, irrigation systems that provide water for multiple purposes are preferable and can save women considerable time (Nigussie et al. 2017, van Koppen and Hussain 2007). For example, in Ethiopia, women tend to use the irrigation technologies for multiple purposes including livestock watering and domestic uses, while men use them strictly for irrigation (Nigussie et al. 2017).

Even when men dominate irrigated production decisions and output, and the direct benefits of irrigation skew towards men, women still acknowledge the indirect benefits for their household and families. Often the goals or achievements women define for themselves are not ones that directly benefit them but those that benefit others in their household or community, such as increased household income that is used to enroll children in school or help others in the community (Bryan and Garner 2020, Meinzen-Dick et al. 2019, Nigussie et al. 2017). For example, in Kenya and Tanzania, despite their low ownership of and control over pumps, women perceived household benefits from pump use, including improved food security and an increase in household assets (Njuki et al. 2014). In Ghana, women noted social status and ability to lend other people money as benefits of increased

household income from irrigation (Abujaja and Odonkor 2016).

However, in some cases, where there are considerable constraints to women's engagement in irrigation and limited ability to reap direct benefits, women may rationally seek other pathways to pursue their own goals. Research from Northern Ghana suggests that even when men take over irrigation activities with the introduction of new technologies, women are relieved to be free from the drudgery of irrigation and able to devote more time to other livelihood activities that may provide them with more direct benefits (Bryan and Garner 2020).

2.3.3 Group-Based Irrigation

Group-based approaches to irrigation can also be found, though few studies exist on gender or women farmers experiences in group irrigation. Given that motorized pumps and other technologies are costly for individual farmers to adopt, and also that weak markets make even affordable technologies difficult to access, small groups of households or individuals sometimes share the costs and efforts to invest in irrigation. Yet in other cases, non-profits or donors support small groups in an area to engage in irrigation.

Resources

Shared or group-based arrangements can address other resource constraints to engaging in small-scale irrigation,

such as accessing land and labor. A case study from Lesotho suggests that irrigation through groups reduces time women spend irrigating and makes it easier to use and troubleshoot any problems that arise with the technology (Riley and Krogman 1993). In some cases, working together in groups on may facilitate women's access to jointly managed areas of land for irrigated production. While not focused on changes in women's access to land, a study from Benin suggests that women can effectively engage in small-scale irrigation by working together in groups on shared plots of land (Alaofe et al. 2016). This intervention installed solar pumps and drip kits on vegetable garden plots that were sub-divided and managed by groups of 30-35 women farmers, enabling them to increase access to nutritious foods and income. (ibid).

Agency

Sharing of household-level technologies like pumps or irrigation infrastructure like boreholes requires more collective agency than purchasing a pump for personal household use. What matters then is the extent to which can women participate in these shared arrangements. In Ghana, where small groups of men and women farmers gained access to motor pumps (some single sex and some mixed groups), women in groups that received the pump still generally considered their husbands to be the owners of the pump and let them decide how it was used (Bryan and Garner 2020). However, not all group members had

equal access to the pump—some farmers who could afford to repay the bulk of the loan (typically men) had more control over how the pump was allocated to others in the group (ibid).

Benefits

Addressing only some factors of inequity in a small group system is insufficient to achieve positive outcomes for women. In Malawi, women had agency in the plot allocation process and in choosing the crop for their plots, but they felt little control over benefits because they did not participate in the marketing and usually did not know how much revenue had been generated (Lefore, Weight, and Mukhamedova 2017).

Yet other studies have shown that targeting women's groups makes it easier for them to participate in and retain the benefits from small-scale irrigation. For example, a solar garden intervention in Benin increased the number of women engaging in fruit and vegetable production and increased the variety of fruits and vegetables produced and consumed by the members of the women's groups (Alaofe et al. 2016). Women in farmer groups that gained access to irrigation also increased their income and allocated more income to food purchases, health care and education suggesting considerable gains in household nutritional status and increased decision-making authority of women (ibid).

However, project design and how technology is deployed can also limit the benefits to women in group systems. In a project in Mali, solar pumps were used to lift groundwater into storage tanks for women to produce vegetables on small plots. However, labor constituted the largest cost because women were expected to manually take water from the tanks to distribute on their plots, and analysis showed the plots were too small to allow women to profit from surplus, women gained extremely low returns, and ultimately, many women chose to opt out of the project in the community (Gebrezgabher, Amewu, and Mul 2017).

Another observation from the literature on group-based irrigation is that men's groups are often self-financed, whereas women's group-based irrigation is often in the form of donor-funded projects. The source of funds has implications for influence over irrigation technology and use, as well as the aims. While men who invest can choose the technology, the crops and how to spend any profits, women may be engaged in projects aimed at production for direct consumption, as in general food security aims (WP on WUAs) or household nutrition (Gebrezgabher, Amewu and Mul 2017), rather than income. As one study on projects that target household gardens noted, very little is known about actual benefits for women (Merrey and Langan 2014). Women are also often engaged by donor-funded projects through village savings and loan projects, but most VSLAs do not save or lend enough to enable

women to invest in labor-saving technologies, such as pumps, so have not addressed the credit constraints that women farmers face (Hagos et al. 2017).

2.4 Achieving Development Outcomes through Women's Participation in Small-Scale Irrigation

Regardless of the type of system or technology for small-scale irrigation, irrigation has long been recognized for its potential to contribute to agricultural intensification and farm profitability (Burney, Naylor, and Postel 2013, De Fraiture and Giordano, 2014, Giordano and de Fraiture 2014, Giordano et al. 2012, Xie et al. 2014, You et al., 2011). The discussion above, which is based on in-depth case studies, suggests that small-scale irrigation may also contribute to women's empowerment to the extent that constraints related to women's access to resources and lack of agency are overcome. Apart from these potential benefits for women, more research is emerging that documents the benefits of small-scale irrigation for other development outcomes, such as increasing food and nutrition security. Many of the quantitative studies provide additional evidence for the experiences of women and men farmers documented in the case studies.

Analysis suggests that irrigation interventions may influence nutrition outcomes along the same pathways as broader agricultural interventions—namely through changes in production outcomes and income—but also in

more specific ways, such as changes in water supply, sanitation, and hygiene (Domènech 2015, Passarelli et al. 2018). Irrigation affects agricultural production outcomes by broadening the range of crops that farmers can cultivate, including crops that also have higher nutritional value, and increasing the diversity of crops produced (Alaofè et al. 2016; Burney, Naylor and Postel 2013; De Fraiture and Giordano 2014; Passarelli et al. 2018). Small-scale irrigation also affects the availability and stability of food supply by enabling more cropping seasons, including during dry periods (Aseyehgn, Yirga, and Rajan 2012), and by reducing the risks of rainfed production (Fox and Rockström 2003; Oweis and Hachum 2006). Reducing the risks of rainfed production in turn, may reduce encourage more investments in agricultural production (Abay et al. 2021).

Small-scale irrigation also has the potential to influence nutritional outcomes through an income pathway. Irrigation either introduces the production or increases the yields and quality of high-value crops, which can increase farm income through the sale of surplus produce (Burney and Naylor 2012; Passarelli et al. 2018). The income gained may be used to increase spending on nutritious foods, health care, and education (Alaofè et al. 2016; Burney and Naylor 2012). Irrigation can also expand employment opportunities for other households are not directly engaged in irrigated production (Namara et al. 2011).

Irrigation may contribute to changes in the WASH environment affecting health risks, health status, and utilization of nutrients from food depending on the water source and irrigation system in place. On the positive side, irrigation can improve household access to water for hygienic and other domestic purposes, when multiple uses are considered in the design of the irrigation system. A study from Pakistan found that the use of irrigation water for domestic purposes reduced the incidence of diarrhea, thereby, improving the nutritional status of children (van der Hoek, Feenstra, and Konradsen, 2002). However, in some cases, the quality of irrigation water may not be appropriate for human consumption and irrigation may increase health risks, if not properly managed, through an increase in vector-borne diseases (Keiser et al. 2005). Irrigation may also increase runoff of agricultural chemicals, such as fertilizers and pesticides, which can affect water quality and human health (Mateo-Sagasta et al. 2017). In other words, irrigation is associated with some factors that could improve the WASH conditions of households and, therefore, women's empowerment and health, but those factors also require careful consideration to achieve positive outcomes.

As women have different preferences for how irrigation is applied and because they often pursue goals related to securing food and water for the household and children's well-being, changes in women's empowerment are likely to affect the pathways to these development outcomes in

important ways. In term of the production pathway, because women have their own preferences for the types of crops that are planted and how these crops are used (e.g. for home consumption), interventions targeted to women for the purpose of intensifying irrigated home garden production have been shown to improve nutritional outcomes (Burney et al. 2010; Iannotti, Cunningham, and Ruel 2009; Olney et al. 2009, 2015). Similarly, in terms of the income pathway, women also have different preferences than men for how income is spent, prioritizing expenditures on food, schooling, and health care (Gillespie, Harris, and Kadiyala 2012; Meinzen-Dick et al. 2012). Again, studies suggest that when women control or have influence over income from irrigated production, they spend it in ways that improve family well-being (Alaofe et al. 2016, Njuki et al. 2014, Burney et al. 2010, Hagos, et al. 2017, Gebregziabher et al. 2017).

In terms of the water supply pathway, as women tend to prefer irrigation systems that provide water for multiple uses, such systems can save women's time and improve the WASH environment, depending on the quality of water and the way it is managed (Theis et al. 2018; van Koppen et al. 2009). Saving women's time can lead to greater investments of time in childcare (Burger and Esrey 1995; Cairncross and Cuff 1987; Diaz, Esrey, and Hurtado 1995; Miller and Urdinola 2010), which has positive health implications, such as reducing the incidence of diarrhea and improving nutritional outcomes

of children (Pickering and Davis 2012), and improving hygiene practices (Aiello et al. 2008; Motarjemi et al. 1993). However, to the extent that irrigation increases women's time in agricultural production, this could lead to a reduction in the amount of time that mothers spend on household activities like cooking and caring for their children (Bénéfice and Simondon 1993; Brun, Reynaud, and Chevassus-Agnès 1989; Vaughan and Moore 1988), with potential negative consequences for nutrition.

Research for more than a decade has shown the high numbers of people who can potentially adopt and benefit from SSI, but those optimistic numbers include women farmers. If women are not given equitable access, and if women do not benefit and, therefore, do not sustain participation in irrigated production, then the numbers who actually benefit may be substantially lower than projections. Further, if equity in access is not achieved, and women do not take part in the expansion of irrigated production, then they are likely to lose longer-term access to natural resources (Lefore, et al 2019). In other words, not achieving equity has implications for women farmers in both the short- and long-term, as well as consequences for overall household nutrition and health.

2.5 Conclusions

Research on gender and small-scale irrigation has grown over the past 20 years from a focus on women's

participation in communal irrigation schemes to issues related to household-level irrigation. CGIAR research has contributed considerably to this body of literature including most recently through studies that highlight the importance of intra-household dynamics in determining the extent to which women participate in and benefit from small-scale irrigation. The focus on what goes on within households has also been possible through the application of research tools and data collection efforts that focus on intra-household dynamics, as opposed to earlier research that often compared male and female heads of household. Additional case studies that allow comparisons across countries and regions shed light on how the opportunity structure, and in particular gendered farming systems, influence the ways in which women can participate in and benefit from irrigation. However, less research has compared the nuances related to gender and irrigation across different types of small-scale irrigation systems and related technologies. This review paper aims to fill this gap by comparing and contrasting issues related to the distribution of resources, the ways in which women negotiate in and participate in irrigation decisions at multiple scales, and the benefits they are able to achieve under different irrigation systems, with different irrigation technologies, and under different social contexts.

Gender analysis is needed to inform the development of irrigation systems and programs to shape how small-scale irrigation technologies spread, such that these

interventions take into consideration the opportunity structure within which women engage in irrigated production, the specific challenges related to the scale of the intervention, and the types of technologies promoted or available in the broader market. These factors strongly influence women's access to productive resources, the type of agency needed for women's active participation, and the benefits that women can accrue. While gender-responsive design could help to avoid creating new or worsening existing gender disparities, it may not guarantee gender equality in scheme operations, since schemes typically reflect "existing social relations in power" that have historically favored men (Lefore, Weight, and Mukhamedova 2017, World Bank 2014).

Under communal schemes women's collective agency is essential for women to participate in the design, operation, and management of the scheme in ways that benefit them. Once schemes are designed, it becomes difficult to retroactively redistribute the resources and benefits within the scheme in ways that benefit women (Chancellor and O'Neill 1999a). Women in dual-farming systems have more opportunities to negotiate for land and water resources from the scheme and control the benefits from engaging in irrigated production but still face considerable constraints. In male-dominated farming systems, where women have few opportunities to participate meaningfully in irrigation, women may benefit most from the development of multiple use systems

through which they may increase their access to domestic water (van Koppen and Hussain 2007). Negotiating for these benefits still requires some level of collective agency so that women may participate in decisions related to the design and operation of the schemes. External actors, such as governments or NGOs, may play a role in more equitable development of communal schemes, by allocating plots within the scheme to women or groups of women and supporting women's meaningful participation in water management groups.

With household-level irrigation, intra-household bargaining is essential for women to negotiate for access to land, water, and other resources. However, their ability to bargain for their own needs and preferences is still strongly influenced by social norms and other factors within the opportunity structure, such as the type of farming system and their expected roles within it. Here, the types of technologies that are available for small-scale irrigation and the extent to which women can use them in ways that they prefer become more important for determining the benefits women are able to achieve through small-scale irrigation. Interventions that facilitate the expansion of small-scale irrigation at the household level should consider the appropriateness of the technologies being promoted for women's needs and the particular constraints women face to controlling the technologies and reaping the benefits from their use.

There is still very little research about the constraints and opportunities for women to benefit through small-scale irrigation arrangements that fall somewhere between communal and household schemes. These arrangements, such as shared or group-based arrangements or even rental arrangements between a group of farmers, may become increasingly important as they demonstrate potential to sustainably reach and scale irrigation to more resource-poor smallholder farmers. Moreover, targeting groups of women may make it easier for them to collectively engage in small-scale irrigation activities as some programs have already demonstrated (Alaofe et al. 2016). More research is needed on these types of arrangements to ensure that they are scaled in a gender-sensitive way that enables women to participate in and benefit from irrigation including in both irrigated production and the provision of irrigation services.

Moreover, while this synthesis groups case studies by the scale of small-scale irrigation system, the relationship between other dimensions of small-scale irrigation systems and gendered outcomes needs further exploration. These dimensions include different modalities and approaches to delivering small-scale irrigation interventions and how these different approaches shape the distribution of benefits to men and women farmers. For example, demand-driven approaches may exclude women, because they often lack the resources needed for initial investment in irrigation

equipment, while project-based approaches may more successfully reach and benefit women. Many projects are currently targeting finance for irrigation through asset-based financing, yet these finance mechanisms will continue to exclude women until some of the factors discussed above are integrated into the credit scoring tools. Another dimension that requires further analysis relates to how different ownership, operation, and governance arrangements of small-scale irrigation systems influence women's ability to participate in and benefit from irrigation.

It is also important to point out that when women participate in small-scale irrigation within these different modalities, there are potential benefits that go beyond those the women themselves gain, given women's social and livelihood roles in the household and community. In communal schemes women can contribute to the overall efficiency of the scheme by sustainably intensifying production on plots they manage. Women can also contribute to food security goals by producing nutritious crops, such as fruits and vegetables, for home consumption as well as for sale in local markets. The income women earn from engaging in irrigated production can also contribute to improve their family's and community's well-being. Therefore, gender-sensitive irrigation programs and investments can magnify the benefits of small-scale irrigation.

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3. UNDERSTANDING THE PATHWAYS TO WOMEN'S EMPOWERMENT IN NORTHERN GHANA AND THE RELATIONSHIP WITH SMALL-SCALE IRRIGATION

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Abstract: Women's empowerment is often an important goal of development interventions. This paper explores local perceptions of empowerment in the Upper East Region of Ghana and the pathways through which small-scale irrigation intervention targeted to men and women farmers contributes to women's empowerment. Using qualitative data collected with 144 farmers and traders through 28 individual interviews and 16 focus group

discussions, this paper innovates a framework to integrate the linkages between small-scale irrigation and three dimensions of women's empowerment: resources, agency, and achievements. The relationship between the components of empowerment and small-scale irrigation are placed within a larger context of social change underlying these relationships. This shows that many women face serious constraints to participating in and benefitting from small-scale irrigation, including difficulties accessing land and water and gender norms that limit women's ability to control farm assets. Despite these constraints, many women do benefit from participating in irrigated farming activities leading to an increase in their agency and well-being achievements. For some women, these benefits are indirect—these women allocate their time to more preferred activities when the household gains access to modern irrigation technology. The result is a new approach to understanding women's empowerment in relation to irrigation technology.

3.1 Introduction

Irrigation interventions have considerable potential to contribute to agricultural intensification and farm profitability (You et al. 2011; Giordano et al. 2012; Burney et al. 2013; De Fraiture and Giordano 2014; Giordano and de Fraiture 2014; Xie et al. 2014). Small-scale, farmer-led irrigation is a promising approach to rapidly scale irrigation adoption leading to livelihood and food security gains for vulnerable populations (You et al. 2011; Burney et al. 2013). Moreover, as climate change makes rainfed production riskier, irrigation is emerging as an important strategy to increase resilience to climate shocks and stressors (Nangia and Oweis 2016).

Until recently, less focus has been paid to other potential benefits of irrigation, such as improved nutrition and health, and the pathways through which irrigation contributes to these outcomes. Evidence suggests that small-scale irrigation broadens the range of crops that farmers may cultivate, improves food security and diets (Burney et al. 2010; Namara et al. 2011; Burney et al. 2013; de Fraiture and Giordano 2014; Alaofè et al. 2016; Passarelli et al. 2018), and increases the availability of nutritious foods throughout the year (Baye et al. 2021). Irrigation can also increase economic access to food, asset accumulation, employment opportunities, and spending on education and health care through an income effect (Namara et al. 2011; Burney and Naylor 2012; Passarelli

et al. 2018). Several studies have documented that these related benefits, such as improved diets, nutrition, and health, are also associated with women's empowerment (e.g. Malapit and Quisumbing 2015; Ross et al. 2015). While the literature demonstrates the potential of irrigation to have broad benefits, its direct relationship with women's empowerment is relatively undocumented.

A growing body of research aims to understanding the potential pathways to support women's empowerment as an outcome of development interventions (Cornwall 2016; Malapit et al. 2019). One key pathway is through the accumulation of productive assets that provide opportunities for women to earn and control additional income, expand their decision-making authority, and improve their well-being (Kabeer 1999; Meinzen-Dick et al. 2011). A review of eight agricultural development interventions (ranging from gender blind to gender transformative) found that asset levels increased because of the interventions, but only a few led to women's greater control over assets (Johnson et al. 2016). Importantly, interventions that expand access to assets alone are not enough to support women's empowerment. According to Cornwall (2016), while external interventions play a role in removing obstacles and creating opportunities for women's empowerment, women themselves must be the agents of change in their own lives.

Expanding access to agricultural technology and inputs tends to support women's empowerment, but the evidence remains limited (Anderson et al. 2021). Furthermore, technology adoption can improve outcomes for women, like dietary diversity, and women's empowerment further magnifies these benefits (Kassie et al. 2020). However, there may be trade-offs with technology adoption, such as labor displacement, that can disproportionately impact women (Vemireddy and Choudhary 2021). Interventions that expand women's access to technologies for small-scale irrigation, such as motor pumps, therefore, have the potential to support women's empowerment by expanding their control over agricultural production decisions, income decisions, and time allocation decisions. In some cases, however, irrigation could negatively impact women's control over land and production as water usage and land values increase, particularly in context of large-scale irrigation projects (Harris 2006). Therefore, there remains a gap in understanding how technologies, like irrigation, foster women's empowerment and under what conditions.

A gap also exists in understanding how women's empowerment supports technology adoption and the allocation of benefits from technology use, including in the case of irrigation. For example, an increase in women's decision-making authority over production and income decisions could lead to the adoption of irrigation systems. Conversely, women's disempowerment, such as

their lack of control over productive assets like land, limited input in household and community decision-making, and heavy workloads often results in lower adoption of irrigation, limited participation in governance of irrigation, or fewer benefits from irrigation (Theis et al. 2018; Imburgia 2019; Lefore et al. 2019). These varied experiences reinforce the need to understand the nuanced and contextual relationship between irrigation and women's empowerment.

A growing interest in building empirical evidence of interventions' contributions to women's empowerment has largely focused on the development of consistent and comparable quantitative measures of empowerment, such as the Women's Empowerment in Agriculture Index (Alkire et al. 2013; Malapit et al. 2019), with regional (e.g., Southeast Asia, Gupta et al. 2019) and sector adaptations (e.g., for livestock, Galiè et al. 2019). However, quantitative approaches may miss important nuances in local understandings of empowerment and the impact pathways of development interventions that may be uncovered through complementary qualitative research (O'Hara and Clement 2018). This research adapts a well-established conceptual framework of empowerment (Meinzen-Dick et al. 2019, referencing Kabeer 1999) to map the multiple pathways through which a specific small-scale irrigation intervention interacts with aspects of women's empowerment in the Upper East Region of Ghana. This paper uses qualitative data collected through

life history interviews and gender-disaggregated focus groups with men and women farmers and traders. The study centers around an intervention that distributed motor pumps to groups of farmers for irrigation on household plots. The analysis of the relationship between small-scale irrigation and women's empowerment is placed within an understanding of local definitions of empowerment and underlying processes of social change. The result allows for a systematic analysis of the complex processes of women's empowerment grounded in theory, while responding to the contextual lived experiences of participants. The results shed light on the ways in which development interventions, particularly those that expand access to small-scale irrigation technologies, interact with women's empowerment.

3.2 Conceptual framework: Linkages between Small-Scale Irrigation and Women's Empowerment

Women's empowerment is multi-dimensional and understood as both an outcome (increased access to and control over resources and decision-making ability) and a process of change (the process of expanding people's freedom to act and capacity to make choices) (Kabeer 1999; Nussbaum 2000; Kabeer 2001; Datta and Kornberg 2002; Alsop et al. 2006; Stern et al. 2005). The foundational framework for women's empowerment used for this study draws on the definition developed by Kabeer (1999), as interpreted by Meinzen-Dick et al. (2019).

Women's empowerment in this framework is conceptualized as an iterative process by which individuals improve their ability to make strategic life choices (agency) by utilizing resources, leading to improvements in well-being outcomes (achievements), such as food and nutrition security, and/or economic and social status (Figure 3.1).

This study further adapts the women's empowerment framework of Kabeer (1999) and Meinzen-Dick et al. (2019) to illustrate how the introduction of small-scale irrigation relates to the various components of empowerment. Figure 3.1 shows that small-scale irrigation interacts with each of the components of empowerment differently. Certain components—namely resources and agency—are needed for women to be able to adopt and utilize small-scale irrigation technologies and practices as shown by the arrows pointing from these components towards small-scale irrigation. Evidence shows that women face greater resource- and agency-related constraints in adopting irrigation practices and technologies, such as less access to land and water for irrigation, less access to financial capital, restrictive social norms, lack of access to knowledge and training, and heavier work burdens at home (van Koppen et al. 2012). These constraints not only limit women's ability to adopt irrigation practices and technologies but also limit their ability to benefit from them. For example, women have less influence over decisions related to the use of irrigated

crops or the spending of income from the sale of irrigated crops (Theis et al. 2018).

At the same time, irrigation interventions may also contribute to women's agency or disempowerment through changes in their control over agricultural production decisions, income decisions, and time use. Irrigation activities targeted towards women, for example on plots managed by women or on irrigated home gardens, have been shown to increase women's control over irrigated produce and income, and improve nutritional outcomes (Iannotti et al. 2009; Olney et al. 2009; Burney et al. 2010; van den Bold et al. 2013; Olney et al. 2015). Irrigation can also affect women's time in different ways. It can either relieve women's time burden or add to it depending on the type of irrigation technology being applied (e.g., either manual or motor pump). Time allocation may also shift among different family members when technologies are adopted (Theis et al. 2018), which can influence time spent caring for children (Cairncross and Cliff 1987; Burger and Esrey 1995; Miller and Urdinola 2010) or engaging in income-generating activities (Koolwal and Van de Walle 2013).

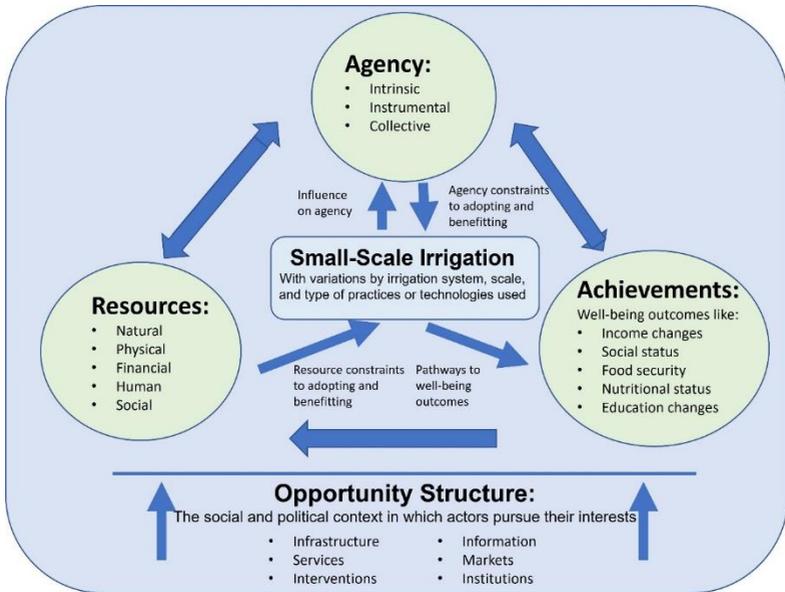


Figure 3.1: Framework for Small-Scale Irrigation and Women’s Empowerment

Source: Adapted from Meinzen-Dick et al. (2019, referencing Kabeer 1999).

Finally, irrigation may lead to well-being outcomes (achievements) for women through several pathways (Domènech 2015; Passarelli et al. 2018) and changes in women’s agency intersect these pathways in critical ways. For example, women’s involvement in agricultural and irrigation decisions has implications for production choices. These include the types of crops that are planted, how these crops are used (e.g., sold in the market or

consumed at home) (Carr 2008), and how to spend the income earned from selling irrigated crops (Gillespie et al. 2012; Meinzen-Dick et al. 2012). Women's involvement also has potential positive implications for nutrition, health, and education (Burney et al. 2010; van den Bold 2013).

The resulting relationship between irrigation and women's empowerment is heavily dependent on the broader social, political, and institutional context that governs men's and women's behavior and interactions (the opportunity structure in Figure 3.1) (Narayan 2005; Petesch et al. 2005; Alsop et al. 2006). For example, social norms governing men's and women's roles in the household and community might prohibit women from engaging in certain activities, like irrigation using manual pumps (Njuki et al. 2014). Women also have different preferences for irrigation practices and technologies given their socially-determined roles in the household, community, and agricultural activities (Theis et al. 2018).

Adapting this framework allows us to understand women's empowerment, as expressed by women and men of four communities in the Upper East Region of Northern Ghana, in the context of a small-scale irrigation intervention. Rather than relying solely on survey measurements that capture only a moment in time, this framework serves to unpack the complex relationships

underlying women's empowerment and identify the processes through which it is experienced.

3.3. Study Area, Data, and Methods

3.3.1 Study Context

The Upper East Region of Ghana, shown in light green at the top right corner of the map in Figure 3.2, is characterized by a single rainfall season between May and October, followed by a long dry season, with an annual average rainfall amount of 1,000 mm (Ministry of Food and Agriculture 2016; Ampadu and Cudjoe 2020). Production in the region is characterized by rainfed, subsistence production of staple crops, including maize, millet, rice, and soy. Irrigated production takes place mainly during the dry season and is dominated by onions, followed by okra, tomato, red pepper, watermelon, and leafy green vegetables (Mekonnen et al. 2019).

Groundwater is the main source of irrigation water for half the irrigators and is usually obtained by hand dug wells in the riverbed during the dry season, with irrigated plots typically located close to the water source. Small reservoirs (dams) are another main source of irrigation water for about a quarter of households in the study area, providing easier access to water for those with land near the dam. Most irrigating households obtain and apply water using cans or buckets and very few have access to

modern technologies for small-scale irrigation, like motor pumps (Mekonnen et al. 2019).



Figure 3.2: Map of the Regions of Ghana.

Source: The Permanent Mission of Ghana to the United Nations.

Note: Approximately one year after data were collected for this study, the Regions of Ghana were revised (December

2018) and 6 new regions were established. This did not affect the designation of the study sites, which remain in the Upper East Region, Garu-Tempane District.

Household survey data collected from the study sites show that many people live in large compounds with their extended family. In 56 percent of households, men have more than one wife, and 22 percent of households are female headed. Few household heads (32 percent) received any schooling and only 15 percent are literate (18 percent of male heads are literate, while only 3 percent of female heads are literate). The average age of male household heads is 53 years while for female heads it is 60 years. Approximately 43 percent of households are Muslim, while the remaining are Christian (38 percent) or hold traditional beliefs (19 percent).

Many households live on the cusp of undernutrition and poverty during the long dry season with few options to improve their well-being, aside from migration to other areas of the country or non-farm employment (Abdulai et al. 2018). The Upper East region experiences the highest incidence of wasting in the country (9%), a level that is considered severe by the World Health Organization (GSS 2015). While calorie availability has increased over time, much of this comes from staple foods (Ecker and Van Asselt 2017) and lack of dietary diversity remains one of the key determinants of child undernutrition in the

country (Boah et al. 2019). Small-scale irrigation offers the potential to expand and diversify production to create longer growing seasons that increase nutrient-rich food availability.

3.3.2 Intervention, Sampling, and Data Collection

Data were collected in July and August 2017 by two researchers (both female) and two facilitators/translators (one female, one male) in four villages and two markets in the Garu-Tempane District of the Upper East Region, Ghana. Selected villages were part of an international development project implemented by iDE. This project operated in nine villages in the Upper East Region of Ghana due to 1) their proximity to ongoing activities and 2) high potential for irrigation based on an ex-ante assessment using biophysical (slope, surface water access, and groundwater access) and socioeconomic (distance to markets) indicators. Within each village, farmers self-organized into groups of five (same-sex and mixed-sex groups) to receive training in group dynamics and micro credit. Villages were randomly divided into treatment (4) and control (5) communities. Within each treatment community, some of the farmer groups were selected to receive a motor pump for small-scale irrigation through a random lottery.

Four villages, two treatment villages (Mongnoori and Yidigu) and two control villages (Akara and Asikiri),

were randomly selected for qualitative data collection midway through the intervention. Participants in the research were selected from the set of households that were surveyed between November 2015-February 2016, before the start of the intervention. Participants were selected to participate in the qualitative research based on their irrigation status at baseline (mix of irrigating and non-irrigating), participation in the program (treatment and control), and individual empowerment scores calculated using the Women's Empowerment in Agriculture Index (mix of empowered and disempowered) (Alkire et al. 2013).

The qualitative data collection protocols used for the study were adapted from instruments developed for the project-level Women's Empowerment in Agriculture Index (pro-WEAI) (for details on how these tools were developed see Meinzen-Dick et al. 2019). The two translators/facilitators were trained on the purpose of and methods for implementing the protocols for two days prior to the start of data collection. The protocols were translated during the training following discussions among the research team.

In each village, focus groups on empowerment topics were carried out with two groups of approximately 8 men and women separately with a facilitator/translator of the same sex in the local language. Topics included women's roles in the community, leadership qualities, participation

in community and household decisions, women's mobility, and inheritance and marital patterns. Two additional focus groups were conducted separately with men and women farmers selected to receive the motor pumps in the two treatment villages. One seasonal calendar focus group (4-5 farmers both men and women) was conducted in each village to identify key gendered livelihood activities and the implications for men's and women's time use, income sources and expenditures, and other important events throughout the year. All focus groups lasted around 2 hours each.

Life history interviews were carried out with six farmers in each village (two men and four women) for a total of 24 interviews. Each interview lasted between 1-1.5 hours. In each village interviews covered a mix of irrigators and non-irrigators, pump users and non-pump users, and empowered and disempowered individuals (based on their WEAI score). Women interviewees covered each possible combination of these attributes, while treatment villages only included men irrigators who were empowered and disempowered and men in control villages were non-irrigators (empowered/disempowered). The life history interviews were semi-structured and aimed at giving space for the respondent to discuss the personal experiences that have shaped their attitudes and beliefs. The interviews also explored topics, such as gender roles, decision-making, intra-household dynamics, relationships with the community, and perceptions of self. Interviews

were led by two researchers with simultaneous translation by the facilitators/translators.

In addition, four interviews with market traders were carried out: two in a large market (Basyonde) and two in a small market (Garu). Interviews focused on the location of sales and physical access to markets, seasonality, price determination, payment methods, gender barriers to market participation, and market characteristics. Table 3.1 summarizes participants by data collection method and gender. Interviews lasted for 1-1.5 hours and were led by two researchers with simultaneous translation by the facilitators/translators.

Table 3.1: Sample Size by Method and Gender (Number of Participants)

	Focus Groups		Individual Interviews		Total Participants
	Empowerment Topics (same sex) (12 FGDs)	Seasonal Calendar (mixed) (4 FGDs)	Life History (24)	Market Trader (4)	
Female	48	10	16	2	76
Male	48	10	8	2	68
Total	96	20	24	4	144

Source: Authors.

Interviews and focus groups were recorded, transcribed, and translated into English. The transcripts were imported into NVIVO and files were classified according to data collection method, interview, translator, interviewer, and participant data (gender, age of the interviewee, ethnicity, village, irrigation status, pump status, empowerment

score). We approached coding as a decision-making process, which considers aspects of the code in line with the methodology and research questions (Elliott 2018). A set of thematic codes (nodes) and sub-themes was developed based on the topics covered in the protocols, which link to the elements in the conceptual framework. Nodes and themes were not considered to be mutually exclusive, and text was coded with multiple nodes or themes where appropriate. Themes that emerged from reading the transcripts were added to the original list of nodes. After coding all transcripts, some nodes or sub-themes were merged or separated to create new nodes. Table 3.2 presents the list of general nodes used, the description of themes covered within each node, and a description of how these nodes link to elements of the conceptual framework.

Table 3.2: Nodes and Sub-Themes for Qualitative Analysis

Nodes: Main Headings	Description of Themes Covered	Link to Conceptual Framework
Income and expenditure decisions	Ability to control income from various livelihood activities and make expenditure decisions in line with personal needs, priorities, and preferences	Indicator of instrumental agency
Intrahousehold relationships	Characterization of the relationships between adult decision-makers in the household (e.g. level interest alignment and cohesion, respect, unity/discord, domestic violence), family structure,	Indicator of intrinsic, instrumental, and collective agency

	marriage and courtship, parenting and parenthood	
Leadership and community	Characteristics of community leaders and powerful people, decision-making processes at the community level, and changes in community leadership roles of men and women over time	Collective agency, enabling environment
Markets	Ability to access markets and participate in market transactions including selling agricultural products and purchasing agricultural inputs or household goods	Enabling environment
Mobility	Ability to travel freely throughout the community, neighboring communities, to local and distant markets, and other important places	Instrumental agency
Nutrition and health	Decisions on food purchases, food preparation, infant and young child feeding practices, medical decisions, health experiences	Achievements
Other decisions	Decisions about other domestic activities (e.g. cleaning, caring for children, fetching water or energy)	Instrumental agency
Crop production	Decisions regarding land allocation, crop choice, planting, division of labor, input use, harvesting, post-harvesting practices, and sale of crops. Access to information regarding crop production.	Instrumental agency
Irrigation (achievements, agency and resources)	Experiences with accessing resources for irrigation, decisions related to irrigation at the household and group/community levels, and achievements related to irrigation	Irrigation and the relationship with resources, agency and achievements
Psychological aspects	Aspirations, life satisfaction, self-efficacy, self-esteem	Intrinsic agency
Resources	Inputs to agricultural production and other livelihood activities, productive assets, education and human capital, financial	Resources and enabling environment

	resources, natural resources (land, water, energy), infrastructure	
Shocks	Idiosyncratic shocks (e.g. illness, death of family member), conflict, shocks to production, and climate/weather-related shocks	Achievements
Time	Division of labor, work burden related to domestic work, agricultural production activities, irrigation, other livelihood activities, and overall workload	Instrumental agency

Source: Authors

3.4 Results

Results from the qualitative data collection are presented on each relationship in the conceptual framework—i.e., between resources and irrigation, agency and irrigation, and achievements and irrigation. While relationships are broken down in the following analysis, the framework emphasizes the continued process and inter-connectedness between these aspects.

3.4.1 Resources for Empowerment and Small-Scale Irrigation Linkages

Participants repeatedly mentioned that there are important differences between men and women in terms of their access to and use of resources needed to adopt and sustain irrigation production. Women are more constrained in their access to essential natural resources, like land and water, labor, and other agricultural inputs (fertilizer, fencing), which limits their ability to benefit from

irrigated production. Men and women are more equally constrained with respect to some resources like access to enough credit to purchase a motor pump. These differences have considerable implications for the ability of women to adopt and benefit from small-scale irrigation, and their pathway to empowerment.

Natural Resources

Many farmers in the Upper East Region stressed the importance of having access to land for their success in farming and the ability to provide for their families. Even more than just having access to land, owning land is considered important for empowerment among both men and women farmers. However, accessing irrigable land was a much greater challenge for women. Due to patrilineal inheritance systems in Northern Ghana, women primarily access land through their land-owning husbands or by borrowing or renting land from other men in the community or family members living nearby. In most households, depending on the size of the landholding, women are allocated a plot to farm, and in polygynous households, sometimes jointly with their “rival” wives. However, because of population growth, land is becoming increasingly fragmented with subdivided areas often too small to provide enough food for the family let alone turn a profit. When the land size for the household is too small, women may not be allocated any land to farm for themselves but will contribute unpaid

labor to the household plots. When men die, land is mainly passed on to male children. In some cases, widows may still have access to their late husbands' land through their children, and have more control if children are too young to manage farming operations. In other cases, control of the land may revert to the husband's older brother or father.

Renting or "begging" for land is common, but there is typically a price to be paid in cash or in kind for access to the land. However, women, whose husbands do not allocate land to them, are often unable to afford to rent land to cultivate for themselves. Some women noted that when they beg for land, they are given lesser quality lands to farm, particularly if they cannot afford to pay to rent better land. Further, when women invest in this land, they risk the owner reclaiming the land once it has increased in its ability to produce.

"[T]he one who has his own land, the land that is fertile, he farms on that. And, if you go to him to beg, he gives you the infertile land. If he is a troublemaker, and you apply fertilizer—after knowing that you did apply fertilizer and the land is now good, he will come for it the next rainy season. So, you would have thought this time it will help you because you applied fertilizer, he has also stopped you from farming there" (Yidigu, FGD, women, pump users).

Access to water for irrigation is closely tied with access to land near the water source, which shaped women's empowerment opportunities and experiences. Communities in the study area access water from ponds or small reservoirs (dams) or groundwater from the dry riverbed. Because there are no conveyance systems, water from these sources is applied to plots located near the source. As irrigable land has higher value, this can magnify the competition over its access. The resulting difficulty for women (and some men) to access the land near the water source limits their ability to irrigate.

In Mongnoori, where there is a small reservoir that is well-maintained and more water is available, women reported having better access to water for irrigation. However, even in this community, living farther away from the reservoir made it more difficult for both men and women to access water for irrigation: "We, those who are not strong, cannot travel that distance to work. The people here go to the dams at Basyonde and Zong to farm, which is far. So, we, those who do not have the strength, can't go there" (Mongnoori, FGD, men, no pump). Women also stressed that traveling to plots far away from the home disadvantaged older women who were unable to make the journey.

In communities where dry season irrigation is done using water from the dry riverbed, accessing water requires digging a hand-dug well each irrigation season—a labor

intensive and physically demanding task. Women are not considered physically strong enough to dig the hand-dug wells and rely on their husbands or hired labor to do it. Insufficient water was a constraint for some farmers to benefit from the motor pumps, especially those in Yidigu. According to one man (Yidigu, FGD, pump users), “Water was the challenge [for some people to use the pump...] There were some places you could use the machine. Other places you couldn’t use the machine to get water.”

Lack of water also limits the amount of land people can cultivate during the dry season. As a result, some husbands do not allocate land to their wives, but rather direct them to assist with the irrigated plots that they control. In the case of one man (Yidigu, irrigator), his wives “help” him with the irrigated farming by preparing food for the laborers, picking weeds, and fetching water. Working together on one plot with his wives is more efficient and minimizes the risk if there is not enough water for separate plots: “If we have different plots and we don’t get enough water, it becomes a problem. If we also farm on the same piece of land, and all of us take the jerricans, we can water and finish in no time” (Yidigu, interview, man, irrigator).

Financial Resources, Productive Assets, and Inputs

Even when women have access to land and water for irrigation, they lack complementary inputs, such as fertilizer or fencing. Women irrigators reported that their lack of access to fertilizer or a delay in the timing of fertilizer application affects the productivity of their irrigated plots, which limits their ability to benefit from small-scale irrigation. Fencing is considered important because it is needed to protect irrigated plots from destruction by livestock during the dry season when they graze freely. As with the hand-dug well, fencing is built by hand each dry season using mud and sticks. Both men and women reported that women do not have the “strength” to build their own fences and do not have the financial resources to hire labor to construct fencing. Because it is a time-consuming and arduous task, men prioritize building fences around their own dry season plots and often do not invest in fencing around their wives’ plots.

Both men and women lack access to financial resources, particularly credit needed to purchase irrigation equipment. Farmers acknowledged that having access to irrigation pumps through the iDE project was helpful for increasing agricultural productivity during the dry season. However, this benefit was not universal, as those who are older, or less physically able, were not able to take advantage of the pumps in the same way. According to

one woman focus group participant about receiving the pump, “if we say it didn’t help us, then we are lying. It has helped us a lot. But, our mothers who were not having strength to work in the garden, they wouldn’t know whether it helped or not....” (Mongnoori, FGD, women, pump users).

Some women also reported benefiting directly from engaging in irrigated production, especially when they gained access to motor pumps. The pumps increased these women’s instrumental agency, by providing additional income to expand their independent production activities beyond the small plots allocated to them by their husbands. One woman (Mongnoori, FGD, pump user) mentioned that the pumps “helped us to get money” to rent more land, buy inputs like seeds and fertilizer, and hire labor.

However, not all women have access to motor pumps and, ultimately, their husbands decide how the pumps will be used. In this case, the lack of agency to make decisions over productive resources, makes it more difficult for these assets to contribute to women’s empowerment directly. Moreover, the lack of access to and control over complementary resources, like land, makes pumps an ineffective resource for many. Even those women in groups that received motor pumps said they gave them to their husbands to control, since “[We] can’t do [our] own [irrigated farming] because we don’t have land.” (Yidigu,

FGD, women, pump users). Moreover, social norms about ownership of agricultural machinery hindered some women's ability to benefit from using the pump, even if they themselves participated in groups that gained pump access.

3.4.2 Women's Agency and Small-Scale Irrigation

The findings indicate that women's agency is generally increasing in the study areas, irrespective of the irrigation intervention. Participants reported that women are becoming more involved in agricultural production decisions and choosing to engage in other income-earning activities. Women discussed contributing the income they earn to cover household expenses, such as school fees or health expenses; although, for some women this was not considered a positive change. Furthermore, women discussed taking a more active role in the community, including joining groups, with more women becoming respected leaders in the community.

Intrinsic Agency

Women's intrinsic agency varies according to individual circumstances, including the level of relative wealth, experience with shocks, and level of education. Overall, the findings suggest that intrinsic agency and achievements are inextricably linked, whereby achievement of personal goals can improve life satisfaction and increase intrinsic motivation. Many

women and men expressed the belief that if you were hardworking, you would be successful and achieve your goals. Engaging in irrigation, because it is a labor intensive and difficult activity, contributes to a sense of strength and pride. Men from Yidigu praised women who maintain a dry season garden, describing that others in the community “will see them as proud women” (Yidigu, FGD, men, pump users).

On the other hand, men and women who are not able meet their own basic needs and those who are unable to work due to injury or illness expressed a sense of shame and fatalism about the future. A sense of despair stemmed from some farmers’ inability to improve their welfare despite their best efforts. Lack of intrinsic agency hinders women’s ability to irrigate. Particularly in communities where irrigation is only possible by hand-dug wells, women perceive that they are not physically strong enough to dig a well for irrigation. “We do onion farming, but women are not strong enough to water the onions.... We dig down very deep to fetch water and women can’t dig that deep because they are not strong enough.... I mean they don’t have the energy to dig and fetch water from the pit” (Asikiri, interview, woman, irrigator). While both men and women acknowledge that digging wells is grueling work, the perception that women are not strong enough may also be influenced by cultural norms about gender appropriate work, rather than a lack of strength on the part of the women.

Instrumental Agency

Participants defined the ability of farmers to exercise instrumental agency by several factors including their ability to participate in and influence production (and other livelihood) decisions, their control over income or participation in spending decisions, and their ability to engage freely in livelihood or social activities that benefit them. Women who are involved in dry season cultivation report direct benefits from irrigation, such as control over income from the irrigated plots they manage, and indirect benefits, including greater income and food security for the household. Access to motor pumps provides even greater benefits by reducing the labor burden of irrigation and increasing income from irrigated production. In many cases, women reported that the introduction of motor pumps freed their time from engaging in irrigated production and allowed them to invest time in other preferred livelihood activities. In this case, an increase in women's agency from irrigation led to their movement out of irrigated agriculture.

Decision-Making

There were a range of opinions regarding joint decision-making that often intersected with the age of the respondent and household composition (i.e., the number of wives and the size of the compound). The general trend was towards women participating more in decision-making about important household matters, ranging from

production to health care decisions, with younger men and women reporting greater levels of joint decision-making. Many men acknowledged that women play a role in decision-making to accomplish household goals, from providing input to making decisions autonomously.

While men still dominate agricultural decisions, both men and women acknowledged women's greater participation and input into farming decisions compared to the past. In general, women work on the main rainy season plots, which are predominantly controlled by men, and then also cultivate their own plots of land, which their husbands allocate to them. Work on men's plots generally takes priority over women's: "If there is work to be done on his farm, he can say you should come and work there. So, you go and do your own work when his is done" (Asikiri, FGD, women). The prioritization of men's production activities may also hinder women from investing in the plots they control, including hiring labor to build fences or dig wells for irrigated cultivation.

Women do participate in decisions on the main household plots. Across all villages, most men agreed that taking production decisions jointly is ideal and will have better results (even yields) and they acknowledged that both husbands and wives contribute to the same goals of providing food and income for the family. Despite this recognition, most men and women viewed women's participation in decision-making as an advisory role while

men retain the final say. This was true especially about rainy season production and sale of harvest, which is typically the largest source of household income. Men also tend to make decisions about the output from the household's main irrigated plots (whether to sell or consume), except in the case of plots allocated for women to manage. For irrigated plots that men manage, women are still responsible for taking the crops to market for sale when directed by their husbands.

There were mixed experiences related to the plots that women cultivate themselves. Some women and men reported that women decide how to manage their own plots and retain control over the income. Others acknowledged that their husbands direct their work on these plots, from deciding which crops should be planted to what is done with crops produced. Some men and women noted that men allocate separate plots to their wives as a risk-mitigating measure. This is because the produce and income earned from men's and women's plots is often allocated for different purposes, including saving for unexpected events. In some cases, the food crops women produce are saved as a backup for when the harvest from the main rainfed plots is exhausted or if there is a crop failure. However, men also control productive resources, which limits women's production options: "A woman cannot just decide that 'this is what I want to do' and not tell her husband or landlord.... men are the ones who will release their bullocks to you to plough... Also,

you don't have land to farm so you must inform them” (Asikiri, FGD, women).

While some men favored women's increased involvement in irrigated production, as well as their financial contribution to the household, some expressed negative opinions about women's autonomy in dry season production. Interviews suggested that the discomfort is more with women's control over income, rather than their autonomy in production decisions. “When the women do the work in the dry season, some time ago, the men will transplant the crops, water them and then the women will harvest them and sell them so that the money will be for both of them. But recently, most of the women are wild, that they do not want to do that again. They will plant with their husbands and also they will go out and get another plot and plant for only themselves” (Akara, FGD, men).

Control Over Income

The results of the study show a trend towards women having increased ability to earn their own income and greater control over spending decisions, despite the expressed reluctance of some men. Discussions and interviews revealed considerable variation in the ways in which households make spending decisions and in the degree of knowledge that husbands and wives have about the earnings of their spouse.

While women have greater income-earning opportunities and control over income than they did in the past, this is accompanied by greater expectations about women's financial contribution to meet household food, education, health, and other basic needs. Women tend to control minor expenditure decisions, like food purchases, whereas other expenditure decisions are made jointly (e.g. paying school fees or seeking medical care). When it comes to large purchases, like motor pumps, men tend to lead the decision but acknowledge that their wives should be informed and consulted as a sign of respect.

Some men supported women earning their own income by allocating land for women to produce crops. The same was also true for irrigated plots that women manage during the dry season: "Yes they [my wives] do have their own plot as well. When my wives and I cultivate eight acres of land we use it for consumption, but I have also given each of them one acre each to cultivate the crops they are interested in and sell their produce for income for themselves" (Mongnoori, interview, man, irrigator). Women also have a stake in spending decisions on income earned from the sale of irrigated crops from plots that their husbands' control, especially when they have provided labor to produce those crops: "The one who worked on the garden owns the money [from the sale of irrigated crops]" (Mongnoori, FGD, men, pump users). However, as with production, husbands are the final decision-makers on spending decisions.

Women reported having even greater control over income earned through other livelihood activities, like trading, pito brewing (local alcoholic beverage), shea butter processing, dawadawa (local spice) making, providing services, and fuelwood production. Some women prefer earning their income through these activities, rather than sharing income earned through farming with their husbands: “I would prefer hair dressing. If it is hair dressing, the proceeds would be for me but with the sale of the pepper, I will share with my husband.... We both take care of the pepper and when it is matured, we harvest and I sell them” (Basyonde, market trader, interview).

Women’s increasing earnings and financial contribution changes power dynamics in the home. Some men seemed relieved that women can reduce their financial burden, and some expected women to cover household expenditures like school fees and food. A woman from Akara noted that she is able to earn income for herself only because her husband does not earn enough: “If I am going to do labor work, or trade or anything, it is because he [husband] doesn’t have enough to support me and, therefore, he will allow me to do it. If he had money to give me, he would have prevented me from doing this work” (Akara, interview, woman, irrigator). Some men considered the income their wives earned as their own, while others were uncomfortable with women’s increasing contribution and see it as a threat to their role as household head and provider. “[If a woman has more

money than the man] in our Kusaug tradition, there will be a problem. When you talk, she will not mind you; and if you do not take care, she can even beat you” (Mongnoori, men, FGD, no pump).

Women also had mixed feelings about growing expectations for their contribution. Some felt that it was a burden to have the responsibility to bring in income when they do not have the means to earn enough. Others wanted more independence and felt pride in their ability to provide for their family. One woman from Akara described the pressure placed on her to provide for her family: “My father farmed a lot and had large stock of food and so looking for food to feed the family was not the job of my mothers and my father also supported his children's education. But now everything is on me. My husband is not able to support” (Akara, interview, woman, irrigator).

Time Burden

Women in the study area have a heavy workload with domestic responsibilities, farming, and other livelihood activities. Irrigated production takes place during the dry season (lasting 4 months) and women play a large role in watering crops using traditional, labor-intensive methods. Because crops must be watered continuously during this period, irrigated production prevents people from engaging in other activities or traveling to visit family in other communities.

Depending on the source of water (dam or dug well), the location of the plot with respect to the water source, and the irrigation technology available, the time it takes to irrigate varies dramatically. Both men and women farmers who use traditional methods view irrigation as a physically exhausting activity. While many women engage in irrigation using traditional methods, especially women whose husbands are unable, many men considered it as sparing their wives if they don't have to engage in irrigated production: "My wife can help in the garden, especially in transplanting. But if it is watering the plants, women because they carry children or are pregnant, it is dangerous to go to the well and back, so I don't allow my wife to help. I do most of this myself" (Akara, interview, man, irrigator).

Even though it is tedious, some women want to have the opportunity to engage in dry season farming because of the benefits, like having access to vegetables, and prefer irrigation to other dry season activities, like burning charcoal. While irrigating with traditional methods is considered burdensome, having access to pumps saves women's time watering or allows them to leave irrigating to their husbands. "Your husband farms [in gardens] and you water and thank God associations have come and we can now get access to machines [pumps] and the men will use them to irrigate. So, now we only observe, and they irrigate" (Mongnoori, FGD, women, pump users).

Collective Agency

Both men and women placed considerable value on collective agency, whether it be through working together as a family unit or participating in groups at the community level. Working together enables women to make strategic choices, leading to better well-being outcomes or achievements. Women are also increasingly involved in groups which facilitate their access to financial resources (especially through shared savings groups), information and training, and resources from outside groups, like NGOs. However, even when women participate in same-sex groups, group activities sometimes require the approval of husbands. As women in Akara reported, “If I see that an organization like that comes to help us with our water issues, I have to talk to my husband first and tell him of the benefit of the proposed activities of the organization and we will then decide” (Akara, FGD, women). Some women focus group participants also described participating in joint farming activities on rented plots of land with some success. However, the landowner reclaimed land after the first season. Thus, resource constraints related to land access trumped women’s collective effort to gain greater autonomy in production.

Collective agency facilitates the purchase, use, and maintenance of irrigation equipment. This is because purchasing and maintaining pumps is costly and difficult

for individual farmers or farm households. Arrangements for sharing or renting modern irrigation equipment are not generally available. Participants reported that the groups formed through the project facilitated labor sharing: “He will come with the bicycle and take it [the pump] and ask you to help him on his farm. We helped each other. If one person is going to do it, one has to help him, when it comes to you too, he will help you” (Yidigu, FGD, men, pump users). However, sharing the pump was sometimes difficult, particularly when farmers in the same group were not located near each other. Men in Mongnoori indicated that moving the pump between group members was even more difficult for women.

3.4.3 Well-Being Achievements and Small-Scale Irrigation

Personal achievements mentioned by study participants include economic status, being able to meet basic needs, education, success in farming, and maintaining food security—all of which are strongly linked and contribute to one’s social status in the community. Leaders in the community were viewed as having a higher level of financial security, education, social connections, and leadership qualities that enabled them to offer help to others. Such descriptions provide an understanding of what members of the community can aspire to achieve. In both cases, at the personal or family level as well as at the community level, many of the achievements people

described related to doing things for others. For example, many men and women discussed goals related to educating their children rather than themselves.

Engaging in irrigated production increases the social status of both men and women as it demonstrates that a person is hardworking. In particular, women who do dry season production are respected by both men and women in the community as hardworking contributors to their family's well-being. Women in the focus group in Akara described irrigators as "good women." Men also value the contribution of these "hardworking" women: "They [women who do dry season garden work] are women who are hardworking...and look beautiful. The women who are not working in the garden they are not like them" (Mongnoori, FGD, men, no pump).

Irrigation also provides resources for families to afford school fees and medical expenses, which support health outcomes as achievements: "Some [crops irrigated with pumps] were sold and others consumed. Part of the money [from the sale of irrigated crops] was used to pay school fees and your child might not feel well, and you could send him or her to the hospital" (Mongnoori, FGD, men, pump users).

Irrigation brings greater food security by increasing the stability of food supply over the course of the year: "If you don't work in the garden, you will sell the food crops you harvested during the rainy and you will be in hunger"

(Mongnoori, FGD, men, pump users). Households also produce different crops with irrigation and consume a portion of what they grow leading to an improvement in diet quality: “We farmed different crops [when we got the pump], we plant onion, tomatoes, pepper, okra, garden eggs, and vegetables” (Yidigu, FGD, men, pump users).

3.5 Discussion and Conclusions

Given increasing interest in women’s empowerment by development organizations, it is important to consider the ways in which interventions may overlay theoretical and conceptual understandings of empowerment. The irrigation project in the Upper East Region of Northern Ghana provides an example of how the three dimensions of women’s empowerment (resources, agency, and achievements) can be influenced by irrigation interventions and the extent to which irrigation offers a pathway to women’s empowerment. These lessons hold significant opportunities for both deepening our understanding of women’s experiences as well as informing future interventions.

This paper contributes to the growing body of literature and interest in understanding the opportunity for interventions to support women’s empowerment as an outcome. Efforts are being made to develop coordinated and consistent tools and methods to measure changes in women’s empowerment outcomes across contexts, using

both qualitative and quantitative approaches that are linked to widely accepted theoretical concepts of empowerment (Malapit et al. 2019). While the need for consistent measurement is important, qualitative research offers the opportunity to explore local understanding of empowerment in ways that both challenge and validate academic concepts (Meinzen-Dick et al. 2019). For example, while researchers often focus on measures of women's agency as a key component of empowerment, qualitative research across different cultures and local contexts found that women tend to place greater emphasis on achievements, such as increasing income and helping others, rather than agency (Meinzen-Dick et al. 2019).

While the framework adapted in this paper provides a structure for understanding the pathways for women's empowerment through irrigation, there are still limitations to its application. In a few cases, there were central themes that shaped women's ability to adopt and benefit from irrigation in a way that fostered empowerment that were not limited to a particular empowerment dimension. For example, "strength" was often mentioned by participants as a critical component for irrigating successfully. However, this term often conflated physical strength (resources), financial capacity (resources), and willingness to participate in the activity (agency), in ways that were both real (achievements) and perceived, given social norms about labor allocation (opportunity structure). In this case, the framework is limited in how to

analyze this concept's impact on empowerment as it is split across several dimensions. In general, however, it was possible to analyze the themes that emerged using the theoretical constructs of resources, agency, and achievements, even though the research participants themselves did not make such distinctions.

Evidence of the potential for irrigation to contribute to women's empowerment tends to be scattered across context-specific case studies without a unifying framework for tracing the interaction between irrigation and empowerment and the conditions under which irrigation contributes to women's empowerment (Bryan and Lefore 2021). This literature suggests that the ways in which irrigation influences women's empowerment depends on contextual factors (the opportunity structure) as well as the type of irrigation technology, the scale of the irrigation system, and the approach used to implement the intervention (Bryan and Lefore 2021). Thus, when applied to other contexts and interventions, the framework adapted in this paper may yield quite different results. Some of the relationships between irrigation and empowerment observed in this context as a result of the motor pump intervention may play out similarly in other contexts. However, it would not be appropriate to draw general conclusions from the application of the framework in this study.

That said, the results of this research provide several insights about the potential pathways for small-scale irrigation to influence women's empowerment. The findings showed that women did not necessarily benefit from irrigation in direct ways, such as through control over the motor pumps as a productive asset, but rather through more indirect ways, such as reduced labor burden in agriculture, particularly in irrigated production. Social norms typically prohibit women from owning large assets, like livestock, land, or pumps, as has been demonstrated by other research in this context (Doss et al. 2014; Lambrecht 2016). Even when women acquired motor pumps through groups, they considered their husband to have control over the asset. However, when motor pumps became available, many women viewed the decreased time burden as an opportunity to focus on more preferred livelihood activities.

The results also pointed to serious resource constraints that limit the extent to which women can participate in irrigated production. Specifically, women can only access land for irrigated cultivation through their husbands and, therefore, have less control over the decision of whether to produce irrigated crops. Another study from Northern Ghana similarly shows that landownership strongly affects aspects of women's agency and achievements, including participation in agricultural decision-making, decisions on farm income, group membership, and time allocation (Yokying and Lambrecht 2020). In other

contexts, such as India, women have overcome resource constraints by collectively cultivating leased land with other women farmers (Agarwal 2020). In Northern Ghana, women's collective agency is growing, including through other economic activities outside of agriculture. However, given the difficulties some groups of women faced in maintaining access to leased land for autonomous production, this approach may be more difficult in the study context without specific outside intervention to facilitate and maintain women's land access. Thus, it is not necessarily the lack of collective mobilization, but the challenge of access to resources despite collective action that hinders women from benefitting fully from irrigated production.

Resource constraints were even greater for women in villages where water scarcity concerns were more prominent. These challenges will only intensify as pressure due to population growth leads to greater land fragmentation and natural resource scarcity (Abubakari et al. 2016). It is not surprising then, that a framed field experiment by Kramer and Lambrecht (2019) found that women in Northern Ghana prefer to allocate resources towards business activities, like trading agricultural and non-agricultural products and food processing, and that both men and women value diversified investments. For some women in our study, it is also the perceived opportunities to directly benefit from engaging in alternative livelihood activities that lead them to pursue

other pathways to empowerment outside of agriculture. While some women are drawn to alternative income earning opportunities, women that do engage in irrigation reported directly benefiting from this activity, including through control over income from the plots they cultivate themselves. This finding has also been observed in other contexts, such as Ethiopia, Tanzania, and Kenya, especially when women's irrigated production is limited to smaller sales of vegetables (Theis et al. 2018) or to lower value crops (Njuki et al. 2014).

To the extent that engaging in irrigation increases women's control over income and contribution to household expenditures, this may also indirectly increase women's decision-making role in the household. However, other studies have shown that economic interventions alone are not sufficient to dramatically increase women's decision-making authority. To achieve women's empowerment and gender equality, programs must integrate gender transformative approaches, such as facilitated household dialogues (e.g. Karimli et al. 2021). The framework developed in this study to understand women's empowerment pathways could be applied in other contexts and to other types of irrigation interventions. Doing so would inform the ways in which interventions are designed, introduced, and implemented to ensure that they address gender-specific constraints and consider women's preferences. Such analyses are especially important as opportunities for irrigated

cultivation expand, through investments in irrigation infrastructure and the dissemination of irrigation technologies, to ensure that women participate in and benefit from these interventions.

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4. DOES SMALL-SCALE IRRIGATION PROVIDE A PATHWAY TO WOMEN'S EMPOWERMENT? LESSONS FROM NORTHERN GHANA

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ABSTRACT

As with any new agricultural technology or practice, the expansion of small-scale irrigation technologies requires the consideration of important gender dynamics. Women's lack of agency and access to resources relative to men, and other social constraints, often limit their ability to adopt and benefit from agricultural technologies. At the same time, expanding access to agricultural technology to women may provide a pathway for empowerment. This paper explores the potential for small-scale irrigation technologies to increase women's empowerment by evaluating the impacts of an intervention that distributed motor pumps to small groups of farmers in Northern Ghana. The paper draws on two

rounds of survey data that included the Women's Empowerment in Agriculture Index, before and after the motor pump intervention was implemented. To control for possible selection bias at the baseline, the difference-in-difference method is used to estimate the impact of the program on indicators of women's empowerment. Spillover effects are estimated by comparing outcomes of farmers in treatment villages that did not receive the pumps with farmers in control villages, where no motor pumps were distributed. The findings suggest some potential for small-scale irrigation technologies to provide a pathway for women's empowerment, however, there are also potential negative impacts, including among households that did not benefit from the intervention. The results highlight the need to pair interventions that distribute agricultural technologies with complementary investments in infrastructure that increase access to water for irrigation as well as other activities and approaches that ensure women can reap the benefits.

4.1 Introduction

Small-scale irrigation is a key strategy for increasing the agricultural output and incomes of smallholder producers in many countries in sub-Saharan Africa (Xie et al., 2014; Burney et al., 2010). Other benefits of irrigation include improvements in food security, nutrition, and health outcomes by increasing household disposable income, by diversifying production toward more nutrient rich foods, such as fruits and vegetables, and by increasing household access to a domestic water source (Mekonnen et al., 2019, Xie et al., 2018, de Fraiture and Giordano, 2014; van Koppen et al., 2014; Namara et al., 2005; Frenken, 2005). Irrigation can also increase climate-resilience by reducing production risk and increasing food availability throughout the year, including during the lean season, leading to improved dietary diversity (Baye et al., 2021). While irrigated area remains small (only 4 percent of cultivated area) in sub-Saharan Africa, there is considerable potential for expansion in many parts of the region, and private investments in small-scale irrigation technologies are proliferating (Giordano et al., 2012; de Fraiture and Giordano, 2014).

While irrigation investments in Ghana have largely targeted large- to medium-scale schemes, more recent emphasis has been given to the development of smaller schemes and infrastructure and partnering with the private sector to expand access to technologies for small-scale

irrigation (MoFA, 2018). Small-scale irrigation is defined as irrigation that farmers control themselves for cultivating small plots of land, using technologies and systems which they operate and maintain at the household level or in small groups or communities (Bryan and Lefore, 2021). Despite these policy efforts, actual diffusion of technologies for small-scale irrigation remains slow due to the high upfront cost of the technologies, lack of availability of the technologies and supporting services (e.g. financing and extension), lack of coordination among stakeholders, and the limited engagement of farmers in the diffusion process (Balana et al., 2020; Minh et al., 2020; Atuobi-Yefoah, Aberman, and Ringler, 2020).

As with any new technology or practice, there are important gender dynamics to be considered with the expansion of small-scale irrigation technologies. Women's lack of access to resources and more limited agency relative to men, and other social constraints, often limit their ability to adopt agricultural technologies (Deere and Doss, 2006; Doss and Morris, 2001; Peterman, Behrman, and Quisumbing, 2014). In the case of irrigation, women face barriers to adoption, such as lack of access to agricultural land, lack of labor for irrigation, greater time burden, and social norms that prohibit women's use of particular types of irrigation technologies, such as treadle pumps (Nation, 2010; Van Koppen, Hope, and Colenbrander, 2013; Namara et al. 2014; Njuki et al.,

2014; Imburgia, 2019; Lefore et al., 2019). Moreover, once adopted, the costs and benefits of agricultural technologies may not be equally distributed across different family members in the same household (Theis et al., 2018). The extent to which women benefit from new agricultural technologies, like motor pumps, depends in part on their bargaining power in determining how technologies are applied and used, who provides the labor, and who controls the agricultural output and income from the sale of irrigated crops (ibid).

While women often face greater constraints in adopting, using, and benefitting from irrigation technologies, some case studies show that when women overcome these constraints, they benefit in important ways (Bryan and Lefore, 2021). Several studies suggest that increasing women's access to small-scale irrigation for home garden production, can provide economic opportunities for women, reduce their time burden, and increase assets and income controlled by women (Graham et al., 2016; van Houweling et al., 2012; van den Bold et al., 2013; Burney et al., 2010). Conversely, irrigation has the potential to disempower women relative to men to the extent that it increases their workload or limits their input into production decisions and control over the use of income from irrigated production (Nation, 2010). Thus, understanding the circumstances under which small-scale irrigation provides an opportunity for women's empowerment deserves greater attention.

Much of the existing literature on women's empowerment explores the ways in which women's empowerment contributes to other development outcomes, such as improvement in agriculture productivity (Seymour, 2017), increase in production diversity (De Pinto et al., 2020) or improved food security and nutrition (Malapit and Quisumbing, 2015; Kassie et al., 2020). A growing body of literature examines the extent to which development interventions, including those that aim to increase women's access to and control over productive assets, support women's empowerment (Cornwall, 2016; Johnson et al., 2016; Malapit et al., 2019; Anderson et al., 2021). Conceptual framing of women's empowerment in the literature has largely converged around the definition of Kabeer (1999), which describes empowerment as a complex process of change, whereby women access resources and exercise agency leading to improvements in their well-being outcomes and other achievements. Women's empowerment is multidimensional and complex—while some aspects, such as objective outcomes and achievements, are easier to measure and observe; other aspects, such as agency, can be subjective and more difficult to measure (Laszlo et al., 2020). Nevertheless, tools to capture the multiple dimensions of women's empowerment that are linked to the theoretical concepts, including various aspects of women's agency, have been developed and are becoming more widely used (Malapit et al., 2019). These tools, including the Women's

Empowerment in Agriculture Index (WEAI), have evolved over time into a set of comparable and complementary indicators to diagnose and monitor changes in women's empowerment and have been widely used across contexts, offering consistency in empowerment measurement (Alkire et al., 2013; Malapit et al., 2017; Malapit et al., 2019; Martinez, Myers, and Pereira, 2021).

More recent applications of the WEAI focus on measuring women's empowerment as an outcome of development interventions that aim to reach, benefit, and empower women and have been applied across a range of contexts with varied results (Johnson et al., 2018; Malapit et al., 2019). Some recent examples include a study by Kumar et al. (2021) that finds that women's participation in self-help groups in India increases women's empowerment scores and gender parity, largely through an increase in their control over income, decision-making over credit, and active involvement in groups. Crookston et al. (2021) examine the impact of a set of interventions designed to increase resilience on measures of men's and women's empowerment in Burkina Faso and find that the intervention protected program participants from empowerment losses due to an economic shock during the study period. Quisumbing et al. (2021) found that an intervention that provided agricultural, nutrition, and gender-sensitization trainings to men and women in Bangladesh increased women's empowerment outcomes.

This paper examines the extent to which an intervention that provided motor pumps for small-scale irrigation to groups of men and women farmers in Northern Ghana affected measures of women's empowerment using indicators from the Abbreviated Women's Empowerment in Agriculture Index (A-WEAI) developed by Malapit et al. (2017). The analysis focuses on two composite measures of women's empowerment, an individual empowerment score and the number of adequacies achieved across several measures of empowerment, as well as indicators of key aspects of women's empowerment thought to be affected by the intervention: women's input into production decision-making, control over assets, control over income, and work burden. Results shed light on the extent to which expanding access to irrigation technology on its own benefits and empowers women and points to potential pitfalls of this approach.

4.2 Background

4.2.1 Policy Context

Public irrigation investments in Ghana have been largely targeted towards large-scale irrigation schemes in Northern Ghana; however, these schemes demonstrated limited effectiveness in terms of economic benefits to farmers, due to poor construction, operation and maintenance, lack of support services, and land insecurity

(Owusu, 2016; Dittoh et al., 2013; Laube et al., 2012). These large-scale schemes complement the development of hundreds of small reservoirs that have been constructed to capture rainwater for multiple uses, including irrigation (Acheampong et al., 2018) as well as more recent interest in other water sources, including groundwater and water harvesting schemes (Adam et al., 2016; MoFA and GIDA, 2012). However, current policy guidance still emphasizes increasing public investment in developing and rehabilitating irrigation schemes and infrastructure (MoFA, 2010; MoFA, 2018).

Many smallholder farming households have already developed their own rudimentary irrigation facilities and practices, typically consisting of hand-dug wells and buckets for extracting and applying water for irrigation. Few smallholder farmers use modern irrigation technologies (Dittoh et al., 2013; Laube et al., 2012). There is little direct institutional and policy support for private farmers investing in small-scale irrigation, as this is considered the domain of the private sector (Namara et al., 2014; 2010; Owusu, 2016). Moreover, there is a lack of official information on the area covered by ongoing private small-scale irrigation and on the extent of proliferation of small-scale irrigation pumps throughout the country (Namara et al., 2014; 2011; 2010; Owusu, 2016). However, studies suggest that small-scale irrigation covers 14 times more land than the area covered

by public irrigation schemes and benefits 500,000 smallholder farmers in the country (Namara et al., 2014).

Private sector investment is increasing in the areas of importation, manufacturing, and retailing of irrigation equipment (Minh et al., 2020; Atuobi-Yeboah et al., 2020). However, most imported products are targeted towards large-scale commercial farms and the scale of locally-manufactured irrigation equipment targeted to smallholders remains too limited to accelerate the diffusion of irrigation technologies (ibid). Retailers that distribute irrigation equipment, such as motor and manual pumps, water tanks, and PVC pipes, are typically located in large urban areas and often depend on partners, such as NGOs, to distribute equipment to farmers (ibid). Moreover, irrigation equipment supply chains are not gender-sensitive—technologies are not designed and distributed in ways that meet the needs of women (Minh et al., 2020). Both men and women farmers lack knowledge and access to service providers to support the installation, operation, and maintenance of irrigation equipment (ibid).

Given the important role women play in the agriculture sector, the Gender and Agricultural Development Strategy (MoFA, 2015b) provides a detailed framework for integrating gender into agricultural policies, programs, and projects. While the strategy does not mention irrigation specifically, it highlights the need to develop

and disseminate gender-sensitive technologies along agricultural value chains (ibid). In line with these mainstreaming efforts, Ghana's Irrigation Policy acknowledges the importance of increasing women's access to land and water as well as their participation in local water management organizations. However, gender mainstreaming in policy has not yet translated into practice and new and improved technologies are much less likely to be disseminated to women (MoFA, 2007) and there is currently little coordination or oversight of private sector and development partners to ensure equitable and efficient diffusion of small-scale irrigation technologies (Minh et al., 2020). Both men and women smallholder farmers remain constrained in adopting technologies for small-scale irrigation, such as motor pumps, because of the high initial investment cost, despite the potential to increase farm profits and incomes (Balana et al., 2020, Wrigley-Asante et al., 2017).

4.2.2 Intervention Design and Theory of Change

While efforts to expand small-scale irrigation are ongoing, access to motor pumps in many parts of the country remains extremely limited. The technologies are generally not available in local markets, including in the Upper East Region. Moreover, motor pumps are unaffordable for many smallholder farmers and farmers lack credit access to facilitate adoption of motor pumps. Thus, there are virtually no sales of motor pumps in the

study area, though some farmers buy pumps from traders who cross the border from Togo. This research evaluates the impact of an irrigation intervention implemented in the Upper East Region of Ghana by International Development Enterprises (iDE), through which small groups of men and women farmers were provided preferential loans to adopt water extraction technologies (motorized diesel pumps) for irrigation during the dry season. The pumps distributed to farmers cost 890 cedis (US\$147 at the current exchange rate in October 2021), and farmers were expected to repay the loan in several installments following the dry season harvest. Thus, the intervention took a market-based approach to expanding small-scale irrigation technologies by targeting key constraints to motor pump adoption—credit and technology access. The ultimate objectives of the intervention were to increase productivity of dry season agriculture, improve diets and food security, and contribute to women’s empowerment.

While the project did not include any activities that were intended to challenge patriarchal norms, such as facilitated dialogues, the distribution of an important productive asset (the motor pump) could lead to women’s empowerment through four pathways. First, the project assumed a high degree of participation in the project by women because women in the target communities are often responsible for dry season farming as men engage in other commercial activities, such as cross-border

businesses. Thus, the project would empower women directly by improving their access to and control over productive assets. Second, the project assumed that motor pumps would enable women to expand production of high-value crops and increase the income they generate from dry season farming. This is because existing dry season farming in these communities typically involves using small buckets or jerricans to bring water from the source to the fields—a particularly inefficient method of irrigation that limits the extent and profitability of irrigated production. Third, the project hypothesized that having access to motor pumps would decrease women’s time burden by reducing the amount of time they spend irrigating or collecting domestic water using buckets. Fourth, the project expected that more women having access to and control over modern irrigation technologies and income from irrigation would increase their decision-making authority in the household, including over important production decisions. In addition to these expected impacts on women’s empowerment, the project envisioned that both women and men would also benefit from improvements in food and nutrition security, due to greater availability of irrigated produce and more income for food purchases.

The project also anticipated potential challenges to achieving gender equity in program outcomes, including women’s more limited access to land and water resources and the risk that men may take over irrigation

technologies and activities if they become more profitable. Other identified risks include that women would be less likely to adopt the technology despite having won the lottery, due to higher risk aversion to accept the loans being provided for the purchase of motor pumps and the associated re-payment requirements. The project aimed to minimize this risk by offering more favorable terms than other credit providers in the area, including a lower interest rate and a delay in repayment until after the harvest.

In each village, farmers were directed by iDE to self-organize into groups to receive a group loan to purchase a motor pump. All farmers in the community were invited to participate in the intervention on a voluntary basis. Both men and women joined groups so that the final set of groups included some same-sex groups and some mixed groups. In some cases, multiple members of the same household joined groups. Overall, two-thirds of the group members were women, but the number of women participants varied across communities. The precise number of groups formed in each village depended on the amount of water available for irrigation and the level of interest among farmers.

Farmers first organized into “confidence” groups of around 20 farmers to receive group loans from a micro-finance institute to purchase agricultural inputs, such as seeds and fertilizers. A total of 42 confidence groups were

formed across villages. The confidence groups were further broken down into smaller “trust” groups of 5 farmers each. A sub-sample of trust groups was randomly selected to receive a loan to purchase a motor pump through a lottery process in a subset of villages. Thus, the level of randomization was at the trust group level and the lottery was conducted during a meeting with most members of each trust group present. Therefore, not all trust groups within the larger confidence groups would receive a pump through the lottery. Given liquidity constraints, microfinance organizations are typically not able to provide loans large enough for farmers to purchase motor pumps. Therefore, iDE managed financing of the loans which could only be used for the purchase of a motor pump to be shared by members of the group. Trust groups that won the lottery were expected to share the pump amongst all group members and each member was expected to contribute to repayment of the loan.

The intervention faced some challenges in implementation. First, pumps were distributed to trust groups that won the lottery in December of 2015, after the dry season cultivation had already started. Therefore, farmers were not able to utilize the pumps to increase irrigated area and profits during the first year of the program and were unable to repay the loans following the dry-season harvest. Several farmer groups returned the pumps to iDE for later re-distribution before the next dry season (beginning in September 2016). Second, while

most groups repaid the full loan amount, some groups did not complete payments and returned the pumps to iDE. Furthermore, there were irregularities in the redistribution of the pumps in September 2016 that resulted in some farmer groups not receiving the pumps as intended. At the end of the program approximately 60 percent of the farmer groups had received the pumps and repaid the loans. Moreover, while the program intended all 5 trust group members to share the pump equally, some group members reported to the research team that they had less access to the pump, although individual pump use was not tracked by the program implementors.

4.3 Data

4.3.1 Study Area

The intervention was carried out in the Garu-Tempene District in the Upper East Region of Ghana. This region is characterized by one rainfall season followed by a long dry period. Irrigated cultivation largely takes place during the dry season. The most important crops produced with irrigation in this area are onions, okra, tomato, pepper, watermelon, and leafy green vegetables, all of which are considered high-value crops (Mekonnen et al., 2019). These crops are sold in local markets by women vendors, and some (especially onions) are bundled and transported

(typically by male traders) to larger urban centers, namely Accra and Kumasi (IFPRI, 2020).

The survey data show that the main sources of water for irrigation include groundwater, typically extracted from the dry riverbed through hand-dug wells, and surface water bodies, such as small reservoirs, dams, and ponds. In communities where hand-dug wells are needed to obtain water (as opposed to small reservoirs or dams), men are responsible for digging the wells in the dry riverbed every season, while women assist with irrigating plots located near the water source using buckets or jerricans (Bryan and Garner, 2020). Most households used rudimentary methods to apply water to their fields, namely jerricans, buckets and hoses. Other irrigation application methods include flooding, furrow, and level basin (gravity) and a few households used more water efficient methods, such as sprinkler or low-cost drip. At the start of the intervention, very few households in the study area used motor pumps or even manual pumps to extract water for irrigation.

Irrigators that use any type of pump or gravity irrigate more land, and hence have higher potential for increased income and productivity gains. While most farmers, including those that irrigate and those that do not, report using their own seeds, irrigating households were more likely to report purchasing local seed, including improved seeds. Farmers reported that the main constraints to dry

season agriculture include plant disease, insect damage, insufficient water, and, to a lesser extent, weeds. Most farmers irrigated twice per day and spent an average of 2.5 hours per irrigation.

There are clear gender-differentiated livelihood and farming roles in the study area. Women assist their husbands with the main household plots but often cultivate their own plots of land allocated to them by their husbands or other family members (Bryan and Garner, 2020). There are some crops grown by both men and women, but women tend to select different crops on the plots that they cultivate themselves, such as leafy greens, given their consumption preferences (*ibid*). Women participate in irrigated production and often provide the labor for irrigation, which is particularly time consuming with manual methods.

Women also participate in alternative livelihood activities, including petty trading, shea butter and groundnut processing, and brewing and selling the local drink Pito, basket weaving, and other activities (Bryan and Garner, 2020; Lawson et al., 2020; Lolig et al., 2014). Women are also responsible for the sale of crops produced by the household in local markets and tend to dominate market transactions, except in the case of livestock. Because women do not own land but access it by borrowing from their husbands or other family members, this limits their ability to make decisions regarding

production and affects their willingness to apply agricultural inputs and adopt new agricultural practices, especially ones that require technical knowledge and upfront investment, like small-scale irrigation (Bryan and Garner, 2020; Lawson et al., 2020).

4.3.2 Data and Sampling Frame

This paper uses household and intra-household survey data collected from selected sites in Ghana by IFPRI and the University of Development Studies in Tamale, Ghana. The baseline survey was carried out between early November 2015 to early February 2016 in 9 villages in Garu-Tempane District in the Upper East Region of Ghana where a total of 800 households were interviewed across these communities. The endline survey round was conducted between December 2017 and February 2018, covering 759 households. The intervention, whereby pumps were distributed to 42 trust groups of farmers through a random lottery, took place after the baseline round was completed.

This region was selected for the intervention given its location near the iDE area of operation where similar interventions were implemented; but farmers in the selected villages were not previously reached by any irrigation intervention. The area was identified as having high potential for irrigation expansion based on an ex-ante analysis. The sampling frame was based around the iDE

intervention, whereby households that self-selected into the intervention were randomly divided into treatment and control groups. Because farmers self-selected into groups, the number of participants that volunteered to participate in the intervention was uneven across villages. In some villages there were as few as 20 program participants and in the largest community (comprised of several adjacent villages) there were close to 300 participants. Given the large differences in the number of farmers and trust groups across villages, assignment of treatment and control villages was based on a random selection of paired villages with similar levels of program participation. This was done based on the assumption that differences in voluntary program participation reflected differences across communities—e.g. that villages where participation was high were likely to have better access to water resources for irrigation and more households irrigating at baseline.

After the program was introduced, farmers organized into groups and the baseline survey was completed, households were assigned to treatment and control groups based on the random selection of treatment villages and lottery-winning trust groups within treatment villages. Not all households that originally joined groups and participated in the baseline survey ended up participating in the lottery (see the last 2 columns of Table 4.1). Out of the 412 group participants in the intervention villages,

iDE records showed that 351 people participated in the lottery, of which 171 were in trust groups that won.

Table 4.1: Distribution of farmers, trust groups, and lottery winners across villages

Community	Assignment	# of farmers	# of trust groups	# of lottery participants	# of lottery winners
Mognoori	Treatment	295	59	250	121
Akara	Control	157	31	n/a	n/a
Gbanterago Alemgbek	Control	114	23	n/a	n/a
Asikiri	Control	58	11	n/a	n/a
Yidigu	Treatment	57	11	49	24
Denegu	Treatment	39	8	38	19
Bugri Natinga	Control	39	7	n/a	n/a
Binipiala	Treatment	21	4	14	7
Zule	Control	20	4	n/a	n/a
Total		800	158	351	171

Source: Authors.

After the program was introduced, farmers organized into groups and the baseline survey was completed, households were assigned to treatment and control groups based on the random selection of treatment villages¹ and

1 The villages of Akara and Gbanterago Alemgbek together were paired with Mognoori village; Asikiri was paired with Yidigu; Denegu was paired with Bugri Natinga; and Binipiala was paired with Zule for the random selection of villages into treatment.

lottery-winning trust groups² within treatment villages. Not all households that originally joined groups and participated in the baseline survey ended up participating in the lottery (see the last 2 columns of Table 4.1). Out of the 412 group participants in the intervention villages, iDE records showed that 351 people participated in the lottery, of which 171 were in trust groups that won.

This results in the following groups of households in our sample: 1) lottery winners in early treatment villages, 2) lottery losers in early treatment villages (and non-participants), and 3) farmers who formed groups in control villages that did not participate in the lottery. Spillover effects can be determined by comparing the outcomes of households from trust groups in treatment communities that did not win the lottery with households from groups in control communities.

The survey included household-level modules on agricultural activities, socio-economic characteristics, livelihoods, nutrition, health, and food security among other topics. The survey also included a modified version of the Women's Empowerment in Agriculture Index (WEAI) to measure the relationship between women's empowerment and irrigation. The WEAI is an intra-household survey-based tool, asked of both the main male

2 Half of the trust groups in the randomly-selected villages were assigned into treatment through a public draw of lottery.

and female decisionmakers in a household used to determine inclusion of women in domains important to the agricultural sector. It was modified for this study to include more questions and response codes related to irrigation. In addition to the original WEAI modules, additional questions on credit, savings, group membership, access to information, and access to extension were asked of both men and women respondents from the same household.

4.4 Methods

The treatment group is composed of households in trust groups that won the lottery to receive a motor pump, in villages where the lottery was carried out. We estimate the intent-to-treat effect, regardless of whether the households in the lottery-winning trust groups actually used the pump, given inconsistencies in pump distribution and repayment across lottery-winning groups, and uneven sharing among trust group members. The intervention was designed to provide two alternative control groups to evaluate the impacts of the program on indicators of women's empowerment. The first control group (control 1) is comprised of those households in trust groups that did not win the lottery as well as those in villages where no lottery was held. However, if the pumps were shared outside of the winning trust groups, households within treatment villages may have gained access to motorized pumps even if they did not participate in a group that won

the lottery. Given the possibility of such spillover effects within treatment villages, a second control group (control 2), comprised only of households in control villages, was also used. Figure 4.1 illustrates these two different control groups: control group 1 is shown by the larger outline, while control group 2 is shown by the dotted outline.

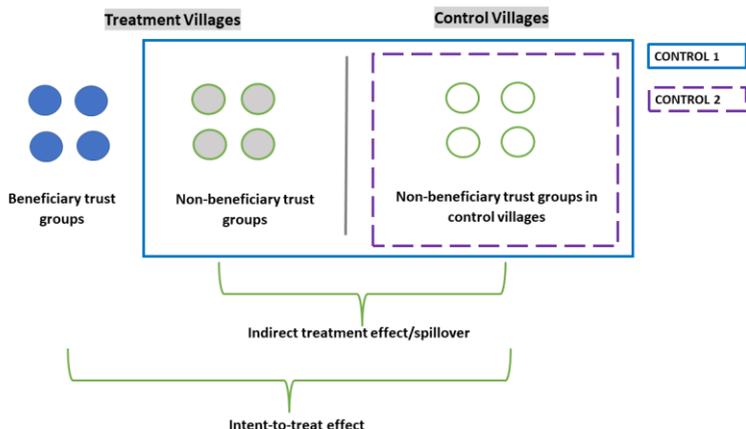


Figure 4.1: Experimental Design

Source: Authors.

To control for possible selection bias at the baseline the difference-in-difference method is used to estimate the impact of the program on indicators of women's empowerment:

$$Y_i = \beta_0 + \beta_1 T_i + \beta_2 R_i + \beta_3 T_i * R_i + \beta_x X_i + \varepsilon$$

Y represents the set of measures of women's empowerment. In the case of the difference-in-difference estimation, these outcomes are the individual A-WEAI score (composed of 6 sub-indicators), the number of A-WEAI sub-indicators for which the individual achieved adequacy (0-6), and the set of sub-indicators for input into production decisions, control over assets, control over income, and work balance. β_1 accounts for the difference between the treatment and control groups prior to the intervention, β_2 captures the trend over time (R signifies round), β_3 captures the intent-to-treat effect. The model also includes a set of control variables (X_i) comprised of individual and household characteristics. Baseline levels were used for some control variables thought to be influenced by the intervention. Individual control variables include age, whether the participant had any formal schooling, religion, and whether the household had multiple wives. Household level controls include household size, number of children under 5, size of agricultural landholdings at baseline, distance of the plot from the household, tropical livestock units (TLU) at baseline, irrigation status at baseline, source of water, and experience with shocks. Standard errors are clustered by confidence group (42 groups) and village-level dummies are included. The same model is run for both sets of control households (control 1 and control 2) as described above.

Spillover effects are also estimated by comparing outcomes of members of non-beneficiary trust groups in the treatment villages with non-beneficiary groups in control villages. The spillover estimation includes a control for the intensity of the potential spillover that is defined as the number of trust groups that won the lottery within the larger confidence group.

4.4.1 Baseline Characteristics

The A-WEAI is an aggregate index comprised of two subindices: the five domains of empowerment (5DE) and the gender parity index (GPI) (Malapit et al., 2017). The 5DE is based on 6 weighted sub-indicators of various aspects of women's empowerment covering 5 domains: 1) input into agricultural production decisions, 2) access to and control over productive resources, 3) control over income, 4) community leadership, and 5) time allocation (Alkire et al., 2013). The sub-indicators are adequacy scores, which take the value of one if a woman achieves adequacy in that indicator or zero if she does not. The six sub-indicators of women's empowerment within the 5 domains of empowerment are: input into productive decisions, ownership of productive assets, access to and decisions on credit, control over the use of income, group membership, and work burden. The weights given for each indicator in the construction of the 5DE are shown in Table 4.2.

One of the benefits of the WEAI tools is that they are decomposable into sub-indices, sub-indicators, and population subgroups (Alkire et al., 2013; Malapit et al., 2017). A selected set of outcome indicators was used to assess the impacts of the intervention on women’s empowerment based on the theory of change for the intervention. These include aggregate measures: the A-WEAI individual empowerment score (5DE) composed of the 6 sub-indicators shown in Table 4.2 and the number of adequacies achieved (0-6). We also assessed the impact of the intervention on 4 key sub-indicators that were hypothesized outcomes of the intervention: input in production decisions, ownership of productive assets, control over income, and work balance.

Table 4.2: A-WEAI Domains, Indicators, and Weights

Domains	Sub-indicators	Weight
Production	Input in productive decisions	1/5
Resources	Ownership of assets	2/15
	Access to and decisions on credit	1/15
Income	Control over use of income	1/5
Leadership	Group membership	1/5
Time	Work balance	1/5

Source: Malapit et al., 2017.

A comparison of the average value of the dependent variables revealed no statistically significant differences at the baseline between women in households assigned to treatment and control group 1 as shown in Table 4.3. Weighted individual empowerment scores (5DE) for women were 0.69 in control group 1 and 0.72 in the treatment group and the average number of adequacies achieved was approximately 4 for both treatment and control groups. Women were more likely to achieve adequacy in having input into agricultural decisions and control over income at the baseline compared to asset ownership and work balance. However, balance tests using control group 2 show significant differences between treatment and control with respect to women's involvement in agricultural decision-making, whereby women in the treatment group are more likely to achieve adequacy in this indicator.

Some household-level independent variables did differ across treatment and control groups 1 and 2 at the baseline. Households in the treatment group were more likely to have more children under the age of 5 and were more likely to have larger land holdings. In the case of control group 2, these households were significantly more likely to have shorter distance to plots than the treatment group. There were no differences with respect to average household size, whether the household irrigated at baseline, livestock holdings, sources of irrigation water, and experience with shocks. The fact that there were few

statistically significant differences suggests that the treatment and control groups were relatively well balanced at baseline.

Given that they survey did not have complete WEAI data for every household in the sample and because of attrition between rounds 1 and 2, there are fewer observations in the final endline and panel datasets used for the analysis. Therefore, the results are weighted to account for possible attrition bias. The results with and without the weights for attrition were robust—the direction and significance of the impact estimates remain consistent.

Table 4.3: Summary Statistics of Dependent and Independent Variables at Baseline for Women in Treatment and Control Households

Dependent vars	Treat (obs=139)	Control1 (obs=370)		Control2 (obs=238)	
5DE score	0.72	0.69		0.68	
Number of adequacies	4.06	3.98		3.97	
Input into agricultural decisions	0.89	0.85		0.83	*
Asset ownership	0.55	0.56		0.54	
Control over income	0.91	0.89		0.86	
Work balance	0.53	0.52		0.49	
Independent vars					
Household size	6.96	6.8		6.93	
Children under 5	0.97	0.78	*	0.79	*
Land size (acres)	7.39	6.47	**	6.44	*

Average plot distance (mins)	25.54	22.52		19.68	**
Tropical livestock units (TLU)	3.22	3.69		4.05	
Household has irrigated plots	0.7	0.69		0.68	
Household has groundwater for irrigation	0.47	0.49		0.48	
Household has surface water for irrigation	0.23	0.21		0.21	
Experienced climate shock	0.49	0.43		0.50	
Experienced idiosyncratic shock	0.4	0.46		0.42	

Source: Authors

4.5 Results

4.5.1 Impacts of the Intervention on Measures of Women's Empowerment

Different estimations were run comparing women assigned to the treatment group with both alternative control groups, while spillover effects were estimated by comparing outcomes of women in the treatment villages in households that did not win the lottery with women in control villages where no lottery was conducted. The results using the first control group (non-beneficiaries in treatment villages and control villages) showed a significant positive impact of treatment on one of the indicators of women's empowerment—women in lottery-winning households were more likely to achieve

adequacy in control over the use of income (Table 4.4). The positive impact of the intervention on women's role in expenditure decisions may reflect women controlling a larger share of household income, as profits from agricultural production and household income increases because of the introduction of motorized pumps for small-scale irrigation. Descriptive and qualitative results suggest that women may also have benefitted from a reallocation of household budgets—some women reported not having to purchase vegetables in the market given greater availability of vegetables from own production (Bryan and Garner, 2020). While descriptive survey results indicated that pump users sold most of their irrigated output, most also kept a small portion for household consumption. As a result, 39 percent of households who won the lottery reported consuming different foods because of having access to the pump. Pump users also reported using the income from the sale of irrigated crops to purchase other foods (32 percent), pay school fees (66 percent), and pay medical expenses (46 percent).

Results show that the program did not have a significant impact on aggregate measures of empowerment (AWEAI score and number of adequacies) or the other adequacy measures (input into productive decisions, ownership of assets and work balance). The finding on control over assets is not surprising—qualitative research from the study sites suggests that even when women were

in groups that won the lottery, these assets were turned over to and controlled by their husbands due to social norms giving men greater control over large agricultural assets, such as machinery (including pumps) and livestock (Bryan and Garner, 2020). Limited control over the pumps may also explain the fact that the intervention did not directly increase women's role in production decisions. These results also suggest that even if women's time spent irrigating declined because of the intervention, as descriptive data indicate, women likely increased time devoted to other livelihood activities. Thus, it seems that gaining access to the pump did not reduce women's overall work burden, but rather shifted time allocated to different livelihood activities.

The results also show some significant differences between women in the treatment and control groups at the baseline after controlling for other factors. Women in the treatment group already had higher individual empowerment scores and were more likely to achieve adequacy in input into agricultural production decisions. Moreover, the results indicate that women's empowerment is increasing over time. Between rounds 1 and 2, the aggregate empowerment scores as well as individual adequacy scores for asset ownership and work balance increased for all women in the study areas, while there appears to be a decrease in women's participation in agricultural decisions over time. Again, this suggests that as women's agency increases, they shift away from

agricultural production to engage in other livelihood activities.

While the results using the first control group (i.e. the control group including both lottery losers in treatment villages and women in control villages) showed a positive impact of the program on women's control over income, the set of results using the alternative control group (only women in non-treatment villages) showed no significant program impacts. However, the signs on the coefficients using control group 2 are very similar to the results with control group 1. Thus, it is likely that efficiency gains using the larger control group account for the fact that we only see significant impacts of the program using this model. Moreover, the balance tests indicate that control group 1 is a more suitable control for the treatment group.

Table 4.4: Difference-in-Difference Intent to Treat Effect on Indicators of Women’s Empowerment, Alternative Control Groups

	Control 1					
	A-WEAI score	No. of adequacies	Production decisions	Ownership of assets	Income decisions	Work balance
TreatxRound	-0.00548 (0.0344)	0.0462 (0.194)	-0.166 (0.407)	0.606 (0.390)	1.318** (0.670)	-0.451 (0.400)
Treat	0.0531* (0.0272)	0.266 (0.157)	0.761** (0.361)	0.0927 (0.300)	0.214 (0.569)	0.181 (0.365)
Round	0.0985*** (0.0199)	0.689*** (0.121)	-0.673** (0.325)	1.036*** (0.190)	-0.0458 (0.230)	1.297*** (0.246)
Age	0.00301*** (0.000669)	0.0161*** (0.00380)	0.0498*** (0.0105)	0.0129 (0.00840)	0.0404*** (0.0154)	0.0160** (0.00643)
Schooling	-0.0172 (0.0375)	-0.0451 (0.218)	0.310 (0.362)	-0.282 (0.319)	-0.159 (0.437)	-0.375 (0.282)
Cowives	0.0188 (0.0180)	0.0931 (0.104)	0.493** (0.203)	-0.318 (0.200)	0.688* (0.358)	0.0515 (0.201)
Muslim	0.00209 (0.0184)	0.0105 (0.109)	0.297 (0.297)	0.0717 (0.272)	0.865** (0.441)	0.0412 (0.185)
Traditional	-0.0306 (0.0196)	-0.115 (0.115)	-0.213 (0.285)	0.169 (0.262)	-0.311 (0.366)	-0.115 (0.189)
Household size	-0.000990 (0.00269)	-0.0155 (0.0156)	-0.0160 (0.0346)	-0.0460 (0.0423)	-0.0163 (0.0403)	0.0176 (0.0311)
Children under 5	6.24e-05 (0.00812)	0.0325 (0.0533)	0.0278 (0.144)	0.0560 (0.104)	-0.00860 (0.121)	-0.0865 (0.102)
Land size at baseline	-0.00289 (0.00191)	-0.0116 (0.0101)	-0.0485** (0.0214)	0.00308 (0.0193)	-0.0328 (0.0319)	-0.0329 (0.0202)
Plot distance	-7.45e-05 (0.000447)	0.000332 (0.00253)	-0.00972 (0.00595)	0.00310 (0.00348)	-0.00477 (0.00855)	-0.00191 (0.00411)
TLU at baseline	-0.00125 (0.00184)	-0.00488 (0.0103)	-0.0306 (0.0239)	-0.00818 (0.0205)	-0.0128 (0.0285)	-0.0132 (0.0175)
Irrigation at baseline	0.0461*** (0.0166)	0.265** (0.106)	0.476** (0.231)	0.416* (0.240)	0.403 (0.296)	-0.0300 (0.210)
Water source	-0.0119 (0.0211)	-0.120 (0.130)	-0.570** (0.259)	0.173 (0.290)	0.266 (0.382)	0.0398 (0.167)
Climate shock	0.0248 (0.0151)	0.143* (0.0825)	0.215 (0.324)	0.114 (0.183)	0.684** (0.322)	0.0243 (0.132)

Idiosyncratic shock	0.0280* (0.0162)	0.216** (0.0875)	-0.528** (0.223)	0.238 (0.152)	0.272 (0.413)	0.0359 (0.151)
Constant	0.525*** (0.0600)	3.128*** (0.321)	-0.507 (0.762)	-0.518 (0.614)	-0.875 (0.788)	0.0468 (0.625)
Observations	742	742	742	742	742	742
R-squared	0.148	0.167				

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: Village dummies included

Table 4.4: Difference-in-Difference Intent to Treat Effect on Indicators of Women's Empowerment, Alternative Control Groups, Continued

	Control 2					
	A-WEAI score	No. of adequacies	Production decisions	Ownership of assets	Income decisions	Work balance
TreatxRound	-0.0270 (0.0418)	-0.0369 (0.240)	-0.540 (0.594)	0.172 (0.401)	1.028 (0.835)	-0.534 (0.478)
Treat	0.00946 (0.0402)	-0.120 (0.278)	1.305** (0.597)	0.161 (0.938)	0.0726 (0.616)	-0.0652 (0.311)
Round	0.119*** (0.0307)	0.765*** (0.178)	-0.334 (0.479)	1.446*** (0.225)	0.414 (0.263)	1.391*** (0.376)
Age	0.00263*** (0.000608)	0.0145*** (0.00337)	0.0527*** (0.0109)	0.00569 (0.00827)	0.0357** (0.0155)	0.00813 (0.00804)
Schooling	-0.0257 (0.0374)	-0.0834 (0.227)	0.261 (0.431)	-0.453 (0.349)	-0.515 (0.470)	-0.510* (0.290)
Cowives	0.0225 (0.0194)	0.116 (0.110)	0.465** (0.209)	-0.543** (0.235)	0.624* (0.344)	0.194 (0.241)
Muslim	-0.00856 (0.0202)	-0.0331 (0.126)	0.100 (0.365)	-0.0947 (0.351)	0.773 (0.624)	-0.0666 (0.245)
Traditional	-0.0389 (0.0232)	-0.120 (0.140)	-0.455 (0.310)	0.158 (0.362)	-0.524 (0.377)	-0.237 (0.260)
Household size	-4.68e-05 (0.00352)	-0.00849 (0.0203)	-0.0372 (0.0389)	-0.0158 (0.0526)	-0.0274 (0.0374)	0.0107 (0.0408)
Children under 5	-0.00498 (0.00877)	0.00337 (0.0591)	0.0115 (0.156)	-0.00607 (0.104)	-0.0725 (0.114)	-0.106 (0.110)
Land size at baseline	-0.00283 (0.00198)	-0.0129 (0.0105)	-0.0414 (0.0270)	-0.0190 (0.0172)	-0.0486 (0.0305)	-0.0175 (0.0242)

Plot distance	-7.88e-05 (0.000475)	0.000171 (0.00272)	-0.0146* (0.00756)	0.00385 (0.00472)	-0.00924 (0.0115)	0.00103 (0.00582)
TLU at baseline	-0.000574 (0.00185)	-0.00197 (0.0108)	-0.0119 (0.0230)	-0.00607 (0.0264)	0.0132 (0.0313)	-0.0186 (0.0189)
Irrigation at baseline	0.0490*** (0.0169)	0.295*** (0.101)	0.421 (0.283)	0.535* (0.279)	0.555 (0.359)	-0.190 (0.245)
Water source	-0.0201 (0.0244)	-0.173 (0.154)	-0.589* (0.314)	0.0303 (0.385)	0.121 (0.426)	-0.0233 (0.208)
Climate shock	0.00676 (0.0184)	0.0371 (0.102)	0.0582 (0.383)	0.131 (0.260)	0.531 (0.375)	0.0226 (0.140)
Idiosyncratic shock	0.0235 (0.0186)	0.211** (0.0985)	-0.786*** (0.230)	0.325* (0.183)	-0.0326 (0.620)	0.0409 (0.175)
Constant	0.544*** (0.0599)	3.200*** (0.303)	-0.310 (0.781)	-0.270 (0.586)	-0.392 (0.719)	0.504 (0.751)
Observations	536	536	536	536	536	536
R-squared	0.165	0.180				

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: Village dummies included

The estimation of spillover effects shows that women in households that did not win the lottery were less likely to achieve adequacy in production decisions, control over assets, and input into income decisions than women in the control communities where no lottery was conducted even after controlling for differences between these groups at baseline and over time (Table 4.5). Moreover, exposure to the intervention (as represented by the number of trust groups within the larger confidence group that won the lottery) is shown to have a negative effect on women's input into agricultural production decisions.

This somewhat surprising result suggests that the lottery may have created some conflicts in treatment villages that had a negative impact on women within households that did not win the lottery. In fact, 16 percent of lottery-winning households did report some conflicts within the community related to the pumps. Moreover, while the intervention specifically targeted communities with a relatively high potential for irrigation, water remains a scarce resource in some of the communities and some farmers reported difficulty obtaining water using the pumps in certain locations. Thus, the intervention may have increased the level of water extraction in intervention communities, whereby access to water for irrigation improved for lottery winners, while at the same time, lottery losers had reduced access to water for irrigation using manual methods. Therefore, the intervention seems to have intensified competition over

resources—both the technologies and water for irrigation—leading to harmful effects on women that did not gain access to pumps and, thus, faced more difficulty in irrigated production.

Table 4.5: Difference-in-Difference Estimation of Spillover Effects

	A-WEAI score	No. of adequacies	Production decisions	Ownership of assets	Income decisions	Work balance
Spilloverx Round	-0.0618 (0.0399)	-0.202 (0.232)	-1.277** (0.548)	-0.877** (0.420)	-2.061*** (0.705)	-0.116 (0.412)
Spillover Round	-0.00777 (0.0576)	-0.424 (0.316)	1.871** (0.766)	-1.216** (0.554)	1.786* (0.931)	0.0340 (0.578)
Intensity of treatment	0.117*** (0.0240)	0.725*** (0.139)	-0.243 (0.309)	1.260*** (0.273)	0.610 (0.377)	1.332*** (0.269)
Age	-0.00874 (0.00937)	-0.0311 (0.0519)	-0.369*** (0.108)	0.161* (0.0958)	-0.122 (0.127)	-0.0176 (0.0963)
Schooling	0.00307*** (0.000835)	0.0164*** (0.00481)	0.0419*** (0.0121)	0.0178** (0.00904)	0.0404*** (0.0151)	0.0142* (0.00863)
Cowives	-0.0349 (0.0415)	-0.0957 (0.234)	-0.228 (0.426)	-0.210 (0.368)	-0.575 (0.483)	-0.0713 (0.361)
Muslim	0.0365* (0.0201)	0.197* (0.114)	0.838*** (0.298)	-0.275 (0.228)	0.574 (0.366)	0.0610 (0.224)
Traditional	-0.00257 (0.0241)	-0.0215 (0.137)	0.532 (0.343)	0.0778 (0.253)	0.675 (0.432)	-0.100 (0.249)
Household size	-0.0230 (0.0281)	-0.105 (0.160)	0.115 (0.397)	0.366 (0.305)	-0.0769 (0.444)	0.0810 (0.318)
Children under 5	-0.00152 (0.00345)	-0.0187 (0.0201)	-0.000642 (0.0507)	-0.0102 (0.0410)	0.00912 (0.0564)	0.00406 (0.0393)
Land size at baseline	0.00105 (0.0142)	0.0549 (0.0849)	-0.0850 (0.196)	0.176 (0.146)	0.0983 (0.227)	-0.105 (0.144)
Plot distance	-0.00205 (0.00291)	-0.00670 (0.0171)	-0.0703** (0.0332)	-0.00281 (0.0316)	-0.0295 (0.0437)	-0.0330 (0.0274)
	-2.19e-05 (0.000535)	0.000426 (0.00316)	-0.0129* (0.00738)	0.00538 (0.00534)	-0.00316 (0.00775)	-0.00188 (0.00525)

TLU at baseline	-0.000958 (0.00167)	-0.00414 (0.0105)	-0.0274 (0.0210)	-0.0135 (0.0235)	0.0189 (0.0292)	-0.00299 (0.0205)
Irrigation at baseline	0.0419* (0.0224)	0.214 (0.130)	0.688** (0.295)	0.502** (0.233)	0.517 (0.376)	-0.0677 (0.247)
Water source	-0.0118 (0.0274)	-0.0561 (0.157)	-0.663* (0.356)	0.534* (0.301)	-0.249 (0.433)	0.264 (0.274)
Climate shock	0.0400** (0.0195)	0.239** (0.113)	0.345 (0.265)	0.00993 (0.212)	0.811** (0.324)	-0.157 (0.216)
Idiosyncratic shock	0.0225 (0.0202)	0.181 (0.116)	-0.661** (0.266)	0.0474 (0.218)	0.319 (0.369)	0.0264 (0.216)
Constant	0.502*** (0.0699)	3.035*** (0.399)	-0.228 (0.915)	-1.382* (0.714)	-1.672 (1.098)	0.256 (0.735)
Observations	538	538	538	538	538	538
R-squared	0.130	0.138				

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: Village dummies included

4.5.2 Other Factors Influencing Women's Empowerment

Other significant findings also shed light on the determinants of women's empowerment in this context. First, the results in all models show that age is a highly important factor affecting women's overall empowerment scores as well as the likelihood that they achieve adequacy in agricultural decision-making, income decisions, and work balance, with levels of empowerment increasing with age. Difference-in-difference results show that having co-wives also generally increases women's empowerment. Using the first control group, results show that having co-wives increases the likelihood of achieving adequacy in agricultural decision-making and input into income decisions. However, results using the second control group also show a decrease in the likelihood of achieving adequacy in asset ownership with co-wives. These results suggest that having multiple wives in the household increase women's bargaining power in agriculture, especially with respect to agricultural and income decisions. Some women did, in fact, report that they were allocated plots of land by their husbands that they farmed jointly with their co-wives. It may be, therefore, that wives were more successful in accessing land and controlling the income from production when they negotiate collectively. On the other hand, asset

accumulation for individual women may be more difficult when family size increases.

Women from households with larger land holdings at the baseline were less likely to have input into production decisions (control 1), while irrigation status at the baseline is associated with higher women's empowerment scores and women's greater input into agricultural decisions and asset ownership. This suggests that irrigation with traditional, manual methods—an activity in which many women in these communities were already engaged before the intervention—already contributed to women's empowerment including women's asset accumulation. It is also possible that women who were more empowered to begin with were more likely to engage in traditional forms of irrigation. That is, women with higher levels of agency may be able to gain access to land and water in order to participate in small-scale irrigation activities. The results also show that women are more likely to achieve adequacy in agricultural decision-making when they have access to groundwater for irrigation, compared to surface water.

Finally, climate and idiosyncratic shocks appear to influence women's empowerment outcomes. The results using the first control group show that women from households who reported experiencing a climate shock in the last two years, including droughts, floods, and storms, are more likely to have higher adequacy scores and greater

participation in income decisions. This may indicate that women contribute more of the income they earn to meeting household needs when their household experiences a climate shock and, therefore, have a larger say in income decisions. Both men and women in the study communities reported intentionally dividing income among spouses to pay for different household expenditures and to cope with shocks that may occur. Women in households that experienced an idiosyncratic shock in the last two years—defined as death or illness of a family member or theft—have higher aggregate empowerment scores and are more likely to achieve adequacy in control over assets. However, these women had less input in agricultural decision-making following an idiosyncratic shock, possibly due to an increased care burden. These results show that women take on larger roles in the household when faced with climate and idiosyncratic shocks. They also suggest that women and men are affected differently by shocks and women also have important roles to play in coping with idiosyncratic and covariate shocks. While women may play an important role in coping with shocks to the household, it is important to view changes in their agency considering the stress that these shocks place on families. That is, while shocks may result in women taking on a larger decision-making role in some respects, such changes may reflect an increasing burden on women to maintain household well-being during times of adversity.

4.6 Discussion

The results demonstrate that expanding access to small-scale irrigation technologies offers a potential pathway for women's empowerment. Results using the first control group showed that women did benefit from gaining access to the motor pump for irrigation by having increased control over income. This suggests that when household resources increase—in this case, when use of the pump technology increases household production, income, and assets directly and indirectly—women also benefit by having greater input in income decisions. It can be difficult to discern the pathways through which the irrigation intervention may contribute to women's empowerment from these quantitative results alone. Qualitative focus groups and interviews with men and women farmers in the study area help to untangle the ways in which the intervention may influence women's empowerment (Bryan and Garner, 2020). This research suggests that the impacts of the motor pump intervention may be indirect—while some women reported direct income benefits of engaging in small-scale irrigation, others described shifting time away from direct engagement in irrigation activities when motor pumps were introduced (Bryan and Garner, 2020). That is, women's increasing control over income may result from their engagement in other livelihood activities because the motor pump intervention enabled them to shift their labor to activities that provide greater direct benefits.

The impact of the intervention on this aspect of women's empowerment must be considered in the context of ongoing social change in the study area. The econometric results in this paper suggest that women's agency in the study areas is increasing over time with women having higher aggregate empowerment scores in both the treatment and control communities at the endline. The results are also consistent with qualitative findings that women in this region of Ghana are experiencing changes in their roles and expectations in the household and in their communities. Qualitative findings indicate that women's economic contribution to their household is increasing with women contributing their own income to pay for basic household needs, like food and education expenses for children, and participating more in agricultural decisions and community leadership roles (Bryan and Garner, 2020).

Thus, in the context of ongoing social change, the impacts of the intervention on measures of women's empowerment appear minimal. The positive impacts of the intervention were limited to increasing women's control over income, while other aspects of women's empowerment were unchanged. This may be attributed to the constraints women face in adopting and benefitting from small-scale irrigation in this context, such as their limited access to resources given patrilineal inheritance norms, which prevent women gaining access to land (especially irrigable land) except through their husbands

(Bryan and Garner, 2020; Yoking and Lambrecht, 2020). Women also lack the labor needed to dig wells and construct mud fences to protect their irrigated plots from livestock that graze openly during the dry season (Bryan and Garner, 2020). Furthermore, social norms that prohibit women from owning large assets, including the motor pumps, are a significant impediment to achieving empowerment gains from small-scale irrigation interventions. The ways in which patriarchal norms hinder women's ability to access and control assets has also been described by other research in this context (Theis et al., 2018; Lambrecht, 2016; Doss et al., 2014). Moreover, the spillover analysis revealed some negative impacts on women from households in intervention villages that did not gain access to the pumps. This suggests that when resources are scarce and access to technologies is limited, women may be at an even greater disadvantage and experience setbacks in their ability to participate in production and spending decisions and gain control over assets.

While considerable challenges to women's participation in mechanized small-scale irrigation remain, there were also several implementation challenges, including the delay in pump distribution and lack of loan repayment by some groups, that limited the benefits of the intervention for women farmers in trust groups that won the lottery. Moreover, not all households in trust groups that won the lottery had equal access to the technology. Data on

perceptions of program effectiveness from the second survey round, after the intervention was implemented, indicate that the trust groups did not function as intended, with 37 percent of lottery-winning households claiming that they did not use the pump and 25 percent saying that not all trust group members had equal access to the pump. Among lottery winners, farmers who were already irrigating at the baseline were far more likely to reporting actually using the pump. This suggests that it is much more difficult for non-irrigators to use modern irrigation technologies, given additional constraints that prevent them from adopting irrigation practices in the first place. Anecdotal evidence suggests that some farmers who were able to repay the bulk of the loan had greater control over its use and distribution among group members. For all these reasons, the intent-to-treat effects are likely underestimating the impact of the program on women from households that did use the pumps for dry season irrigation.

4.7 Conclusions

The findings in this paper have important implications for the design of policies and programs aimed at expanding small-scale irrigation. Importantly, the results highlight the need for caution during the rollout of irrigation interventions given potential negative spillover effects for women in treatment communities that do not get access to the pumps and the risk of exacerbating competition over

scarce water resources. In particular, randomizing the distribution of agricultural assets among households or groups within the same community may lead to conflicts and should be avoided. Rather, pumps should be made available to all farmer groups in the intervention communities to prevent possible conflicts and scaled to other communities over time. In the case of irrigation interventions, it is also important to determine whether expanding access to irrigation technologies places increased pressure on water resources leading to scarcity. If water availability for irrigation declines because of the intervention, this may exacerbate intra-community conflicts and reduce the long-term sustainability of irrigation in communities with limited water resources and infrastructure. Differences in demand for the intervention across villages, which indicate unequal access to natural resources for irrigation (i.e. land and water), suggest that distribution of motor pumps alone is not enough to spark more widespread adoption of small-scale irrigation. Other infrastructure investments, such as in dams and wells, are needed to increase water availability for irrigation in communities with adequate water resources but inadequate infrastructure to access water.

More research on alternative approaches to the diffusion of small-scale irrigation and the extent to which these facilitate women's empowerment is needed to ensure gender equity in access to and benefits from small-scale

irrigation. It is important to consider the gender implications of alternative interventions to, at a minimum, do no harm to women, including non-beneficiaries. While this paper focused on one specific intervention—the distribution of motor pumps through a random lottery—other alternative interventions, by NGOs, the private sector, and other actors, are also used to expand irrigation access. The difficulties of implementing the complex intervention described in this paper suggest that other modalities of scaling small-scale irrigation should be explored further to evaluate whether they offer a more effective and inclusive option. One possible intervention is a service-based model, whereby farmers owning pump technologies could rent these to other farmers in the community and even provide labor for irrigation. Other approaches are not without their limitations—e.g. the service-based model would still require high initial investment in pump technology by the service provider, which may be especially cost-prohibitive for women. Moreover, farmers lacking access to land and water resources, including women and other resource poor farmers, might find it still too costly to access rental services. Yet some studies suggest that there are opportunities for women to benefit from mechanization services when programs are designed appropriately to ensure their participation (Theis et al., 2019).

For any small-scale irrigation intervention to benefit and empower women, it should be accompanied by other

complementary interventions that address the constraints women face, like household dialogues that lead to more inclusive decision-making processes about how technologies are applied and who controls the output and income from the use of those technologies (Theis et al., 2018). In addition, women's lack of access to land and water resources in the study area remains a key impediment to women being able to benefit directly from small-scale irrigation without complementary interventions that enable women to access these resources more easily.

Finally, more research is needed to weigh the irrigation pathway against alternative pathways to women's empowerment provided by other livelihood choices. Studies suggest that women's engagement in alternative livelihood activities, such as petty trading, increase their decision-making power at the household level and resilience to shocks and stresses (Lawson et al., 2020, Wrigley-Asante, 2011). Ultimately, providing multiple pathways for women's empowerment will allow women to choose the option that best meets their needs and preferences, enabling them to achieve their goals and live meaningful and fulfilling lives.

4.8 References

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Appendix 4.1: Supplementary Material, Single Difference Estimation and Results

A.4.1 Methods and Data

The motor pumps for small-scale irrigation were randomly distributed to farmer groups. Assuming the randomization was successful, a first difference model may be estimated to measure the impact of the intervention on indicators of women’s empowerment. The following model is estimated:

$$Y_i = \beta_0 + \beta_1 T_i + \beta_x X_i + \varepsilon$$

Where B_i captures the effect of the treatment on the different indicators of women’s empowerment (Y_i): the individual Pro-WEAI score (3DE), number of adequacies (0-10), individual adequacy scores for input into production decisions, control over assets, control over income, and work balance, and X represents the set of control variables. As with the difference-in difference results, this model is applied to estimate the impact of the treatment using both control groups and to estimate spillover effects in the treated communities.

Table A.4.1: Pro-WEAI Domains, Indicators, and Definitions

Domain	Indicator	Definition of Adequacy
Intrinsic agency	Self-efficacy	“Agree” or “strongly agree” with a set of self-efficacy questions

	Attitudes about intimate partner violence	Believes husband is NOT justified in hitting or beating his wife in all 5 different scenarios.
Instrumental Agency	Input into productive decisions	Makes decisions solely, jointly (and feels they have at least some input into decisions), or feels they could make the decision if they wanted to for a range of production decisions.
	Ownership of land and other assets	Owns solely or jointly at least one of the following: three small assets, two large assets, or land.
	Access to and decisions on credit	Belongs to a household that used credit in the past year and participated in at least one decision about it OR feels they could access credit if they wanted to.
	Control over the use of income	Has input in decisions about how to use income and output of all agricultural and non-agricultural activities they participate in.
	Work balance	Works less than 10.5 h per day: Workload = time spent in primary activity + (1/2) time spent in childcare as a secondary activity
	Visiting important locations	Visits at least two locations once per week (city/market/relatives) OR visits one location at least one per month (health facility/public meeting)

Collective agency	Group membership	Active member of at least one group
	Membership in influential groups	Active member of at least one group that can influence the community to a medium extent or greater.

Source: Adapted from Malapit et al. (2019)

Note: Indicators in **bold** are those that comprise the A-WEAI.

One key difference between the first difference and difference-in-difference models is that they use different aggregate measures of women’s empowerment. During the endline survey round, additional modules were added to the intra-household survey as part of a pilot test of the project-level Women’s Empowerment in Agriculture Index (pro-WEAI). These included modules on mobility, attitudes about domestic violence, membership in influential groups, and self-efficacy.

The pro-WEAI contains 12 sub-indicators, which are mapped to 3 domains of empowerment: intrinsic, instrumental, and collective agency (Malapit et al. 2019). The version of the pro-WEAI used in this paper is comprised of 10 sub-indicators all given equal weight in the index.³ These indicators are shown in Table A.4.1 with the definition of adequacy for each indicator. Six of

³ Data to calculate two sub-indicators—autonomy in income and respect in the household—were not collected.

these indicators are shared with the A-WEAI and these indicators are highlighted in bold. Thus, the aggregate pro-WEAI measures—the individual pro-WEAI score (10 indicators) and the number of adequacies (out of 10) are used in the single difference model that relies on endline data. The single difference model was run also for the same sub-indicators as in the difference-in-difference model: input into productive decisions, ownership of assets, control over income, and work balance.

A.4.2 First Difference Results

Results using the first control group show that women in households that won the lottery for a motor pump were more likely to achieve adequacy in having input into productive decisions and asset ownership (Table A.4.2). Women's role in agricultural decision-making has been increasing over time in the study communities (Bryan and Garner 2020), and these results suggest that this trend may accelerate with the introduction of new agricultural technologies.

While the results using the first control group show positive effects on women's empowerment, the results using the second control group (women in the control communities only) show conflicting results. Women in households that won the lottery are still more likely to have input into agricultural decisions. However, the results show negative impacts of the program on women's

work balance and control over income. Engaging in irrigated production increases the workload of farmers, particularly in the dry season, when farmers engage in irrigated cultivation. Descriptive analysis of our plot level survey data shows that women and men both provide labor for irrigation using traditional methods, with women spending more time on irrigation activities on average. When motor pumps are used, men are more likely to provide labor for irrigation, however, women still spend more time irrigating, on average, when involved. Evidence from qualitative research similarly suggests that when motor pumps are introduced, men take over irrigation activities, freeing up women's time to engage in other livelihood activities (Bryan and Garner 2020). Thus, the results that women's workloads increase with the introduction of motor pumps may be indirect—with women spending more time on other income-earning activities. The results on control over income contradict the difference-in-difference results and suggest that men may have more control over income following the introduction of motorized pumps. This result is also plausible—it suggests that men control more of the income from the sale of irrigated crops when motor pumps are used for irrigation, compared to when women irrigate using traditional methods. However, the results from the difference-in-difference model which controls for differences at baseline as well as over time are preferred.

The first difference results show no positive spillover effects for women in treatment villages that did not win access to the motor pumps through the lottery (Table A.4.3). Rather, consistent with the difference-in-difference model, results suggest that there were negative spillover effects with respect to women's control over assets. Women in treatment villages that did not win the lottery were less likely to achieve adequacy in control over assets compared to women in control villages where no lottery was conducted. This could be because women in the treatment villages anticipated receiving later benefits from the program and decided to forgo purchasing assets, while women in control villages may have been more inclined to invest in productive assets. It may also relate to challenges women who did not have access to the pumps faced in accessing water for irrigation in communities where more water was being extracted (because of the lottery winners use of the pumps).

As with the difference-in-difference results, other factors emerge as important determinants of women's empowerment in this context. First, the results show that age affects the likelihood that women achieve adequacy in agricultural decision-making, income decisions, and work balance with levels of empowerment increasing with age. Larger land size is associated with lower overall empowerment scores, an increasing work burden for women, and less control over assets. Furthermore,

women's empowerment scores increase as plot distance from the household increases.

Climate and idiosyncratic shocks appear to influence women's empowerment outcomes. First difference results show climate shocks as having a negative impact on both pro-WEAI aggregate empowerment scores and control over income (control group 2), with evidence suggesting that these results are driven by negative effects on women's self-efficacy and attitudes towards domestic violence (results not shown). Women in households that experienced an idiosyncratic shock—defined as death or illness of a family member or theft—have higher aggregate empowerment scores, suggesting that women take on larger roles in the household when faced with idiosyncratic shocks.

Table A.4.2: First Difference Results, Alternative Controls

	Control 1					
	A-WEAI score	No. of adequacies	Production decisions	Ownership of assets	Income decisions	Work balance
Treat	0.0235 (0.0237)	0.235 (0.237)	0.477* (0.286)	0.854** (0.430)	0.112 (0.256)	-0.381 (0.282)
Age	0.000269 (0.000833)	0.00269 (0.00833)	0.0411*** (0.0122)	0.00942 (0.0103)	0.0180* (0.00992)	0.0280** (0.0110)
Schooling	0.0252 (0.0261)	0.252 (0.261)	0.328 (0.410)	-0.165 (0.303)	-0.0587 (0.337)	-0.0497 (0.345)
Cowives	-0.0149 (0.0179)	-0.149 (0.179)	0.218 (0.244)	-0.356 (0.281)	-0.103 (0.256)	-0.412 (0.261)
Muslim	-0.0200 (0.0202)	-0.200 (0.202)	0.168 (0.328)	-0.199 (0.254)	0.0399 (0.332)	0.174 (0.228)
Traditional	-0.0451 (0.0277)	-0.451 (0.277)	0.509 (0.419)	0.253 (0.325)	-0.0361 (0.417)	-0.210 (0.291)
Household size	-0.00259 (0.00284)	-0.0259 (0.0284)	-0.0696 (0.0423)	-0.0122 (0.0385)	0.0301 (0.0442)	-0.00900 (0.0340)
Children under 5	-0.0118 (0.0125)	-0.118 (0.125)	0.340** (0.164)	0.201 (0.147)	-0.0327 (0.130)	-0.0827 (0.171)
Land size	-0.00154 (0.00134)	-0.0154 (0.0134)	-0.0118 (0.0182)	-0.0148 (0.0181)	-0.00762 (0.0177)	0.0506*** (0.0162)
Plot distance	0.000767** (0.000345)	0.00767** (0.00345)	0.00480 (0.00478)	0.00735 (0.00662)	0.0148*** (0.00502)	0.00250 (0.00748)
TLU	0.000844 (0.00209)	0.00844 (0.0209)	-0.0294 (0.0181)	-0.0194 (0.0178)	-0.0238 (0.0203)	0.0544** (0.0273)
Irrigation at base	0.0109 (0.0243)	0.109 (0.243)	0.0913 (0.235)	0.0696 (0.248)	-0.345 (0.273)	-0.283 (0.352)
Water source	-0.0183 (0.0247)	-0.183 (0.247)	-0.455* (0.254)	0.0171 (0.333)	-0.144 (0.337)	0.289 (0.309)
Climate shock	-0.0241 (0.0167)	-0.241 (0.167)	0.193 (0.225)	-0.0808 (0.231)	-0.121 (0.197)	0.118 (0.207)
Idiosyncratic shock	0.0517*** (0.0171)	0.517*** (0.171)	-0.271 (0.248)	0.0359 (0.269)	-0.205 (0.207)	-0.0804 (0.252)
Constant	0.691***	6.908***	-0.832	0.710	-0.178	1.433

	(0.0502)	(0.502)	(0.728)	(0.821)	(0.598)	(0.875)
Observations	502	502	502	502	502	502
R-squared	0.098	0.098				

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: Village dummies included

Table A.4.2: First Difference Results, Alternative Controls, continued

	Control 2					
	A-WEAI score	No. of adequacies	Production decisions	Ownership of assets	Income decisions	Work balance
Treat	-0.0372 (0.0492)	-0.372 (0.492)	0.681** (0.347)	1.081 (1.129)	-0.692** (0.319)	-1.085*** (0.415)
Age	0.000668 (0.000920)	0.00668 (0.00920)	0.0455*** (0.0159)	0.00694 (0.0127)	0.0142 (0.0108)	0.0221* (0.0117)
Schooling	0.0326 (0.0286)	0.326 (0.286)	0.233 (0.465)	-0.395 (0.273)	-0.135 (0.398)	-0.113 (0.385)
Cowives	-0.0102 (0.0205)	-0.102 (0.205)	0.216 (0.295)	-0.351 (0.307)	-0.182 (0.253)	-0.430 (0.285)
Muslim	-0.0322 (0.0218)	-0.322 (0.218)	-0.145 (0.351)	-0.385 (0.356)	-0.176 (0.359)	-0.0176 (0.299)
Traditional	-0.0434 (0.0330)	-0.434 (0.330)	0.359 (0.452)	0.319 (0.558)	-0.330 (0.464)	-0.256 (0.423)
Household size	-0.00217 (0.00330)	-0.0217 (0.0330)	-0.0935 (0.0582)	0.0100 (0.0441)	0.0298 (0.0610)	-0.0504 (0.0374)
Children under 5	-0.00737 (0.0148)	-0.0737 (0.148)	0.489** (0.227)	0.181 (0.185)	-0.0854 (0.177)	-0.0416 (0.169)
Land size	-0.00262* (0.00149)	-0.0262* (0.0149)	-0.0307 (0.0200)	-0.0339* (0.0188)	-0.0122 (0.0213)	-0.0492*** (0.0165)
Plot distance	0.00105* (0.000566)	0.0105* (0.00566)	0.000887 (0.00489)	0.00586 (0.0111)	0.0154*** (0.00496)	0.00992 (0.0137)
TLU	0.00320 (0.00251)	0.0320 (0.0251)	0.00142 (0.0243)	-0.000975 (0.0307)	0.00573 (0.0231)	0.0522 (0.0331)
Irrigation at base	-0.00394 (0.0329)	-0.0394 (0.329)	0.0203 (0.311)	0.272 (0.366)	-0.330 (0.349)	-0.492 (0.478)
Water source	-0.0307 (0.0286)	-0.307 (0.286)	-0.603* (0.332)	-0.540 (0.410)	-0.289 (0.429)	0.165 (0.345)

Climate shock	-0.0538** (0.0205)	-0.538** (0.205)	-0.0479 (0.261)	-0.379 (0.275)	-0.462* (0.239)	0.152 (0.200)
Idiosyncratic shock	0.0555*** (0.0149)	0.555*** (0.149)	-0.271 (0.253)	-0.120 (0.346)	-0.166 (0.244)	-0.146 (0.367)
Constant	0.680*** (0.0644)	6.800*** (0.644)	-0.489 (0.759)	0.989 (0.979)	0.279 (0.639)	2.159* (1.175)
Observations	356	356	356	356	356	356
R-squared	0.140	0.140				

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: Village dummies included

Table A.4.3: First Difference, Spillover Effects

	A-WEAI score	No. of adequacies	Production decisions	Ownership of assets	Income decisions	Work balance
Spillover	-0.0576 (0.0520)	-0.576 (0.520)	0.785 (0.737)	-1.236** (0.607)	-0.110 (0.642)	-0.300 (0.767)
Intensity of treatment	-0.0111 (0.00852)	-0.111 (0.0852)	-0.101 (0.101)	0.0274 (0.101)	-0.0384 (0.0981)	-0.0189 (0.113)
Age	-5.10e-06 (0.000854)	-5.10e-05 (0.00854)	0.0273** (0.0126)	0.0114 (0.0122)	0.0118 (0.0113)	0.0325** (0.0128)
Schooling	0.0459 (0.0328)	0.459 (0.328)	-0.293 (0.446)	-0.259 (0.470)	-0.265 (0.437)	0.326 (0.477)
Cowives	-0.00659 (0.0215)	-0.0659 (0.215)	0.299 (0.296)	-0.245 (0.295)	0.00434 (0.263)	-0.365 (0.307)
Muslim	-0.0204 (0.0258)	-0.204 (0.258)	0.457 (0.331)	-0.0925 (0.322)	0.147 (0.309)	0.294 (0.351)
Traditional	-0.0578* (0.0325)	-0.578* (0.325)	0.418 (0.442)	0.351 (0.450)	-0.224 (0.374)	-0.369 (0.486)
Household size	-0.00265 (0.00351)	-0.0265 (0.0351)	-0.0605 (0.0478)	-0.0101 (0.0450)	0.0291 (0.0457)	0.0235 (0.0568)
Children under 5	-0.0161 (0.0150)	-0.161 (0.150)	0.226 (0.200)	0.210 (0.191)	0.0161 (0.195)	-0.174 (0.190)
Land size	-0.00377**	-0.0377**	-0.0106	-0.0165	-0.0312	-0.0489**

	(0.00177)	(0.0177)	(0.0183)	(0.0194)	(0.0193)	(0.0198)
Plot distance	0.000763*	0.00763*	0.00441	0.00719	0.0146**	-0.00300
	(0.000438)	(0.00438)	(0.00594)	(0.00591)	(0.00610)	(0.00645)
TLU	0.00160	0.0160	-0.0438*	-0.0251	-0.0314	0.0632**
	(0.00324)	(0.0324)	(0.0237)	(0.0253)	(0.0245)	(0.0315)
Irrigation at base	0.0100	0.100	-0.00134	0.137	-0.263	-0.575*
	(0.0233)	(0.233)	(0.303)	(0.293)	(0.280)	(0.335)
Water source	-0.00315	-0.0315	-0.244	0.169	0.182	0.912**
	(0.0262)	(0.262)	(0.361)	(0.405)	(0.342)	(0.398)
Climate shock	-0.0150	-0.150	0.160	-0.129	-0.0456	-0.168
	(0.0201)	(0.201)	(0.272)	(0.280)	(0.244)	(0.284)
Idiosyncratic shock	0.0493**	0.493**	-0.401	-0.240	-0.197	-0.247
	(0.0198)	(0.198)	(0.281)	(0.282)	(0.257)	(0.294)
Constant	0.729***	7.292***	0.0465	0.492	0.241	1.364
	(0.0648)	(0.648)	(0.848)	(0.869)	(0.834)	(0.995)
Observations	378	378	378	378	378	378
R-squared	0.113	0.113				

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: Village dummies included

**5. MAKING CLIMATE CHANGE
ADAPTATION PROGRAMMES IN SUB-
SAHARAN AFRICA MORE GENDER
RESPONSIVE: INSIGHTS FROM
IMPLEMENTING ORGANIZATIONS ON
THE BARRIERS AND OPPORTUNITIES**

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ABSTRACT

Research shows that paying attention to gender matters not only for the equity of climate change adaptation programs but also for their efficiency and effectiveness. Many organizations working to increase resilience to climate change with local communities also recognize the

importance of gender, yet the degree to which gender is actually integrated in climate change projects is unclear. This study examines the extent to which organizations involved in climate change and resilience work in Sub-Saharan Africa are integrating research on gender and climate change and incorporating gender-sensitive approaches into their programs using data collected through a Knowledge, Attitudes and Practices (KAP) survey and Key Informant Interviews (KII) targeted at government agencies, local and international NGOs, and other practitioners. The results show that although organizations have access to research on climate change from various sources, more is needed to identify entry points for gender integration into climate change adaptation programs across a range of local contexts. Lack of staff capacity on gender, lack of funding to support gender integration and socio-cultural constraints were identified as key barriers to gender integration by many respondents, particularly from government agencies. Enabling organizations to pay greater attention to the gender dimensions of their programs is possible through greater collaboration across different types of organizations in order to share knowledge and best practices and strengthen the integration of research into adaptation programs.

5.1 Introduction

According to scientific forecasts, sub-Saharan Africa is likely to suffer harsh negative impacts from climate change because of its dependence on rainfed agriculture for food, income, and employment (World Bank 2013, xviii). Wide ranging studies on the impacts of climate change provide strong evidence of negative impacts on crop yields (for example, Nelson et al. 2014) and livelihood outcomes for people in the region (IPCC 2014, 1). Minimizing the negative impacts of climate change on poor smallholder farmers in Sub-Saharan Africa will require sustained efforts to adapt to changing climate conditions, including actions taken by farmers themselves.

The literature on intra-household relations and resource allocation provides strong evidence that men and women have different preferences, responsibilities, access to and control over resources, and decision-making authority and that women are often at a disadvantage (Peterman et al. 2014, Quisumbing 2003, Udry 1996). . A growing number of studies have begun to explore the implications of this gender gap in the context of climate change. Evidence is accumulating which shows significant gender differences in perceptions and impacts of climate change, adaptive capacity, and priorities, needs, and preferences for adaptation (Twyman et al 2014, Bernier et al. 2015).

Research shows that climate change and climate shocks affect men and women differently (Goh 2012). In particular, climate change has implications for gender-differentiated asset dynamics (Quisumbing et al. 2011; Rakib and Matz 2016; Kristjanson et al. 2010). The impact of climate and other shocks on men's and women's assets depends greatly on the socio-cultural context in which these shocks occur (i.e. social norms and gender roles), as well as the type of shock experienced. For example, in Uganda, women's non-land assets declined as a result of climate shocks, whereas in Bangladesh they were unaffected (Quisumbing et al. 2011). In Niger, men were more likely to sell their assets in response to climate shocks given a cultural norm that men are responsible for ensuring the food security of the household (Kristjanson et al. 2010). Other studies suggest there are gender-differentiated impacts of climate change in terms of men's and women's time use. In particular, women's workloads may increase following male out migration in search of off farm sources of income (Djoudi and Brockhaus 2011; Nelson and Stathers 2009).

Growing evidence also shows that women are more constrained in responding to climate change and climate shocks. In part, this is due to the fact that men and women perceive climate change and climate shocks differently, with women often less likely to perceive the impacts of climate change (Twyman et al. 2014; Oloukoi et al. 2014; Mason and Agan 2015). Given that adaptation responses

largely depend on individuals' perceptions of climate change, differences in men's and women's perceptions can have profound effects on whether or not they adapt and, if so, which strategies they choose. Differences in perceptions and responses also relate to the fact that, women are less likely to have access to climate information as well as information about options for responding to climate change (Beauman and Dillon 2014; Bernier et al. 2015; Jost et al. 2015; Katungi, Edmeades, and Smale 2008; Tall et al. 2014; Chaudhury et al. 2012). As a result, women tend to be less aware of options for responding to climate change (Bernier et al. 2015). However, when women are aware of climate-smart practices, they are just as likely as men to adopt those practices (Bernier et al. 2015; Mittal 2016).

Other factors, such as insecure land tenure and social norms, often prohibit women from adopting certain practices that would increase their resilience to climate change. For example, women often have less mobility, which limits their ability to seek off-farm sources of income (Djoudi and Brockhaus 2011; Jost et al. 2015; Naab and Koranteng 2012). Gender differences in resources for adaptation, including assets, inputs, decision-making authority, also constrain women's responses to climate challenges and influence the degree to which women benefit from changes at the household level, such as the adoption of new agricultural technologies (Perez et al. 2014; Deere & Doss, 2006; Doss

& Morris, 2001; Peterman, Behrman, & Quisumbing, 2014; Peterman et al. 2011). This is because women have different preferences and needs for adaptation responses given their gender roles within the household that are often not taken into consideration when technologies are designed or implemented by households (Twyman et al. 2014; Beuchelt and Badstue 2013).

Climate change adaptation programs, therefore, must be mindful of examining gender differences in the level of vulnerability, and the capacity to adapt, as well as the gender implications of new technologies or practices being introduced (Brody et al. 2008, 11). In order to adequately address climate change, it is imperative that the gender-specific barriers to adaptation be addressed in the interest of both gender equality and adaptation efficiency and effectiveness (Terry 2009, 5). However, men and women interact with development agencies differently, with women less likely to be engaged with external agencies working to build adaptive capacity in rural communities (Cramer et al. 2016). At the same time these agencies may be less responsive to the needs and preferences of women (ibid). Ensuring that adaptation programs are gender responsive will require implementing agencies to meaningfully engage women in the design, implementation, and monitoring and evaluation phases of their programming (Ragasa et al. 2013; Beuchelt and Badstue 2013). However, even the most gender-responsive and gender-transformative

projects face considerable challenges in reaching and empowering women (Johnson et al. 2016).

Achieving women's empowerment is difficult, in part, due to the fact that the specific barriers to women's participation in adaptation to climate change are very context specific and there are no one-size-fits-all solutions to increasing women's adaptive capacity (Gonda 2016). Even within the same communities there are important differences between different groups of women, which influence their adaptive capacity (Fischer and Carr 2015). Organizations working to increase the adaptive capacity of rural communities in developing countries, therefore, must first assess gender roles and the specific barriers faced by men and women, including across different groups of men and women (e.g. based on age, marital status, ethnicity, etc.). This is why gender-disaggregated research and tools are critical to support the implementation of gender-responsive climate change adaptation programs.

Yet critical research, data, and capacity gaps remain, which hinder the integration of gender in these programs. At the same time, women's voices are often missing from policy decisions and in leadership roles within implementing organizations which further prevents women's needs from being address through policies and programs (Huyer et al. 2015; Vermeulen 2015). This article examines the extent to which climate change

adaptation programs carried out by various NGOs, government agencies, and others in sub-Saharan Africa are gender-sensitive and the extent to which research can support implementation of more gender-responsive programs. This study approaches this issue by assessing the knowledge, attitudes, and practices (KAP) of organizations implementing climate change adaptation programs through a stakeholder survey and follow-up key informant interviews (KIIs) with selected survey respondents. This assessment highlights the research and capacity gaps identified by these organizations and suggests ways in which stronger partnerships between research organizations and implementing agencies can facilitate the integration of gender into adaptation programs and increase adaptive capacity and gender equity on the ground.

5.2 Approach and Methods

This study uses a knowledge, attitudes, and practices (KAP) approach to assess the knowledge, capacity, perceptions, and activities of individual members of organizations promoting climate change adaptation in sub-Saharan Africa. Originally, this approach was developed to assess how community knowledge and attitudes influenced health behaviour in order to identify entry points for health programs to influence behaviour change (Launiala 2009). This method has since been applied to other fields including recently to assess

organizational and institutional attitudes regarding climate change adaptation and risk management (Ragasa et al. 2013). This study uses a similar approach to Ragasa et al. (2013) to assess the organizational barriers to integrating gender into climate change adaptation policy and programming with the aim of identifying entry points to facilitate better gender integration. Ragasa et al. (2013) assess the general effectiveness of organizations working on climate change adaptation and find that representatives of organizations working on climate change projects believe that greater attention should be paid to gender, social, political, and cultural issues in their design and implementation. This study also highlighted the need for capacity strengthening to improve impact assessment and monitoring and evaluation (M&E) within these organizations. The current study, therefore, aims to identify the ways in which research can be used to strengthen the capacity of organizations to promote adaptation with gender equity.

This tool was carefully developed drawing on the literature on gender and climate change, as well as a review of the programmatic approaches of development organizations that have considerable experience integrating gender into their projects. Best practices for implementing gender-sensitive climate change adaptation programs were identified based on a review of strategy

documents of 7 large international NGOs⁴, which were selected due to their focus on climate change adaptation and/or resilience work in sub-Saharan Africa and their attention to gender. These best practices as well as a review of the literature on gender and climate change were used to guide the development of a Knowledge, Attitudes and Practices (KAP) survey. The survey was targeted to representatives of local and international NGOs, government agencies, and other stakeholders implementing climate change adaptations strategies on the ground in SSA and was disseminated electronically through networks of gender and climate change practitioners and researchers operating in developing country contexts. We followed up the KAP survey with key informant interviews (KIIs) with a selected set of KAP survey respondents.

The survey consisted of 30 questions divided into five sections. The first section solicited basic information about the respondent and their organization, while the second section inquired about access to and integration of various types of information on gender and climate change and the main sources of information. The third

4 The NGOs selected for this assessment include CARE International, Catholic Relief Services (CRS), Oxfam International, GROOTS International, Concern International, Land O' Lakes International Development, Mercy Corps, and Oxfam International with a special focus on the first three due to their larger body of available documentation.

section covered attitudes towards the importance of integrating gender into various stages of the project cycle. The fourth section solicited responses on the extent to which organizations engage in research, the uses of research in project implementation, and constraints to implementing gender-sensitive adaptation programs. Another section of the survey, the findings of which are not discussed in this article, covered the extent to which organizations engage in policy and advocacy activities.

The final sample size of 76 included representatives of government agencies, national agricultural research institutes, national and international NGOs, universities and private sector partners.. Nineteen respondents were identified for follow up Key Informant Interviews (KIIs) and 10 interviews were ultimately completed. KII respondents were selected based on an expressed willingness to participate in a follow-up interview and to have representation across the different organization types. A protocol for the KIIs was developed to guide conversations with the respondents.

5.3 Results from the KAP Survey and KIIs

The KAP survey results are presented below by organization type and insights from the KIIs are added where relevant.

5.3.1 Background of the Respondents

The questionnaire was aimed at representatives of government agencies and local and international NGOs, however, received number of responses were received from representatives of national research institutes in SSA and international research organizations/universities, as well as a handful of donor organizations, and private consultancies. All of these organizations are considered to be key boundary partners for research institutes, such as those in the CGIAR system, in order to bridge the gap between researchers and farmers (CGIAR 2016). Representatives of national research institutes were grouped together with representatives of government agencies given that many respondents from national research institutes categorized themselves as being from a government entity. A new category was created for researchers from international research organizations (e.g. CGIAR centres) and European, US, and South Asian research centres or universities working in sub-Saharan Africa. In total the sample includes 19 respondents from East Africa, 19 from West Africa, 11 from Southern Africa, and 29 respondents based outside the region. In terms of the gender breakdown of respondents, 42 percent were women and 58 percent were men. The breakdown of organization types and the number and share of respondents in each category are shown in Table 5.1. This paper focuses on the responses of government agencies, and local and international NGOs given their sustained

and essential role in implementing climate change adaptation projects on the ground.

Table 5.1: Breakdown of Survey Respondents by Organization Type

Organization type	Freq.	Percent
Government ministries/national research organizations	13	16.3
Local NGOs	17	21.3
International NGOs	23	28.8
International research organizations/universities	11	13.8
Donor organizations	9	11.3
Private company/consultancy	7	8.8

Source: Authors, KAP Survey 2015

The KII participants ranged from executive directors of local NGOs to researchers and project managers in national research and extension service organizations. Of the 10 KII participants, 3 work for local NGOs, 3 work for national research and extension service organizations, 1 for an international NGO, and 1 is a researcher at a local university. KII respondents work in different program areas including crop production, livestock, fisheries, forestry, natural resource management, food security, livelihoods, gender research, and health and nutrition. Of the 10 KII participants, 3 were female and 7 were male. KII respondents came from a range of countries across

East, West and Southern Africa, namely Burkina Faso, Cameroon, Kenya, Mali, South Sudan, Uganda, Zambia, and Zimbabwe.

5.3.2 Knowledge

The Knowledge module in the KAP survey aimed to capture access to and preferences for information, and knowledge integration into adaptation programs and projects on the ground. In general, respondents reported average access to different types of information critical to gender-sensitive climate change adaptation programming, with average scores between 2.7 and 3.5 on a scale from 1 to 5 with 1 being no access and 5 being complete access (Figure 5.1). With respect to different types of information, on average, organizations reported having somewhat greater access to research findings on climate change as it relates to gender, evidence on projected climate change impacts and adaptation responses, and guidelines for integrating a gender perspective into climate change adaptation projects. They reported somewhat less access, on average, to gender-disaggregated data (particularly related to gender and climate change) and tools and resources for gender-responsive climate change adaptation approaches.

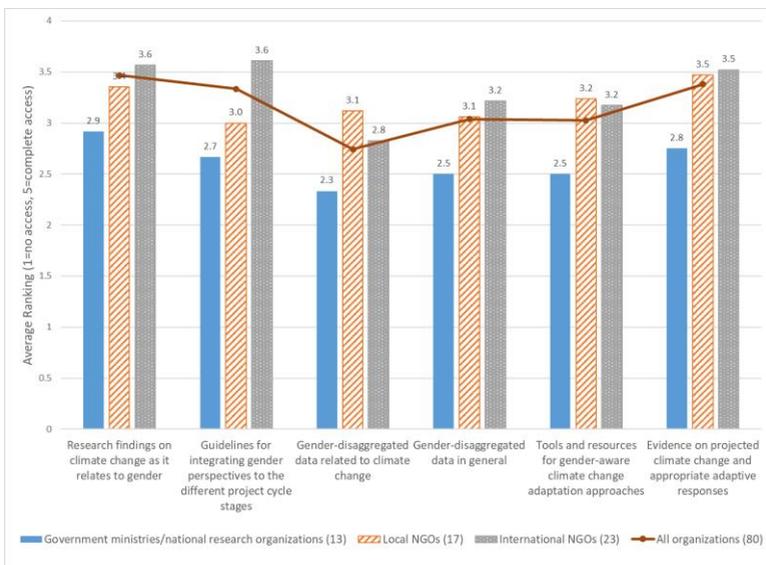


Figure 5.1: Access to Information on Gender and Climate Change (1=no access, 5=complete access)

Source: Authors, KAP Survey 2015

As Figure 5.1 shows, government agencies tend to have lower access to information, compared to local and international NGOs. International NGOs reported having greater access to guidelines for integrating gender into their programming.

Local and international NGOs and donor organizations also reported having slightly better access to sex-disaggregated data, in general, and on climate change, in particular, compared to government ministries/national

research organizations. NGOs may regularly collect sex-disaggregated data during scoping and monitoring to inform their programming. Local and international NGOs were also more likely to report having access to tools and resources for gender-aware climate change adaptation approaches.

Several KII respondents also reported that they were able to find information on climate change as it relates to gender on the Internet. However, several also noted a lack of local, context-specific gender-disaggregated data and research as an obstacle to gender-sensitive climate change adaptation programming. As one respondent from a government-supported research organization mentioned that food and nutrition issues are very different in different regions of the same country. Another respondent from Zimbabwe indicated that community-based applied research would allow practitioners to tailor adaptation programs to the day-to-day problems that a community faces.

KII participants also mentioned a lack of information-sharing between international NGOs, local NGOs, and government entities, which limits the dissemination of context-specific research and case studies that could help local NGOs and implementers to better tailor their activities and interventions. One respondent from a local NGO mentioned that NGOs often engage in interventions and then report to donors and beneficiaries, yet rarely

share findings with other grassroots, community, or local organizations. Another issue mentioned by several KII participants is that sex-disaggregated data was generally not collected until recently. This lack of baseline data makes it difficult to look at outcomes for both women and men as a result of climate change adaptation programs.

Although KII respondents indicated that their projects are moving toward including gender dimensions in their research, this trend is still in the beginning stages and is not always extended to monitoring and evaluation because of inadequate funding. According to KII respondents, lack of funding also causes delays in integrating a gender perspective into climate change adaptation programs and limits the acquisition of physical assets that are required to generate research. In addition to a lack of funding, KII respondents added that program staff and data collectors have a limited understanding of gender issues and the research tools and methods for rigorous M&E.

Survey respondents also reported whether they had access to various information sources, including conferences, peer-reviewed publications, working papers, policy briefs, websites, own data, and internal reports, and their preferences for these sources of information.⁵ The results

⁵ While respondents were asked to rank their top 3 preferred sources of information in order of preference, many respondents listed more than one source of information as “most preferred.”

show that the respondents have access to multiple sources of information, all of which provide different types of information that is relevant for their work. However, some organization types had clear preferences for particular information types. Local NGOs tend to prefer conferences as a source of information; international NGOs prefer websites; national and international research organizations strongly prefer peer-reviewed publications; while donor organizations prefer conferences and policy briefs.

KII respondents who work for local NGOs expressed that the type of information that is most useful to them is information that is practical and evidence-based. They are looking for success stories and best practices to implement, and assistance on scaling-up and out these solutions while tailoring them to the local contexts. Several respondents reported that conferences provide them with this type of information. Participants working with national research organizations and government agencies cited the need for more context-specific research that would help them design appropriate national policies. Peer-reviewed publications of policies or programs that have been successful provide examples on which national policies could be based.

5.3.3 Attitudes

This section aims to capture respondents' perceptions of the importance of integrating a gender perspective into various phases of the project cycle (design and planning, targeting, implementation, and monitoring and evaluation), as well as their perceptions of how effective their organizations are at integrating a gender perspective in actual practice. Respondents were asked how important are different gender considerations during the various stages of the project cycle. The specific gender considerations which respondents were asked to reflect on are shown in the KAP survey questionnaire in the appendix.

Based on these responses we calculated the gap between perceived importance and actual practice with respect to these key gender considerations during the various stages of the project cycle as defined in the questionnaire. A larger gap indicates that the organizations are less effective at integrating gender considerations into projects. However, it also may be an indication that the organizations have high standards for gender integration (as measured by the perceived importance). Detailed results by organization type are presented below for each stage of the project cycle.

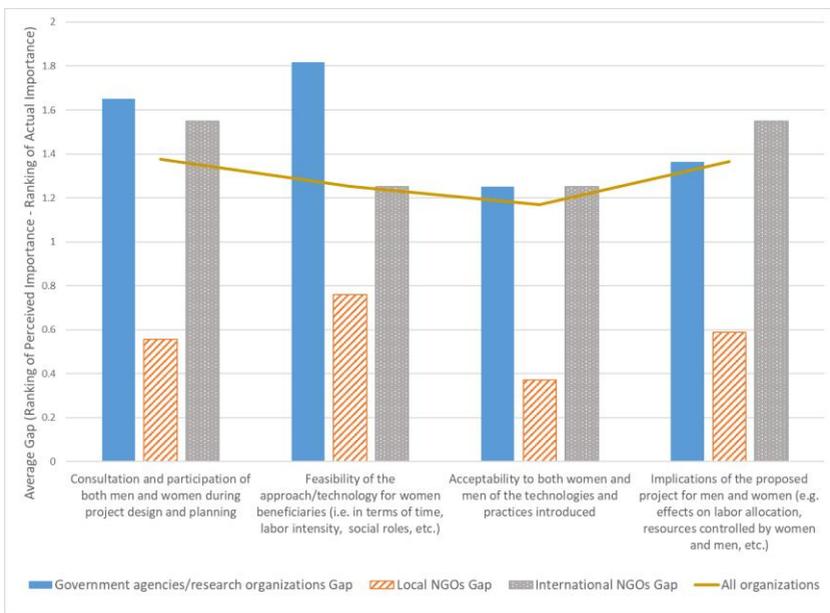


Figure 5.2: Gap between perceived importance of gender considerations and actual practice during project design and planning

Source: Authors, KAP Survey 2015

The perceived importance of gender was high across all organization types and all stages of the project cycle. Average scores were between 3.9 and 4.4 across all organization types. Thus, the gaps described below relate more to the perceived shortcomings in actual practices within the various organizations represented. The results show that while there is greater than a 1-point gap across all 4 gender considerations, the gap between perceived importance and actual practice is highest during project

design and planning. That is, the responses indicated that while gender is considered important during project design and planning, organizations are not taking gender into account to the fullest extent during actual practice. Local NGOs have the lowest gap between perceived importance and actual practice across all 4 gender considerations, which suggests that these organizations are effective at integrating gender into the design of their programs, including consulting men and women during project design, assessing the feasibility and acceptability of technologies and practices by both men and women, and considering the implications of the proposed project for men and women (Figure 5.2). International NGOs also have smaller than average gaps for several gender considerations including considering the feasibility and acceptability of the technology for men and women.

In terms of targeting, there appears to be less of a gap between perceived importance of gender and actual consideration of gender, although there is still room for improvement (Figure 5.3). Local and international NGOs appear to do a better job at using gender as a category to select program beneficiaries, while government agencies/national research organizations have the largest gap in terms of gender-sensitive targeting. Government agencies/research institutes appear to be more effective at targeting based on a number of social vulnerabilities such as class, age, and ethnicity compared to directly targeting based on gender. However, across all organization types,

the gap is larger with respect to considering the intersectionality of gender with other social categories, particularly for international research organizations.

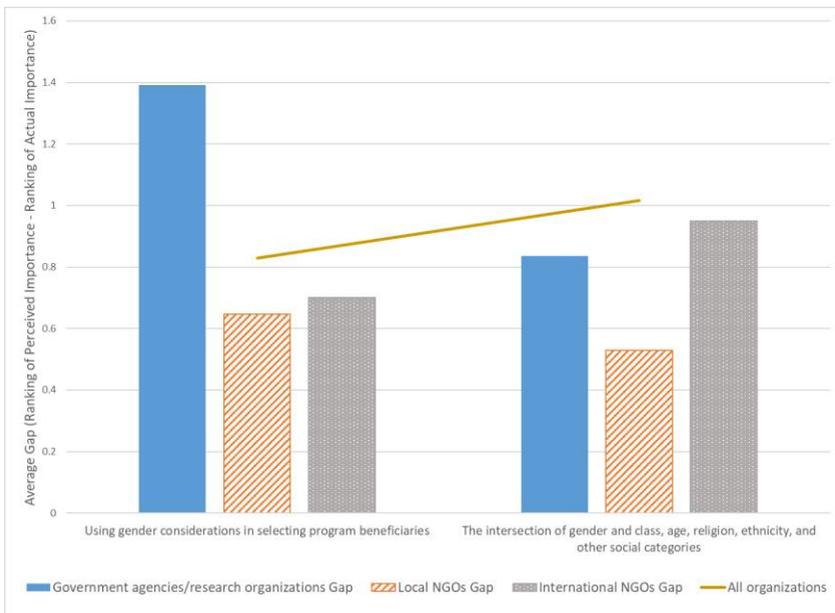


Figure 5.3: Gap between perceived importance of gender considerations and actual practice during targeting

Source: Authors, KAP Survey 2015

When it comes to the integration of gender during project implementation, there is less of a gap in terms of having male and female project staff and a larger gap in terms of conducting training on gender-sensitive programming and taking steps to eliminate gender-specific barriers to program participation (Figure 5.4). Again local NGOs

have the lowest gap, while there is significant room to improve gender-sensitive implementation of programs within government agencies.

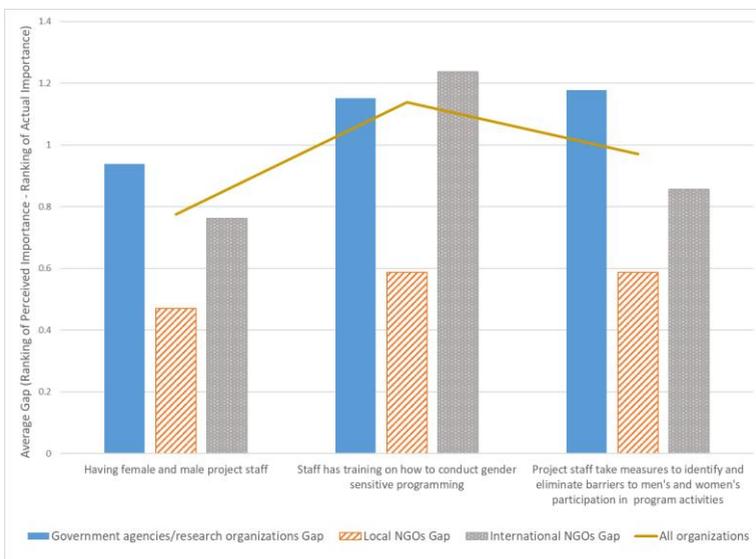


Figure 5.4: Gap between perceived importance of gender considerations and actual practice during implementation

Source: Authors, KAP Survey 2015

In terms of monitoring and evaluation (M&E), most organizations tend to do better at tracking men’s and women’s participation in program activities and less well when it comes to monitoring gender differences in adoption of technologies and practices and monitoring gender differences in the costs and benefits of program participation (Figure 5.5). There is also room for

improvement in collecting gender-disaggregated data and performing gender-disaggregated impact assessments (average gap: 0.8), particularly among government agencies/research organizations and international NGOs to some extent. Again local NGOs appear to have the lowest gap between perceived importance of gender and actual practice across all gender considerations during M&E.

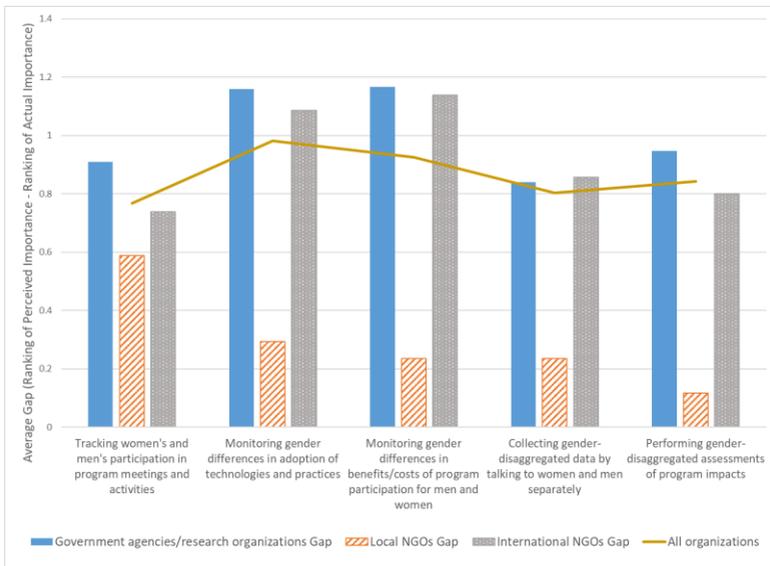


Figure 5.5: Gap between perceived importance of gender considerations and actual practice during monitoring and evaluation

Source: Authors, KAP Survey 2015

KII respondents confirmed that there is indeed a gap between the perceived importance of gender and the

actual implementation of gender-responsive programs. Female KII participants that work for local NGOs stated that retro-fitting gender into existing programs is common, that gender components are treated casually, and that gender dimensions are often neglected as a result of male bias. Another respondent stated that the lack of consideration for the preferences of the end-user of a technology during the design and planning stage affects the adoption of that technology. A respondent from a local NGO made a related argument; however, it is not just women, but local community members that need to be more engaged in the research process because they understand the local contexts better and are in a better position to apply and disseminate the findings. Another respondent from a government organization mentioned that national policies focus more on climate-smart agriculture or adaptation, but not specifically on gender as a result of funding shortages.

Several of the KII respondents mentioned that one of the largest obstacles to integrating gender dimensions throughout the project cycle is that the term “gender” is taken to mean women only, and it may be directly confrontational to cultural norms that limit women’s participation. All of the respondents who cited the misinterpretation of the term gender as a challenge to gender integration also mentioned that programs that try to achieve transformational change on gender roles need to garner community support for the project before they

try to address gender inequalities. In this sense, they recommend that the community be fully engaged and involved in designing the project, and once there is a consensus on what is to be done, programs must work with men and women separately to raise awareness on gender inequalities. As far as targeting, many of the KII respondents mentioned that project beneficiaries, in many cases, happen to be majority female as a result of gender roles that ascribe small-scale farming and other agricultural activities to women as well as to male migration and not explicitly as a result of targeting.

The majority of KII respondents stated that lack of capacity of project staff on gender-sensitive programming is a challenge to implementation. In particular, they expressed a desire for training on why gender matters as well as “training of trainers” to raise awareness on gender issues in local communities. Staff had limited training in gender sensitivity and therefore did not fully understand the importance and need for including gender dimensions in programming. Respondents felt that capacity building in gender-sensitivity needed to be extended to stakeholders from the community level such as chiefs and community leaders, to legislators at the national level, as well as to beneficiaries. KII respondents also indicated that developing culturally-sensitive training material on gender and climate change adaptation in the languages of the beneficiaries would be of great use for increasing awareness on both issues. Another constraint highlighted

by KII respondents is that the number of women in decision-making roles in all of the different organization types is still limited.

KII respondents confirm that M&E efforts are adept at tracking participation of men and women, but less adept at tracking and monitoring gender differences in the adoption of technologies and in costs and benefits of the program participation. Lack of funding specifically designated for M&E, lack of adequate indicators for adaptation M&E, and the focus on quantitative data are cited as challenges to M&E. While most KII respondents stated that their organizations carry out at least a midterm and a final evaluation, they expressed that, in many cases, these evaluations were insufficient to fully evaluate project impact. In addition, many stated that funding shortages at the end of the project cycle or poor planning from the beginning meant having to sacrifice on the quality and extent of M&E that could be carried out. Moreover, the lack of adequate gender-sensitive indicators to measure adaptive capacity and resilience make it difficult to evaluate impact. In particular, respondents mentioned that indicators are often not tailored to measure the differences in needs between men and women, not relevant to the local context, and not linked to other climate and gender-sensitive program areas. One KII respondent gave the example of a livestock program that uses the number of livestock held as an indicator of adaptation to climate change. If this program

does not collect gender disaggregated data, it may miss nuances in terms of how men and women are adapting to climate change, such as what type of animals men and women prefer, herd size preferences of men and women, whether men's or women's livestock holdings are more resilient to climate shocks, and what men and women do differently with any income generated from livestock activities.

Another issue raised by KII respondents regarding M&E is that politicians are using favourable quantitative indicators as proof of development without analysing the qualitative impacts of the program. In addition, a KII respondent from Zambia stated that changes in government changes and turnover make it difficult to follow-through on program implementation, let alone M&E.

The generally higher performance of local NGOs compared to international NGOs and international research organizations with respect to integrating gender considerations into various stages of the project cycle is somewhat surprising, given that international organizations tend to have more resources to develop strategies for gender integration and to monitor progress on the ground. Given that international NGOs may have more gender advisors and specialized staff—these organizations are perhaps more likely to judge their performance against international best practices.

Another explanation for this is that local NGOs are more understanding of the local context and better able to adapt and introduce their programs accordingly. As several KII respondents suggested, local NGOs face a complicated reality on the ground, and therefore need to deal with gender and other social, cultural, and community dynamics, even if gender is not the focus of their work. They emphasized that the way in which projects are introduced to communities (and beneficiaries) is important. In particular, they stressed that the way in which the gender components of a project are introduced to potential project beneficiaries affects their acceptance, buy-in, and engagement with the project. All of the KII respondents agreed that the key to community buy-in of gender-sensitive projects is to involve the community first and then work on raising awareness of gender inequalities and the ways in which they affect adaptive capacity and other cross-cutting areas such as education, health, nutrition, income generation, and others. The respondents further elaborated that successful projects tend to highlight community benefits over individual (gender-specific) benefits, given that this approach is not directly confrontational to cultural traditions and norms.

KII respondents mentioned that projects that start by emphasizing women's benefits and empowerment have not been well received, while projects with the same gender components that have been presented as community-based projects have been accepted by the

community. A KII respondent from Cameroon shared an experience that backs the community first-gender second approach. His project aimed at training young women in CSA practices and singled out women from the onset of project activities, but was met with community resistance. Once he changed his approach and sought out the approval of the community leaders by explaining how the program would benefit the entire community, he received support from the community and the project was successfully implemented.

5.3.4 Practices

This section looks at the practices that the organizations reported engaging in—both current and desired. In particular, we look at the uses of research in these organizations. The objective of this set of questions is to understand current and desired practices for the collection and use of research. This section also included questions aimed at understanding the constraints to implementing gender-sensitive climate change adaptation programs and the specific capacity needs to improve gender integration.

Overall, the findings show that most organizations are already engaged in conducting research for various purposes but the majority of respondents suggested that more research should be carried out, in particular to improve ongoing projects, inform future project design and influence policy. In terms of the types of research

organizations are engaged in, the KAP survey results showed that the highest percentage of organizations tend to conduct impact evaluations. However, it is important to note that the ways in which different organizations define impact evaluation is likely to be dramatically different. Research organizations are more likely to design and conduct more rigorous impact assessments with experimental or quasi-experimental design (e.g. identification of a control group and random assignment of program beneficiaries) while other organizations may be satisfied with outcome monitoring or discussions with beneficiaries as a measure of impact. Government respondents reported high rates of both qualitative and quantitative scoping and background research, as well as monitoring and evaluation research.

The majority of organizations also engage in scoping research (qualitative and quantitative) and monitoring research. Process evaluation research, which assesses the degree to which programs are implemented as planned and the extent to which benefits reach the participants, is the type of research activity that participating organizations are least likely to undertake (although a majority still engage in this type of research). Process evaluations is important to understand why an implementation has or has not been successful in integrating gender considerations. Specifically, process evaluations would assess the degree to which implementers have adhered to the gender-sensitive

components that were set forth from project design as well as the degree to which program activities have been tailored to guarantee quality results that match the cultural, developmental, and gender characteristics of the beneficiaries.

In terms of how research is usually used by participating organizations, the KAP survey results show that research is used equally for making improvements to projects and for writing papers and reports and less likely to be used by participating organizations for presenting at conferences or reporting to donors. Local NGOs are most likely to use research to make improvements to ongoing projects, as well as for advocacy campaigns and presenting at conferences. Government agencies and national research institutes reported using research for writing papers and reports, followed by making improvements to projects and informing policy. For international NGOs, the most common use of research is to report to donors followed by informing future project design and making improvements to ongoing projects.

The KII participants confirmed the KAP survey results regarding the most prevalent types and uses of research. However, KII respondents also criticized the overemphasis on quantitative rather than qualitative research work to improve project design and inform advocacy campaigns. They mentioned that the lack of context-specific qualitative research limits the extent to

which they can carry out relevant monitoring and evaluation of gender-sensitive adaptation projects. Furthermore, one respondent from an international NGO further stressed the need for structured qualitative work. Because adaptation refers to longer run changes in behaviours, organizations, structures, and practices, quantitative indicators for adaptation may only show a small portion of a program's impact. Without complimentary qualitative data, it is difficult to determine whether interventions increased adaptive capacity and promoted transformational change and how. For example, respondents cite that in their politically-complex local environments, quantitative data are often used to justify politicians' interest in specific types of projects. As an extension service officer of a local NGO in Zambia said, politicians use quantitative data to justify implementing programs that aim to improve development outcomes, yet they don't analyse the qualitative impacts of these programs. Qualitative impacts, according to KII respondents, measure the changes in behaviour and knowledge of gender and climate change, as well as the feelings and perceptions that men and women may have with regards to this knowledge that will ensure that technologies and strategies for adaptation are maintained.

KAP survey participants also reported on the ways in which they would like to use research in the future. In particular, organizations expressed interest in using research to make improvements to projects, inform future

project design, and influence policy rather than only present at conferences, write papers/reports, and report to donors. These results show a desire among many organizations to participate more in applied and practical research. Representatives of government agencies/research institutes and local NGOs expressed the most interest in participating in different kinds of research. Government respondents expressed a desire to use research to influence policy and inform future project design, as well as to make improvements to current projects. International NGO respondents appear to be somewhat more interested in using research for making improvements and informing future project design.

KII respondents unanimously agreed that more research, more publications, and a larger knowledge and evidence base would benefit their activities. In particular, KII respondents expressed their desire for more context-specific gender-sensitive research. They also expressed that the information that is of most use to them is practical, drawing from previous experience with integrating gender dimensions into group-based approaches to climate change adaptation. More specifically, they expressed interest in reports on best practices, toolkits, training modules, lessons learned, and success stories related to integrating gender into climate change adaptation programs. They were also interested in materials on the different challenges that men and women face as a result of climate change, and on technologies being developed

that have successfully target gender-differentiated climate change concerns and needs.

KII respondents recognized gender as an important core analytical dimension; however, they also expressed a desire for research that explains how and to what extent other social factors, such as age and ethnicity, play a role in defining vulnerability, adaptive capacity, and adaptation decisions. Other important research gaps identified by KII respondents are studies that link gender-sensitive adaptation, mitigation, and risk management strategies, and quantitative evidence that demonstrates that adaptation leads to the improvement of women's wellbeing through cost-benefit analyses, and social return on investment analyses.

The KAP survey also aimed to identify the constraints to implementing gender-sensitive programs. Specifically, KAP survey respondents were asked to rank a number of various factors affecting the extent of gender integration from 1-5, with 1 being that the factor is not a constraint to 5 that it is a significant constraint (Figure 5.6). On average, all factors were rated above 3. Overall, the largest constraints to implementing gender-sensitive programming were availability of financial resources and the capacity of program staff in areas of gender, followed by the availability of sex-disaggregated data and socio-cultural barriers to women's participation.

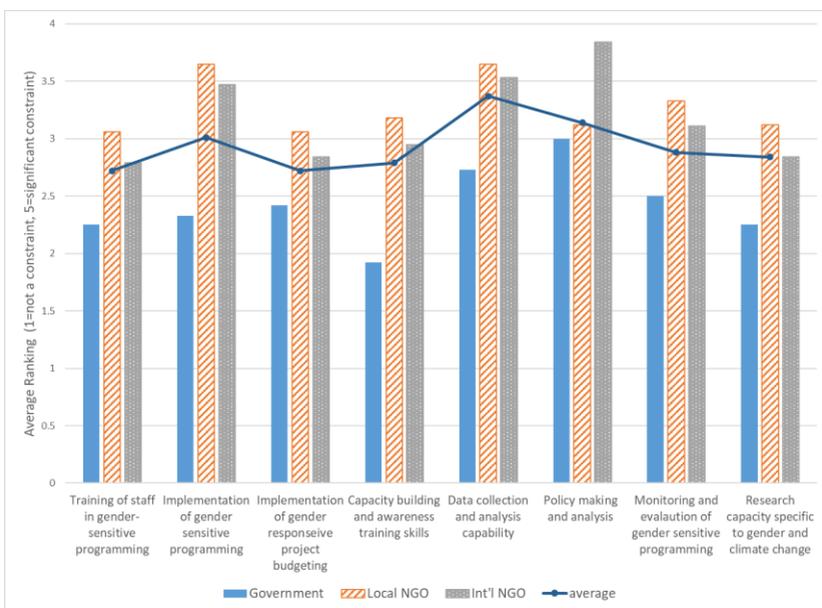


Figure 5.6: Constraints to implementing gender-sensitive climate change adaptation programs (1=not a constraint, 5=significant constraint)

Source: Authors, KAP Survey 2015

For participating government respondents, the largest barrier is the lack of capacity of program staff, followed by issues of financial resources. For local NGOs, funding proves the most significant barrier, followed by socio-cultural barriers to women’s participation. International NGOs identified the availability of funding and social or cultural barriers as the key constraints.

Similarly, KII participants cited lack of funding as a primary barrier to gender-sensitive climate change

adaptation followed by limited willingness of governments/communities to involve women in decision-making and low capacity of program staff in gender areas. Other less frequently mentioned barriers included social and cultural barriers to women's participation, and lack of gender-disaggregated data.

KAP survey respondents also assessed their organization's capacity in several areas, such training in gender-sensitive programming, ability to conduct capacity and awareness training, data collection and analysis skills, monitoring and evaluation, and research capacity on gender and climate change. On average, KAP survey respondents reported greater capacity to collect and analyse data and less capacity to implement gender-sensitive budgeting and train staff in gender-sensitive programming. Local and international NGOs tended to assign higher scores to their own research and gender capacities, while government agencies reported lower capacity in these areas. Many of the organizations, particularly NGOs, are relatively confident in their ability to do carry out gender-sensitive programs. However, there is still some capacity building needed in all areas to push organizations up to the highest levels of capacity and confidence and especially to increase the capacity of government agencies across all these areas.

As previously mentioned, KII respondents highlighted lack of staff capacity as a key barrier to integrating gender

into climate change programming. Many KII respondents mentioned that although they personally had awareness of the importance of gender issues, their organizations and other staff members did not have the same level of awareness and did not prioritize gender considerations in their activities. Several KII respondents mentioned that their organizations have only begun gender mainstreaming, that there is still not a concerted effort to collect gender-disaggregated data systematically, and that gender inclusion in data collection is often the result of high involvement of women in agricultural activities and not because of program guidelines. Many KII respondents felt that capacity building on gender is one of the key components necessary to improve integration of gender concerns into climate change adaptation programming in their organization and country.

5.4 Discussion and Conclusions

The KAP survey results show there is still work to be done to integrate gender into climate change adaptation projects and to bridge research and capacity gaps. Follow-up KIIs helped to bring further context and clarity to the KAP survey results and also highlighted specific areas where additional research and capacity-building activities are needed. Available evidence on gender and climate change suggests that there are key barriers to women's adaptation to climate change, but that these barriers are context specific. While lessons regarding the potential

linkages between gender and climate change (e.g. barriers and outcomes) can be gleaned from the available case studies, such research does not provide the answers required for particular adaptation programs to successfully integrate gender. Addressing this research gap will require programs and projects to integrate more rigorous, academic-style research into these programs, either through stronger partnerships with research organizations or through the application of research tools and approaches, for example in their scoping and M&E work.

This study also showed that while all organization types covered by the KAP survey have some access to information on gender and climate change, several organizations, namely local NGOs, felt that information was not well shared amongst the network of organizations working in the area of climate change adaptation. This finding suggests that there is a large potential to improve the quality of programs dealing with climate change adaptation in a gender-sensitive manner, simply through better communication amongst different stakeholders in order to share lessons learned from previous experiences, as well as tools and approaches, and other information. Government agencies, in particular, may benefit from greater information sharing given that they were less likely to have access to information and research on gender and climate change.

While there is evidence available on the impacts of climate change, participants are looking for research that is more context specific, as well as research providing evidence of the need for investing in women's resilience to climate change. However, as many respondents noted, sex-disaggregated data and analysis remains limited to few case studies and not across a wide range of countries and local contexts. Integrating data collection efforts and more academic-style research into local projects is one way to build the knowledge base on the gender dimensions of climate adaptation. Such efforts would also provide the context-specific information that many organizations are seeking to guide future activities. Again the challenge will be to develop networks so that successful tools used to gather evidence through these projects can be shared with other organizations that would benefit from their use.

Researchers have a role to play in working with implementing organizations to strengthen the research evidence that is generated from these projects and in further developing and promoting tools to support gender-disaggregated assessments across a variety of local contexts. Existing evidence shows that the particular barriers women face in adapting to climate change or adopting new practices or technologies are largely based on the context in which they live. Based on this evidence, researchers are developing tools to help implementing partners identify the specific barriers women face in a

given context as well as culturally appropriate approaches to removing these barriers. Examples include the survey-based tools such as the Women's Empowerment in Agriculture Index (WEAI) or qualitative diagnostic tools to identify particular constraints associated with particular approaches, technologies or value chains. More work is needed to make these tools available to implementing agencies through partnerships, capacity-building workshops and conferences. In particular, these tools and other research products should be well targeted to key individuals from government agencies and national research institutes, who reported having lower access to research and information.

The ways in which information is presented is also important, as the KAP survey showed that different organization types have different preferences for research, information products, and modes of dissemination. Researchers should carefully consider their audience and the intended impacts of their research when engaging in outreach. At the same time, it is clear that many organizations rely on multiple sources of information, which suggests that there is no silver bullet mode of information dissemination. Rather, multiple channels may be needed to reach and influence a target audience.

In terms of integrating gender into climate change adaptation programs, there does seem to be tension in terms of how much emphasis to place on gender. While

gender has become a buzzword in international circles, there appears to be some resistance to emphasizing gender during project implementation—with participants reporting that projects targeting women tend to be less successful than projects that emphasize community benefits. While the way in which communities are approached is important to get community buy-in, it is also important not to lose sight of key gender considerations during project design, targeting, implementation and M&E. Communities must be sensitized to understand that gender-sensitive projects do entail a focus on both women and men and that this joint focus can improve overall outcomes. At the same time it is important that culture is not used as an excuse to justify gender inequality.

Local NGOs reported high effectiveness at integrating research into adaptation programming and they generally had the lowest gap between perceived importance and actual implementation with respect to integrating gender considerations into various stages of the project cycle. At the same time, local NGOs (and also international NGOs, government agencies, and national research institutes) also expressed a strong desire for greater integration of research findings to guide the various project stages. They also reported lack of staff capacity which hinders gender integration. Again this will require greater information-sharing across different organization types as well as a willingness to collaborate and partner with other

organizations to do research alongside programs as they are being designed, implemented, and evaluated. Integrating research into climate change adaptation projects will also require greater funding to carry out more rigorous research with a gender-sensitive focus and prioritization of gender among donors and governments. Such research would not only provide global public goods in terms of increasing the evidence base, but it could also serve a practical purpose by informing adaptation strategies and planning.

One of the key ways that more academic style research could benefit program implementation is through more rigorous impact evaluations. While many implementing organizations reported that they are conducting impact evaluations, this result is somewhat surprising given that impact evaluations can be time intensive and costly. Part of the reason for this result may be that different organizations define and understand impact evaluation differently. Research organizations are more likely to design and conduct more rigorous impact assessments with experimental or quasi-experimental design (and even then not all research organizations do this) while other organizations may be satisfied with outcome monitoring or discussions with key stakeholders as a measure of impact. Again M&E would be an area where greater collaboration between project implementers and researchers could be enormously beneficial. Partnerships between research organizations and implementing

agencies or NGOs should be formed early on, so that project design facilitates rigorous research results. Such partnerships could generate needed experimental evidence on the effectiveness of various adaptation strategies and climate-smart agriculture practices.

The KAP survey and KIIs also highlighted several challenges facing organizations working on climate change adaptation in sub-Saharan Africa. Lack of staff capacity on gender and lack of funding were key constraints to implementing gender-sensitive climate change adaptation programs that cut across all organization types. However, lack of staff capacity on gender at the government level is particularly troublesome as it can perpetuate a cycle of lack of government understanding and thus demand to collect sex-disaggregated data and gender-sensitive programs, followed by a lack of funding and M&E. Other key constraints that were mentioned include lack of prioritization of gender issues by decision makers, lack of progress on gender mainstreaming, and cultural barriers that limit women's participation in projects and prevent women from taking on leadership roles within organizations. While research cannot address many of these challenges, one way in which researchers can help is to support capacity building efforts related to gender and climate change in the region.

Often there seems to be the perception that incorporating a gender perspective into adaptation projects will involve a great deal of additional and burdensome activities that require additional funding. However, integrating gender does not have to be dependent on additional funding, but can be integrated into existing activities to some extent. Such an approach can make project funding more efficient; however, it does require a degree of expertise on gender among program staff. Building staff capacity related to gender is, therefore, crucial in order for climate change adaptation programs to adequately integrate gender.

National governments also have a role to play to ensure that gender considerations are being written into policy guidelines and translated to program activities. Many governments are starting to work on developing baselines and collecting sex-disaggregated data in order to meet international standards of governing bodies such as the UNFCCC and others. While gender is starting to be explicitly mentioned in policies at the international and national levels, this is not yet translating into more gender-sensitive programs on the ground. Local stakeholders and international organizations, especially donors, must pressure governments to adhere to or implement policy guidelines that make gender issues a priority, especially in climate change adaptation, in order to incentivize the roll-out of more gender-responsive programs.

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6. DISCUSSIONS AND CONCLUSIONS

Small-scale irrigation is a promising approach to increase agricultural productivity, improve food and nutrition security, and increase resilience to climate change. Too few smallholder producers have access to technologies for small-scale irrigation in sub-Saharan Africa despite high demand for irrigation, and efforts are intensifying to increase investments and implement interventions to spread small-scale irrigation throughout the region. As these interventions unfold, it is important to recognize the gender implications of the diffusion of small-scale irrigation. A review of the case study evidence, presented in Chapter 2, shows that women face more constraints than men in adopting and benefitting from different types of small-scale irrigation technologies and systems. This dissertation develops a conceptual framework to explore the relationship between women's empowerment and small-scale irrigation drawing on this literature. It then applies this framework to a case study in Northern Ghana, where small groups of men and women farmers received motor pumps for dry season irrigation. It contributes new empirical evidence of impacts of the motor pump intervention on indicators of women's empowerment using mixed methods. Finally, it draws on a knowledge, attitudes, and practices assessment to identify capacity needs for improving gender-sensitive delivery of interventions.

6.1 Major Results and Achievements

6.1.1 Methodological Contributions

Mixed-methods research combines different types of methods, tools, and analyses to address an interrelated set of research questions. It relies on different methods for data collection and analysis, which can be sequenced and integrated in ways that are complementary and build on one another to produce a richer set of results. The methodological contribution of this dissertation is the development of a mixed-methods approach to exploring the relationship between small-scale irrigation and women's empowerment, and to place this relationship in the context of the broader institutional context in which multiple implementing partners are promoting agricultural interventions that increase adaptation to climate change.

This dissertation starts by developing a conceptual framework in Chapter 2 that illustrates the main elements of women's empowerment and describes the relationship between these elements and small-scale irrigation. It applies this framework to analyze the literature on gender and small-scale irrigation organized by type of irrigation to demonstrate how the relationship changes by technology type, water source and scale.

Given the importance of the local context (opportunity structure) in which empowerment processes play out,

Chapter 3 applies the framework to a case study in the Upper East Region of Ghana where a motor pump intervention was implemented. This chapter explores local definitions of empowerment, underlying dynamics of social change, how these dynamics are affected by the introduction of small-scale irrigation, and the potential for small-scale irrigation to contribute to women's empowerment in this context. This research relies on qualitative data collected from focus group discussions with men and women farmers and individual interviews with farmers and traders in selected communities.

This qualitative research complements quantitative impact assessment of the impact of the motor pump intervention on indicators of women's empowerment discussed in Chapter 4. This chapter takes advantage of the randomized nature of the motor pump intervention through which a sub-set of small groups of farmers were selected to receive a motor pump through a random lottery. This analysis uses first difference and difference-in-difference models to evaluate the impact of the program on selected outcome indicators using Women's Empowerment in Agriculture Index and household survey data. While the quantitative assessment attributes changes in indicators of women's empowerment to the irrigation intervention, the qualitative findings from Chapter 3 are essential to understand the pathways through which these impacts are achieved and what factors may contribute to insignificant results and negative spillover effects.

As highlighted in Chapters 2 and 3, contextual factors influence the pathways through which interventions influence women's empowerment. One important component of the opportunity structure or context is the institutional arrangements governing the distribution of technologies and services. Given the central role of private sector partners, NGOs, and other implementing agencies in rolling out irrigation interventions in sub-Saharan Africa in general and Ghana in particular, it is important to understand the capacity limitations of these organizations to carry out gender-sensitive programs and to identify entry points for strengthening capacities in this area. Ensuring that women benefit from agricultural interventions like small-scale irrigation requires strengthening the capacity of implementing organizations to deliver and implement programs in a way that recognizes the unique circumstances women face, including the socio-political factors that results in gender inequality, as well as women's preferences and aspirations. Thus, Chapter 5 presents the results of a knowledge, attitudes, and practices (KAP) assessment of organizations implementing climate change adaptation programs more broadly in order to identify entry points for strengthening the delivery of gender-sensitive programming.

Taken together, these analyses provide a more complete understanding of how new agricultural technologies, like small scale irrigation, may provide one pathway among

many to women's empowerment within complex social-political contexts in which structural inequalities are deeply embedded, social dynamics are continually evolving, and institutions govern the distribution of benefits from development interventions. While the focus of this dissertation is on small-scale irrigation, the same approach could be applied to explore the gender dimensions of other agricultural technologies or climate-smart practices and to identify entry points for and approaches to facilitating women's empowerment through these efforts.

6.1.2 Empirical findings

This study aimed to address the following research questions through literature review, collection of qualitative and quantitative primary data, and a capacity needs assessment of development organizations implementing climate change adaptation programs in agriculture:

- What are the linkages between small-scale irrigation technologies/systems and dimensions of women's empowerment?
- What aspects of women's empowerment are most important for women to adopt and benefit from small-scale irrigation in the context of Northern Ghana?

- How does the introduction of motor pumps for small-scale irrigation affect women's empowerment in Northern Ghana?
- What are the gender-related capacity needs of development organizations working to promote climate change adaptation (of which small-scale irrigation is an important practice)?

Conceptual linkages between women's empowerment and systems/types of small-scale irrigation

The conceptual framework developed in Chapter 2 and applied to the case study literature demonstrates that the gendered patterns of adoption and use of small-scale irrigation, the distribution of costs and benefits, and how these influence other development outcomes depend on the type of small-scale irrigation system (from household to communal schemes), type of irrigation technology, and larger context determining women's roles in farming and livelihood systems. Communal schemes for small-scale irrigation require more resources, agency, and inclusive institutional arrangements for women to successfully participate in and benefit from them. The additional resources needed for communal schemes include labor for operation, maintenance, and repair of irrigation infrastructure such as canals, and access to land with adequate water, particularly plots located closer to the scheme's water source. Women also need to participate in

decision-making both within the households as well as in community spaces where decisions regarding the design, operation, and governance of the schemes are made. Because women often face greater resource and agency constraints, the benefits they receive from communal schemes tends to be more limited.

Growing research on gender and household-level irrigation, shows that women are similarly disadvantaged in terms of access to resources (like irrigable land, labor, technology, credit, and complementary inputs) and intra-household bargaining for access to and use of irrigation technologies and practices in ways that address their own needs and preferences. Because women have less decision-making authority, their irrigation activities are more limited to smaller household garden plots and they may not have control over income from the sale of irrigated produce. Much less research is available on group-based approaches to small-scale irrigation, especially studies exploring the gender dimensions of group-based irrigation. Studies that do exist suggest that many group-based interventions that women participate in are project-based and targeted specifically to women while men's groups are more often self-financed. This suggests that demand driven approaches may exclude women, while project-based, targeted approaches that consider the constraints women face in a given context may be needed to successfully reach and benefit women.

What aspects of women's empowerment are most important for women to adopt and benefit from small-scale irrigation in the context of Northern Ghana?

Chapter 3 applies the framework for understanding the linkages between women's empowerment and small-scale irrigation to a case study in Northern Ghana, where motor pumps were distributed to small groups of farmers in communities where many women and men were already engaged in small-scale irrigation activities using manual methods. Using qualitative research methods, the chapter identifies the resources and aspects of women's agency needed for women to participate in and benefit from irrigation generally and the motor pumps in particular. The interviews and focus groups with men and women producers and traders revealed that women have more limited access to some key resources needed for engaging in small-scale irrigation, particularly less access to land near the water source, limited labor needed to dig wells or construct fencing around irrigated plots, and less access to credit, complementary inputs and other productive assets.

The relationship between women's agency and their ability to use and benefit from small-scale irrigation is complex and runs in both directions. On the one hand, women's agency is required to negotiate for land, participate in irrigation decisions, and control income earned through the sale of irrigated crops. On the other hand, irrigation affects women's agency in both positive

and negative ways. On the positive side, irrigation can increase women's intrinsic agency and increase their social status in the community as they are viewed as hard-working and successful. It also enables some women to earn additional income and source food for their families when they manage irrigated plots. On the negative side, irrigation may increase women's time burden, particularly when manual irrigation methods are used. The motor pump intervention influenced these relationships by changing the allocation of labor within many irrigating households whereby men took over irrigation and women engaged in other livelihood activities. The way these relationships play out also varied across women depending on many factors such as the wealth of the household, availability of family labor, size and location of the farm, and source of water for irrigation.

How does the introduction of motor pumps for small-scale irrigation affect women's empowerment in Northern Ghana?

An investigation of the extent to which the motor pump intervention increased women's empowerment in Chapter 4 revealed some evidence of a positive impact—the motor pump intervention increased women's control over assets and income but did not affect aggregate empowerment scores or other aspects of women's empowerment. Moreover, evidence of negative spillover effects in the communities where motor pumps were distributed

suggests that the intervention created tensions among households that did not receive the motor pumps that negatively affected women's empowerment. Furthermore, the negative spillover effects imply more modest gains among women in households that received the pump—a finding that is further supported by the results using an alternative control group, which showed no significant impacts of the program on indicators of women's empowerment.

While some positive effects were found, the pathways from the irrigation intervention to women's empowerment outcomes are not evident from the quantitative findings alone. Rather, qualitative research presented in Chapter 3, suggests that these positive impacts may be the indirect result of the motor pump intervention. That is, increased control over assets and income by women may have been the result of a shift in women's time allocation to other activities that provided direct benefits and an overall increase in household well-being.

What are the gender-related capacity needs of development organizations?

Chapter 4 demonstrates that programs aimed at increasing the productivity, profitability, and sustainability of agriculture through the dissemination of improved agricultural technologies and practices, like small-scale irrigation, must consider underlying structural inequalities

and gender dynamics if they are to also increase women's empowerment. Through a knowledge, attitudes and practices survey and key informant interviews with representatives of organizations working to promote climate change adaptation throughout sub-Saharan Africa, Chapter 5 shows that the ability of these organizations to deliver gender-responsive programs depends largely on their capacity to integrate gender-sensitive approaches across a range of local contexts.

This chapter identified several key capacity constraints that vary across organization types (government agencies, local NGOs, and international NGOs) including the ability to integrate gender-sensitive research, including the use of sex-disaggregated data, into operations to ensure that programs are designed and implemented in ways that address the differential needs of men and women. Furthermore, the KAP survey revealed that while gender is considered an important factor in the design and implementation of interventions, gender considerations are not integrated adequately in actual practice of the organizations. For example, monitoring and evaluation efforts focus mainly on tracking gendered participation in program activities but not in differential outcomes for men and women. Respondents pointed to the lack of staff capacity as being one of the main impediments to implementation of gender-responsive programming, along with limited availability of research and sex-disaggregated data and insufficient financial resources.

Respondents also pointed to the need for more information sharing on gender-sensitive approaches across organizations working in the climate change adaptation space and stronger partnerships between practitioners and researchers.

6.2 Policy Implications

The findings in this dissertation suggest that there are many factors to consider in the design and dissemination of small-scale irrigation technologies to ensure that these are equitably distributed and that both men and women have the opportunity to engage in and benefit from irrigation. One key factor to consider is the type of irrigation technology or system and the scale at which it is applied. The review of case study literature in Chapter 2 shows that women engaged in household level irrigation prefer technologies that can be applied close to the home in gardens that supply food for the household and an additional source of income that they control. Several case studies also suggest that women prefer irrigation technologies and systems that can be used for multiple purposes—including as a source of domestic water. These case studies suggest that policymakers and program implementers should carefully consider and include women in the design of irrigation systems and technologies to ensure that their preferences are considered and that their needs are met.

Small-scale irrigation interventions must consider the underlying socio-political environment in which men and women play different livelihood and social roles and there are institutional structures including social norms of behavior that determine the extent to which women have access to resources and agency to adopt and benefit from irrigation. As Chapters 3 and 4 demonstrate, women face additional barriers in adopting and using irrigation technologies in ways that meet their needs. Inheritance norms and property rights (formal and informal) strongly influence the distribution of resources required for adopting and benefitting from small-scale irrigation. In Northern Ghana, although many women were already engaged in providing manual labor to irrigate family plots, women often lack access to their own irrigable plots of land, have higher labor constraints, and lack access to complementary inputs like fertilizer. Moreover, social norms regarding asset ownership meant that motor pumps that were distributed to women farmers were ultimately managed by their husbands in many cases. Thus, development agencies and NGOs aiming to expand access to technologies for irrigation should consider the underlying social dynamics in the study area and develop dissemination strategies that address the specific constraints that women face in that context.

In contexts where women's access to productive land is a constraint, purely demand-driven irrigation schemes may exclude many women given their inability to acquire and

utilize irrigation technologies according to their preferences. Rather, group-based approaches may help women overcome such resource constraints by facilitating access to irrigable land, shared labor, and technologies. Other considerations related to technology dissemination include how affordable and profitable is the technology is for men and women given their preferred uses, what knowledge men and women require to use/maintain the technology, and what supporting services are needed (e.g. repair and maintenance services) for irrigation to be sustainable. Another important consideration is the rollout strategy. The findings in Chapter 4 showed that random distribution of the pumps to groups of men and women farmers within the same communities led to possible conflicts that affected women non-beneficiaries (negative spillovers). Thus, rolling out the intervention to all interested farmers selected communities at the same time would be a better way to distribute limited resources while also minimizing intra-community conflicts.

Understanding the local context can also help program implementors identify opportunities for women to benefit indirectly from project activities. For example, if direct engagement in irrigation is difficult for women, are there other livelihood activities along irrigated value chains, such as the local processing and sale of irrigated crops, that may benefit women? Or are there other more preferred livelihood activities that enable women to earn and control income? The findings of this dissertation

suggest that multiple pathways to women's empowerment are possible. For some women, gaining access to the motor pumps freed their time to explore other, more preferred livelihood choices. The key is for development interventions to expand opportunities to the extent possible to women and other marginalized groups including opportunities outside agriculture. Thus, while some women may be able to benefit directly by engaging in small-scale irrigation, others may seek other opportunities to improve their status and well-being outside of agriculture or along food value chains.

This type of livelihood diversification also has positive implications for the resilience of rural agricultural households. A study by Kramer and Lambrect (2019) in Northern Ghana found that both men and women prefer to diversify their investments in both agricultural and non-agricultural activities, but with clear gendered patterns in investments. Data collected through a framed field experiment showed that women were more likely to allocate funds towards business activities, like trading agricultural products, non-agricultural products and food processing activities compared to men, while men invested more in agricultural activities and livestock rearing (*ibid*). These findings support the conclusions of this dissertation, that there are multiple pathways towards women's empowerment and that women's preferences may lead them to choose activities outside of agriculture

when new technologies, like motor pumps, are introduced.

Finally, the extent to which small-scale irrigation interventions effectively reach, benefit, and empower women also depends on the ability of development agencies to deliver gender-responsive programs. Moving beyond simply reaching women (i.e. counting their participation in program activities) to benefitting and empowering women (i.e. increasing their well-being outcomes and expanding their ability to make strategic life decisions) requires knowledge of the local context and dedicated attention that ensure that outcomes for women are achieved (Johnson et al. 2018). As Chapter 5 showed, many organizations, including government agencies, local and international NGOs, and private partners, lack the capacity to design and implement gender-sensitive programs grounded in gender-disaggregated research. This includes gender-sensitive monitoring and evaluation that captures gender gaps in outcomes and process evaluation that traces impact pathways and identifies why a program has or has not been successful at facilitating women's empowerment. Other research has found that even research institutions in Ghana lack the requisite mandate, capacity, and resources to mainstream gender, including incorporating gendered preferences in technology development, such as improved crop varieties (Addison, Mujawamariya, and Bam 2019).

As discussed in Chapter 4, while Ghana's Irrigation Policy acknowledges aims to increase women's access to land and water and participation in local water management organizations, social inclusion policies in irrigation have not translated into practice and new and improved technologies are much less likely to be disseminated to women (MoFA 2007). Efforts to disseminate small-scale irrigation technologies are largely demand-driven and led by NGOs and the private sector with little guidance, coordination, or oversight to ensure equitable and efficient diffusion of small-scale irrigation technologies (Minh et al. 2020).

Thus, greater efforts are needed to build the capacity of implementing organizations to deliver gender-responsive programs. Creating platforms for sharing information, approaches, and lessons learned is one way to build this capacity. Multi-stakeholder dialogues have already been used effectively in Ghana to provide space for identifying shared goals, promoting investment, and scaling small-scale irrigation (Minh et al. 2020). A similar approach could be used to set and monitor targets for social inclusion in irrigation expansion and to share lessons learned and advance more gender-responsive approaches.

6.3 Directions for Further Research

The findings in this dissertation show that aspirations, opportunities, and pathways to women's empowerment

are highly context specific. Thus, one-size-fits-all strategies are not appropriate to expand women's agency, status, and well-being. Gender sensitive, research tools and approaches, therefore, need to be integrated into strategy development, project design, implementation, and monitoring and evaluation. Some guidance for more inclusive irrigation development already exists, such as the Gender in Irrigation Learning and Improvement Tool (GILIT), which focuses on enabling projects to assess gender and access to resources, participation in management decisions, and the distribution of benefits within communal irrigation schemes (Lefore, Weight, and Mukhamedova 2017), and the REACH guidance for inclusive irrigation interventions at the household level (Theis et al. 2018). Such tools should be applied to different contexts to identify gendered preferences for technologies, systems and uses of irrigation, constraints to adoption and use of irrigation technologies and practices, and differential benefits.

There is surprisingly little research on the gendered implications of agricultural technologies and practices. While this dissertation provides some evidence on the women's empowerment impacts of motor pumps for small-scale irrigation, this is only one of many types of irrigation technologies and approaches. The ways in which countries are promoting the expansion of small-scale irrigation varies dramatically from more government-led initiatives to more demand-driven

approaches involving the private sector. More research is needed on the implications for women's empowerment of alternative irrigation technologies, systems, and dissemination approaches. In particular, some promising types of interventions for scaling household-level irrigation include group-based approaches and service-based models. Yet there is very little information on how and whether women may benefit from these approaches. Some evidence suggests that NGO-led interventions targeted to women's groups may help women overcome barriers to irrigation, yet more research is needed to determine the conditions under which such arrangements are possible and beneficial to women. Similarly, research on agricultural mechanization and service-based approaches tends to show that women remain at a disadvantage in terms of acting as service providers and receiving services. Again, more research is needed on which service-based approaches may enable greater women's participation and benefits.

The above-mentioned tools focus on gendered preferences and constraints related to irrigation but not gendered preferences for alternative livelihood options. More research is also needed on the extent to which women's empowerment in agriculture is the most appropriate vehicle for the advancement of women. Rather expanding the range of livelihood options for

women within and outside of agricultural production, including along agricultural value chains and non-agricultural businesses may offer increased choice for women to choose their own empowerment pathways. Thus, more comprehensive research is needed that identifies women's preferences for alternative livelihood options, capacity needs to pursue such options, and the relative barriers and opportunities that exist across these alternative pathways. Ultimately having more diversified livelihood choices reduces the risks that many agricultural households face from climate shocks and stressors and other disturbances, such as conflict or global pandemics.

6.4 References

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- Yimer, F. and F. Tadesse. 2015. Women's empowerment in agriculture and dietary diversity in Ethiopia. *ESSP Working Paper*, 80. Addis Ababa: International Food Policy Research Institute.

CURRICULUM VITAE

ELIZABETH BRYAN

Senior Scientist, Environment and Production
Technology Division
International Food Policy Research Institute (IFPRI)

Elizabeth Bryan, a Senior Scientist in IFPRI's Environment and Production Technology Division, conducts policy-relevant research on gender, sustainable agricultural production, climate-smart agriculture, small-scale irrigation, and the water-energy-food nexus. She has considerable experience integrating gender into large, interdisciplinary research programs involving multiple CGIAR centers and other partners. Elizabeth is skilled at analyzing quantitative and qualitative data for gender research, has published numerous articles based on her work, and regularly presents research results to diverse audiences, including at policy workshops, trainings, and international conferences. She holds an M.A. in Development Economics from American University and an B.A. from Wagner College.

EDUCATION

Ph.D. Agricultural Sciences, University of Hohenheim,
Germany (anticipated 2022)

M.A. International Development / Development
Economics, American University, USA (2007)

B.A. International Affairs, Wagner College, USA (2001)

PROFESSIONAL EXPERIENCE

International Food Policy Research Institute, Washington, DC

Senior Scientist (2019-present)

Senior Research Analyst (2012-19)

Research Analyst (2009-12)

Senior Research Assistant (2007-09)

World Bank (Poverty Reduction Group), Washington, DC

Short Term Consultant (2006-07)

Woodrow Wilson International Center for Scholars (WWICS), Washington, DC

Program Assistant (2002-07)

Center for National Policy (CNP), Foreign Policy Program, Washington, DC

Foreign Policy Program Assistant (July 2001– July 2002)

SELECTED PUBLICATIONS

Njuki, J., S. Eissler, H. Malapit, R. Meinzen-Dick, **E. Bryan**, and A. Quisumbing. forthcoming. A review of evidence on gender equality, women's empowerment, and food systems, *Global Food Security*.

Haile, B., D. Mekonnen, J. Choufani, C. Ringler, and **E. Bryan**. forthcoming. Hierarchical modelling of the constraints to irrigation adoption in Ghana, Ethiopia, and Tanzania. *Water Economics and Policy*.

Bryan, E., R. Meinzen-Dick, and C. Ringler. 2022. Gender, Resilience, and Food Security. In *Resilience and food security: Analysis from a food system*

perspective, S. Devereux and C. Béné (Eds), Palgrave-MacMillan, forthcoming.

Bryan, E. and E. Garner. 2022. Understanding Women's Empowerment in Northern Ghana and the Relationship with Small-Scale Irrigation. *Agriculture and Human Values*, published online January 2022. <https://doi.org/10.1007/s10460-021-10291-1>

Alvi, M. F., S. Gupta, P. Barooah, C. Ringler, **E. Bryan**, and R. S. Meinzen-Dick. 2022. *Gendered impacts of COVID-19: Insights from 7 countries in Sub-Saharan Africa and South Asia*. Washington, DC: International Food Policy Research Institute (IFPRI). <https://doi.org/10.2499/p15738coll2.135042>

Baye, K. D. Mekonnen, J. Choufani, **E. Bryan**, C. Ringler, and J. Griffiths. 2021. Seasonal variation in maternal dietary diversity is reduced by small-scale irrigation practices: a longitudinal study, *Maternal & Child Nutrition*, published online: <https://doi.org/10.1111/mcn.13297>.

Bell, A. R., **E. Bryan**, C. Ringler, and A. Ahmed. 2021. Rice Productivity in Bangladesh: What Are the Benefits of Irrigation? In *Securing Food for All in Bangladesh*, A. U. Ahmed, N. Islam, and M. K. Mujeri, eds. Washington, DC: International Food Policy Research Institute (IFPRI).

Bryan, E., E. Kato, and Q. Bernier. 2021. Gender differences in awareness and adoption of climate-smart agriculture practices in Bangladesh. In *Gender, Climate Change and Livelihoods: Vulnerabilities*

and Adaptations, J. Eastin and K. Dupuy (Eds.), Wallingford, UK: CABI, forthcoming.

Bryan, E., and N. Lefore. 2021. Women and small-scale irrigation: A review of the factors influencing gendered patterns of participation and benefits. *IFPRI Discussion Paper*, 2025. Washington, DC: IFPRI.

De Pinto, A., G. Seymour, **E. Bryan**, and P. Bhandari. 2020. Women's empowerment and farmland allocations in Bangladesh: evidence of a possible pathway to crop diversification. *Climatic Change*, published online: <https://doi.org/10.1007/s10584-020-02925-w>.

Bryan, E. and E. Garner. 2020. What does Empowerment Mean to Women in Northern Ghana? Insights from Research Around a Small-Scale Irrigation Intervention. *IFPRI Discussion Paper*, 1909. Washington, DC: IFPRI.

Bryan, E., F. Hagos, D. K. Mekonnen, D. A. Gemedo, and S. Yimam. 2020. The diffusion of small-scale irrigation technologies in Ethiopia: Stakeholder analysis using Net-Map. *IFPRI Discussion Paper* 1950. Washington, DC: International Food Policy Research Institute (IFPRI). <https://doi.org/10.2499/p15738coll2.133847>

Bryan, E., C. Claire, M. Schulte. 2019. Nutrition-Sensitive Irrigation and Water Management. World Bank, Washington, DC: World Bank. Available at: <http://hdl.handle.net/10986/32309>

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- Bryan, E.**, A. Bell, C. Ringler, and A. Ahmed. 2018. Increasing the Benefits to Small Producers from Crop Production in Bangladesh. *Asian Journal of Agricultural Development*, 15(1): 1-22.
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efficiency and mitigate GHG emissions. *Energy*, 149: 161-172.

Bryan, E., S. Theis, J. Choufani, A. De Pinto, R. Meinzen-Dick, and C. Ringler. 2017. *Gender-Sensitive, Climate-Smart Agriculture for Improved Nutrition in Africa South of the Sahara*. In: De Pinto, A. and Ulimwengu, J.M. (Eds.) Annual Trends and Outlook Report (ATOR): A Thriving Agricultural Sector in a Changing Climate: The Contribution of Climate-Smart Agriculture to Malabo and Sustainable Development Goals. Washington, DC: IFPRI.

Kristjanson, P., **E. Bryan**, Q. Bernier, J. Twyman, R.S. Meinzen-Dick, C. Kieran, C. Ringler, C. Jost, and C. Doss. 2017. Addressing gender in agricultural research for development in the face of a changing climate: Where are we and where should we be going? *International Journal of Agricultural Sustainability* 15(5): 482-500.

Mondal, A., **E. Bryan**, C. Ringler, and M. Rosegrant. 2017. Ethiopian power sector development: Renewable based universal electricity access and export strategies. *Renewable and Sustainable Energy Reviews*, 75: 11-20. available at: <https://doi.org/10.1016/j.rser.2016.10.041>.

Mekonnen, D., **E. Bryan**, T. Alemu, and C. Ringler. 2017. Food versus Fuel: Examining Tradeoffs in the Allocation of Biomass Energy Sources to Domestic and Productive Uses in Ethiopia. *Agricultural Economics*, 48(4): 425-435. doi:10.1111/agec.12344

- Bell, A.R., **E. Bryan**, C. Ringler, and A. Ahmed. 2015. Rice productivity in Bangladesh: What are the benefits of irrigation? *Land Use Policy*, 48: 1-12.
- Aberman, N.L., S. Ali, J. Behrman, **E. Bryan**, P. Davis, A. Donnelly, V. Gathaara, D. Kone, T. Nganga, J. Ngugi, B. Okoba, and C. Roncoli. 2015. Climate change adaptation, assets and group-based approaches: gendered perceptions from Bangladesh, Ethiopia, Mali and Kenya. *IFPRI Discussion Paper*, 1412. Washington, DC: IFPRI.
- Bernier Q., R. Meinzen-Dick, P. Kristjanson, E. Haglund, C. Kovarik, **E. Bryan**, C. Ringler, S. Silvestri. 2015. Gender and Institutional Aspects of Climate-Smart Agricultural Practices: Evidence from Kenya. *CCAFS Working Paper*, 79. Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).
- Bryan, E.**, C. Ringler, B. Okoba, J. Koo, M. Herrero, and S. Silvestri. 2013. Can agriculture support climate change adaptation, greenhouse gas mitigation and rural livelihoods? Insights from Kenya, *Climatic Change*, 118(2): 151-165.
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- Silvestri, S., **E. Bryan**, C. Ringler, M. Herrero, B. Okoba. 2012. Climate change perceptions and adaptation of

- agro-pastoral communities in Kenya, *Regional Environmental Change*, 12(4): 791–802.
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- Bryan, E.**, W. Akpalu, C. Ringler, and M. Yesuf. 2010. Global carbon markets: Opportunities for sub-Saharan Africa in agriculture and forestry. *Climate and Development*, 2(4): 309-331.
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- Bryan, E.** T. Deressa, G. Gbetibouo, and C. Ringler. 2009. Adaptation to Climate Change in Ethiopia and South Africa: Options and Constraints. *Environmental Science and Policy*, 12(4): 413-426.

RECENT PRESENTATIONS AND OUTREACH

- Feb. 2022 *Evidence Brief: State of knowledge on gender and resilience*. Gender, Climate Change and Nutrition Integration Initiative (GCAN) Evidence Brief. Washington, DC: International Food Policy Research Institute (IFPRI).

- Feb. 2022 *Technical Training*: Identifying Indicators using the Reach-Benefit-Empower-Transform Framework (with Ruth Meizen-Dick) for the Innovation Lab for Policy Research, Capacity and Influence (PRCI).
- Feb. 2022 *Presentation*: “Why do gender and nutrition matter for climate change adaptation” at the internal USAID webinar on New Evidence and Key Priorities for Gender and Climate Research co-sponsored by IFPRI and the CGIAR GENDER Platform.
- Dec. 2021 *Project Note*: Exploring Small Scale Irrigation-Nutrition Linkages. Innovation Lab for Small-Scale Irrigation Project Note, 3.
- Nov. 2021 *Presentation*: “Gendered Impacts of Covid-19 in 4 Countries: Kenya, Niger, Rwanda, and Uganda” at a High-Level Policy Dialogue on Policy Responses to the Gendered Impacts of COVID-19 in the Africa Region hosted by FAO.
- Oct. 2021 *Video*: Pathways to more nutrition-sensitive irrigation.
- Oct. 2021 *Poster Presentation*: “Small-scale Irrigation and Women’s Empowerment: Lessons from Northern Ghana” at a poster session on “Irrigation and Women’s Empowerment” at the GENDER Platform Conference Cultivating Equality.

- Oct. 2021 *Presentation*: “Conceptual linkages between gender, climate change and food systems: What does the evidence show?” at a session on “Climate Change, Gender and Agriculture: Implications for Policy” at the GENDER Platform Conference Cultivating Equality.
- Oct. 2021 *Presentation (on demand)*: on “Irrigation-Nutrition Linkages under a Changing Climate” at the Water for Food Global Forum session on “Integrating Nutrition in Irrigation Investments,” sponsored by the Water for Food Daugherty Global Institute, University of Nebraska
- Aug. 2021 *Panel Discussion*: “Irrigation and socio-environmental resilience: Finding confluence between strategy and disaster” organized by the Innovation Lab for Small-Scale Irrigation at Stockholm World Water Week
- Apr. 2021 *AgriLinks Blog*: Toward Resilient Livelihoods, Food Security and Nutrition for All: Gendered Impacts of COVID-19
- Mar. 2021 *IFPRI Policy Seminar*: Towards Resilient Livelihoods, Food Security, and Nutrition for All: Confronting the Gendered Impacts of COVID-19
- Mar. 2021 *Innovation Lab for Small-Scale Irrigation Research Meeting*: Small-Scale Irrigation and Women’s Empowerment in Northern Ghana

- Feb. 2021 *IFPRI Blog*: How women’s empowerment can expand crop diversification as a climate adaptation strategy in Bangladesh.
- Feb. 2021 *Technical Training*: Integrating Mixed Methods in Research (with Ruth Meinzen-Dick) for the Innovation Lab for Policy Research, Capacity, and Influence (PRCI)
- Sept. 2020 *Innovation Lab for Small-Scale Irrigation Blog*: What women want: First steps to inclusive irrigation investments
- July. 2020 *AgriLinks Blog*: COVID-19 & Gender: Potential Pathways of Impact and Research Challenges
- May. 2020 *Presentation*: “The Gendered Impacts of COVID-19 in Developing Countries” for the webinar Harmonization of COVID-19 phone surveys in CGIAR, *CGIAR Platform for Big Data in Agriculture*
- Feb. 2020 *Presentation*: Integrating Gender in Policy Research and Outreach, *USAID Innovation Lab for Policies, Research, Capacity, and Influence (PRCI)*
- Jan. 2020 *AgriLinks Blog*: Getting “Gender Right” is Essential for the Sustainability of Food Systems
- Oct. 2019 *Presentation*: “The Role of Gender for Cross-Sectoral, Transformative Change” in an *IFPRI*

Policy Seminar on Bigger Change, Faster for People and Nature

- Sept. 2019 *IFPRI Blog*: A Focus on Gender is Key to Climate Adaptation
- Sept. 2019 *Presentation*: “Increasing Resilience to Climate Change using a Gender and Nutrition Lens” at the *Danforth Center Annual Conference*, St. Louis, MO, USA
- Sept. 2019 *Presentation*: “Better on Strengthening Men’s and Women’s Resilience to Climate Change” in an *IFPRI Policy Seminar on Adapting to New Climate Realities: Doing More, Better, and New*
- June 2019 *Presentation*: “Why Climate Resilience in Agriculture is not Possible Without Considering Gender” in the session What will it Take to Build Resilient Food Systems Globally? At the *55th Annual Conference of the Association for International Agriculture and Rural Development*
- Mar. 2019 *Guest Commentary: The Chicago Council on Global Affairs*: Considering Gender in Irrigation: Technology Adoption for Women Farmers
- Nov. 2018 *Presentation*: “Resilience for all: Assessing gender and social dynamics for inclusive resilience” at the Resilience Measurement Evidence and Learning Conference, New Orleans, LA, USA

Jun. 2018 *Presentation:* “Addressing gender and nutrition issues in climate-smart technology design and dissemination” at the Cracking the Nut: Promoting Agricultural Technology Adoption and Resilience Conference, Antigua, Guatemala

SKILLS

MS Word, MS Excel, PowerPoint, STATA, NVIVO, and Visuallyzer

LANGUAGES

English – Native; Spanish – Proficient



24 February 2022, Washington, DC

AUTHOR'S DECLARATION

Declaration in lieu of an oath on independent work

according to Sec. 18(3) sentence 5 of the University of Hohenheim's Doctoral Regulations for the Faculties of Agricultural Sciences, Natural Sciences, and Business, Economics and Social Sciences

1. The dissertation submitted on the topic

Small-Scale Irrigation and Women's Empowerment:
Lessons from an Irrigation Intervention in Northern
Ghana

is work done independently by me.

2. I only used the sources and aids listed and did not make use of any impermissible assistance from third parties. In particular, I marked all content taken word-for-word or paraphrased from other works.

3. I did not use the assistance of a commercial doctoral placement or advising agency.

4. I am aware of the importance of the declaration in lieu of oath and the criminal consequences of false or incomplete declarations in lieu of oath.

I confirm that the declaration above is correct. I declare in lieu of oath that I have declared only the truth to the best of my knowledge and have not omitted anything.

Washington, DC USA 11 July 2021

A handwritten signature in black ink, appearing to be 'Elizabeth', written in a cursive style.

Place, Date

Signature