World Development Perspectives 31 (2023) 100529

Contents lists available at ScienceDirect

World Development Perspectives

journal homepage: www.sciencedirect.com/journal/world-development-perspectives

Research paper

Ecological shocks and children's school attendance and farm work in Ghana

Edward Martey [a,1,*], Prince M. Etwire [a,2], Jonathan Mockshell [b,3], Ralph Armah [c,d,4], Eli Akorsikumah [e,5]

[a] Socio-Economic Section, CSIR-Savanna Agricultural Research Institute, Ghana P.O. Box TL 52, Tamale, Ghana
[b] International Center for Tropical Agriculture (CIAT), Apartado Aereo 6713, Cali, Colombia
[c] Institute of Statistical, Social and Economic Research (ISSER), University of Ghana, Legon, Accra, Ghana
[d] Environment for Development (EfD), Ghana
[e] University for Development Studies, Nyankpala, Tamale, Ghana

ARTICLE INFO

Keywords:
Ecological shocks
School attendance
Farm working hours
Ghana

ABSTRACT

Accelerating the education of children and reducing child labor in agriculture remains an important development pathway to preventing intergenerational poverty and achieving the sustainable development goals. While several studies have analyzed the impact of ecological stressors on yield, income, and food security, there is limited understanding of the linkages of prevailing ecological shocks to child education and farm work. In this paper, we examine the effect of ecological shocks of pest and weed invasion on children's school attendance and working hours on the farm using the seventh round of the Ghana Living Standards Survey (GLSS). We employ a multinomial endogenous switching regression (MESR) model that corrects for selection bias and endogeneity originating from both observed and unobserved heterogeneity. The results show that double shocks (pests and weeds) reduced the number of children attending school by 11% and increased children's on-farm working hours by 0.75 h. Comparatively, the decline in the number of children attending school due to weed invasion (0.88) is higher than the decline due to pest invasion (0.43). Furthermore, weed invasion increases children's on-farm working hours by 0.05 h while pest invasion reduces children's on-farm working hours by 0.08 h. Increasing access to improved agricultural technologies bundled with credit and policies are critical to reducing the threats from ecological shocks and improving farmers' welfare. To avert the decline in school attendance and children's working hours requires training farmers to reduce the practice of continuous cropping and to embrace crop rotation and fallow to reduce the spread of pests and weeds.

1. Introduction

In developing economies, family farms play a critical role in ensuring food and nutrition security of households and contributing to economic growth. Children contribute labor to agricultural production and related off-farm activities. Economic burden, social norms, and ecological shocks are major drivers of the forms and types of activities that children participate in the farm. Often, there is a trade-off between children's farm work and spending time pursuing formal education (Dunne and Humphreys, 2022). With the renewed global interest in promoting children's education and reduction of child labor in response to achieving Sustainable Development Goal 4 (SDG 4) (United Nations, 2015), there is a consensus among stakeholders to reduce child labor in agriculture. Through the SDGs, world leaders agreed to achieve universal primary, all-inclusive, and equitable education. Governments have made considerable efforts in promoting children's education across Sub-Saharan Africa (SSA). The case of Ghana is peculiar and characterized by several educational reforms, such as the recent free senior

* Corresponding author.
E-mail addresses: eddiemartey@gmail.com (E. Martey), etwiremaxwellprince@gmail.com (P.M. Etwire), J.Mockshell@cgiar.org (J. Mockshell), rnaarmah@ug.edu.gh (R. Armah), akorsikumah@gmail.com (E. Akorsikumah).
[1] ORCID: 0000-0002-6933-3685
[2] ORCID: 0000-0002-6533-2538
[3] ORCID: 0000-0003-1990-66570
[4] ORCID: 0000-0003-4552-971X
[5] ORCID: 0000-0002-3871-7184

https://doi.org/10.1016/j.wdp.2023.100529
Received 25 June 2022; Received in revised form 27 February 2023; Accepted 16 August 2023
Available online 25 August 2023

high school (FSHS) program that seeks to provide free secondary education for all Ghanaian children (Chanimbe and Dankwah, 2021). Beyond school enrolment and infrastructural provisioning, time spent in school is critical to achieving educational outcomes. But economic, social and ecological drivers impact the achievement of child education outcomes (Dunne and Humphreys, 2022). While the literature has examined child education as it relates to economics and social factors, the exploration of effects of ecological shocks on child education is recent. We aim to contribute to this knowledge gap by examining the effects of ecological shocks on children's school attendance and farm work based on a novel framework, "*edu-workscape*.[6]"

Dunne and Humphreys (2022) developed the edu-workscape framework to explain the interaction between households, children's work, and schooling. Unlike the conventional approach which focused only on the direct link between child work and schooling, the edu-workscape emphasize the interaction between the domains by contextualizing the child in several ways. In the framework, the child is considered to be an active social subject with multiple identities which are likely to influence their experiences of work, education and harm. The conceptualization has several implications for research approach and policy implications. In the scientific literature, the education attainment agenda has been tremendous, attracting several empirical studies on children's education to guide policy (Agamile & Lawson, 2021; Björkman-Nyqvist, 2013; Duryea et al., 2007; Martey et al., 2021; Tabe-Ojong et al., 2021). Many of these studies have revealed important empirical setbacks at the micro level that compromised the attainment of children's educational outcomes. For instance, Agamile & Lawson (2021) demonstrated that farm households' exposure to rainfall shocks significantly reduces the attainment of education by children in Uganda. Martey et al. (2021) used nationally representative data to show that food hardship consistently reduces children's school attendance in Ghana. Glick et al. (2016) highlighted concerns about health and economic shocks on children's schooling. Their study finds that a health shock, measured as parental death or illness, increases the likelihood of dropping out of school among children in Madagascar. Additionally, economic shocks in the form of parental unemployment and lack of assets raises the probability of dropping out in Madagascar.

In addition to economic and climate shocks (Masih et al., 2014), farmers in developing economies are affected by ecological shocks. Ecological shocks include the invasion of pests and weeds that often offset economic and environmental conditions (Mbaabu et. al. 2020; Tabe-Ojong 2022). Pest invasion reduces crop yields and the incomes of farmers (Oliveira et al., 2014) causing losses on field (pre-harvest losses) and in storage (post-harvest losses) (Oerke, 2006). The indirect effect of weed invasion is experienced through competition with crops over resources, serving as host for pests inter alia (Zimdahl, 2018). The invasion of pests and diseases contributes to wide-spread farm income reduction, uncertainty in farming, and farm households' vulnerability. For farmers in an imperfect economy where there is a near absence of farm insurance, obvious strategies to adapting to farm shocks can involve both on-farm and off-farm diversification (Dimova et al., 2015; Asfaw et al., 2019; Bandyopadhyay and Skoufias, 2015). Other studies (Tafere, 2014; Rose and Dyer, 2008) have shown that environmental shocks such as drought or flooding is associated with difficulty in regular school attendance. In contrast, some studies in Ghana (Ananga, 2011), Ethiopia (Boyden et al., 2021), and Madagascar (Moreira et al., 2017) have shown that the type of work children (boys and girls) engage in affect their schooling. The greater need for care-giving and completion of household chores by female children influence their punctuality at school (Dunne and Ananga, 2013). The literature also highlights that school may not necessarily improve learning (Tafere and Pankhurst, 2015; Humphreys et al., 2015) and prevent child work given that tasks assigned to children at school may be demanding which expose them to several risks (Adonteng-Kissi, 2018; Bakari, 2013; Dunne et al., 2005). Finally, the proponents of the edu-workscape suggested that social domains must be discussed within the wider economic, social, temporal, and spatial contexts to understand the compromises that households undertake regularly regarding education and work (Dunne and Humphreys, 2022; Boyden et al., 2021).

In this paper, we define ecological shocks as the spread of field insect pests and invasive weed, *Striga hermonthica* (witchweed) which has been shown to significantly reduce crop productivity, adversely impact the sustenance of people and significantly reduce food security and increase poverty (David et al., 2022; Gowda et al., 2021; Dawud et al., 2017). The invasion of this parasitic weed thrives in places with poor soils and intensive crop cultivation with poor management practices (Gowda et al., 2021). Similarly, the insect pests can cuase damage to crop both on the field and during storage. In the advent of ecological shocks, children may be kept on the farm or tasked with off-farm labor as a coping strategy to reduce the effect of the shocks and contribute to household income. These strategies potentially reduce the contact hours of children with teachers, causing reduction in school outcomes with subsequent long-term effects on the intergenerational transfer of poverty (Kes and Swaminathan, 2006).

Recent studies on income shocks have examined the impact of agricultural and ecological shocks on educational attainment, cognitive skills, and aspirations (Baker et al., 2020; Tabe-Ojong, 2022; Tabe-Ojong et al., 2021). However, there are limited studies on the combined effects of pests and weeds on school attendance and children's farm working hours. A recent study, Tabe-Ojong et al. (2021), demonstrated that ecological shocks (pest and weed invasion) reduce households' aspiration capacity. Using a partial analysis of the edu-workscape framework, our study investigates the link between ecological shocks (pests and weeds) on children's schooling and working hours, using Ghana as a case study. Furthermore, the study expands the immediate impact of ecological shocks on schooling to include both public and private school attendance. We also quantified the effect of the ecological shocks on children's on-farm working hours. This design contributes to the uniqueness of this study. Our results show that double shocks (pests and weeds) reduced the number of children attending school and increased children's working hours on the farm. The result remains robust to an alternative estimation method that corrects for endogeneity.

The rest of this article is structured as follows. Section 2 presents the Ghanaian context on the environment, school attendance and child work while Section 3 presents the conceptual framework that provides the basis for establishing the link between shocks, schooling and child work. This is followed by the presentation of data and descriptive statistics in Section 4, empirical strategy in Section 5, results and discussion in Section 6, and conclusions in Section 7.

2. The Ghanaian context - environment, school attendance, and child work

School attendance is a precursor for achieving educational outcomes such as academic performance. The urge to promote children's education globally and specifically in Ghana has received much attention as manifested in the Sustainable Development Goal Four (SDG 4). The SDG4 focuses on education and aims to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all." Specifically, the goal seeks to promote children's school enrolment and attendance by addressing challenges such as the lack of suitable school infrastructure, shortage of teachers and teaching materials, and high

[6] The edu-workscape is a triangular matrix which includes domains - workplaces, the school, and the household with the child as the central focus of decision-making through the interaction of the three domains. The matrix highlights the fact that children's experiences are shaped by social relations within and between home, school and work in specific contexts. The edu-workscape foregrounds the dynamic interplay within and between each institution and emphasises how the child navigates and experiences this nexus (Dunne and Humphreys, 2022).

school fees, which some parents cannot afford (Boissiere, 2004; DeJaeghere et al., 2006).

Ghana has long introduced the free compulsory universal primary education (FCUBE) policy which mandates government to make basic education fee-free and compulsory. The policy also provides books and other learning materials that pupils needed for school. Subsequently, the government introduced free school meals and free school uniforms (Salifu et al., 2018). This policy also sought to improve the quality of education through expansion of education infrastructure while building the capacity of more teachers at the basic level (Salifu et al., 2018; Akyeampong, 2009). Assessment of the policy show a steady increase in primary school attendance for both boys and girls (Akyeampong, 2009).

Fig. 1 shows the gross enrolment ratio before and after the implementation of the FCUE. The highest gross enrolment ratio pre-FCUE policy is 80%. The gross enrolment ratio increased to 103% post-FCUE policy implementation. Generally, gross enrolment ratio has been increasing after the policy. Similarly, the number of children attending primary school increased after the implementation of the FCUE policy (Fig. 2).

Despite the significant gains made in terms of reducing child labour[7] (International Labour Organization [ILO], 2018) and increasing enrolment, increasing ecological shocks induced by insect pests and invasive weed, poses a serious threat to child education by increasing child work. Although the public cost of education has declined, the private cost of schooling is considerably high due to the long travel distance to and from school (Afoakwah and Koomson, 2021) and costs of supplies. High demand for household chores, competing interest of farming and schooling, and household poverty have contributed to increase in child labour and reduction in school attendance (UNICEF Data Warehouse, 2022). The UNESCO estimate that about 21 percent of children between the ages of 5 to 17 years are involved in child labour (for example, agriculture, fishing industries, prostituting and trafficking, and street work) and 14 percent are engaged in hazardous forms of labour (UNICEF, 2022; Ortiz-Ospina and Roser, 2016). UNESCO estimates approximately two million children to be involved in child labour (Ghana population, 2022). According to ILO and UNICEF, the global increase in child labour is partly attributed to the novel COVID-19 pandemic which led to lockdowns, school closures, and economic struggles, thus forcing children to work (Child Labour: Global Estimates, 2020).

In a typical agricultural household, male children are mostly engaged in one form of an agricultural activity due to high demand for labour which creates a heavy domestic workload for girls (UNICEF, 2022) and thus reduce school attendance (Boateng and Dako-Gyeke, 2022). Low use of labour-saving agricultural technologies and continuous cropping among agricultural households increase pest infestation and weed invasion which requires high cost of control or abandoning farms. In view of this, any agricultural shock may increase labour time for male child or increase labour time for both male and female child in non-agricultural activities and subsequently reduce school attendance and learning outcomes (Boateng and Dako-Gyeke, 2022). The positive effect of ecological shocks on school attendance is more noticeable among households where children travel long distance to school and incur high extra costs of education due to transportation, feeding, and other supplies. Children in such households are pushed into the labour force at a younger age to provides support to their parents on the farm and thus reduce school attendance (Boateng and Dako-Gyeke, 2022; Hamenoo et al., 2018). Anecdotal evidence suggests that within the rural agricultural setting, children engaged in farming are viewed as a positive experience for acquiring valuable skills, cultural identity, and sense of belonging within the community (Krauss, 2013). This study tests the hypothesis that ecological shocks (insect pests and invasive weed) reduce school attendance and increase child farm work.

3. Conceptual framework linking ecological shocks, children's schooling, and work

This section provides the concept underpinning ecological shocks, children's schooling, and farm work among farm households (Fig. 3). Our conceptual framework is based on the tripartite "edu-workscape" framework proposed by Dunne et al., (2021) with slight modification to suit agricultural households. The framework provides insight to the complex household decisions on education and work. We apply this framework to establish the link between ecological shocks and children's schooling and work. The framework shows the "dynamic interplay within and between the institutions and the ways in which the child navigates and experiences the social landscape" (Dunne and Humphreys, 2022; pp.7). In the framework, the child is put in three overlapping social domains (the household, the school, and the workplace (s)) and shows the multiple tensions between these domains. For example, the school domains have a broad and rigid education systems which do not recognize community constraints (Bourdillon et al., 2015). Households are dynamic and belong to the communities where the school operate and have multiple and often changing family structure (Thorsen and Yeboah, 2021). The workplace exists in several locations as communities, households, and schools. The social domains operate within an economic, social, temporal and spatial contexts (Dunne and Humphreys, 2022). The interplay between and within the social domains are influenced by several external factors such as culture, environmental shocks, political forces, and economic policies.

Within the African context, low school attendance may be due to environmental shocks, such as drought or flooding (Rose and Dyer, 2008; Tafere, 2014), migration and mobilities (Martey and Armah, 2021; Robson et al., 2006), and poverty and family crises (Thorsen and Yeboah, 2021; Hamenoo et al., 2018; Jonah and Abebe, 2019; Bandara et al., 2015). As household income falls below a threshold, children are forced to work for the household to meet the basic subsistence requirements through alternative income source (Bandara et al., 2015). The type of work undertaken by children largely affects their schooling. For the purpose of our study, we focused on how ecological shocks (pest infestation and weed invasion) shapes the intercourse between and within the three social domains. Given that the households are agrarian and vulnerable to climate shocks (Serdeczny et al., 2017; Mathenge and Tschirley, 2015), pest infestation and weed invasion are likely to restrict farm households from achieving optimal productivity. Ecological shocks widen the gap between attainable and potential crop yields across many developing nations (Kassie et al., 2018: Tadele, 2017). These shocks contribute to significant crop losses in Africa given the conditions (i.e., temperature and humidity) that enable these shocks to thrive (Tadele, 2017). Reduction in crop productivity due to ecological shocks in Africa ranges between 30 and 60% (Oerke, 2006).

According to Mathenge and Tschirley (2015), households may participate in off-farm work as a long-term strategy to cope with external shocks. Alternatively, households are likely to increase their labour for on-farm activities to reduce the effects of the shocks therefore, reducing labour time for domestic and voluntary activities. However, the allocation of time resources or trade-offs among competing tasks largely depends on household demographics, socioeconomic characteristics, social and cultural norms, and labor availability (Kes and Swaminathan, 2006). The structure of the households is likely to influence labor availability among competing tasks. The extent to which males and females are deployed for farm work is influenced by labor availability and social and cultural norms. The redistribution of labor among competing tasks directly affects crop productivity. Male children are more likely to spend long hours in paid work while female children undertake more domestic unpaid work. Children undertake paid work to complement household income and support schooling. Similarly, children may work

[7] Child labour is defined as the employment of children that violates state, federal, or international laws because of the type of work performed or the age of the child involved (Merriam-Webster, s.v. "Child Labor," Accessed July 1, 2022, https://www.merriam-webster.com/dictionary/child labor.).

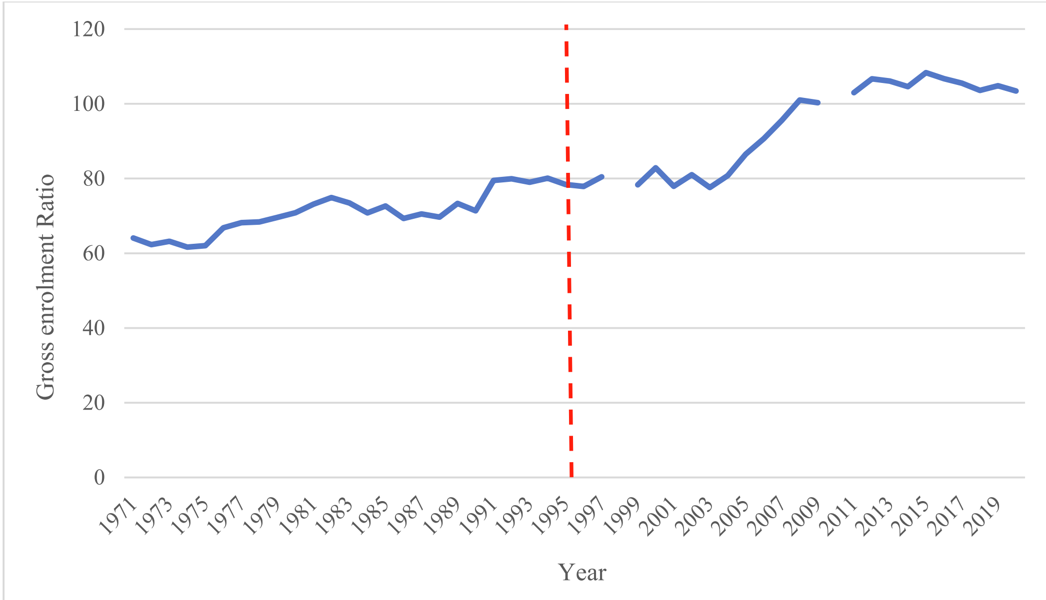

Fig. 1. Primary Gross Enrolment Ratio in Ghana, 1971–2020 Source: World Data Bank, 2023 (https://data.worldbank.org/indicator/SE.PRM.ENRL?locations=GH).

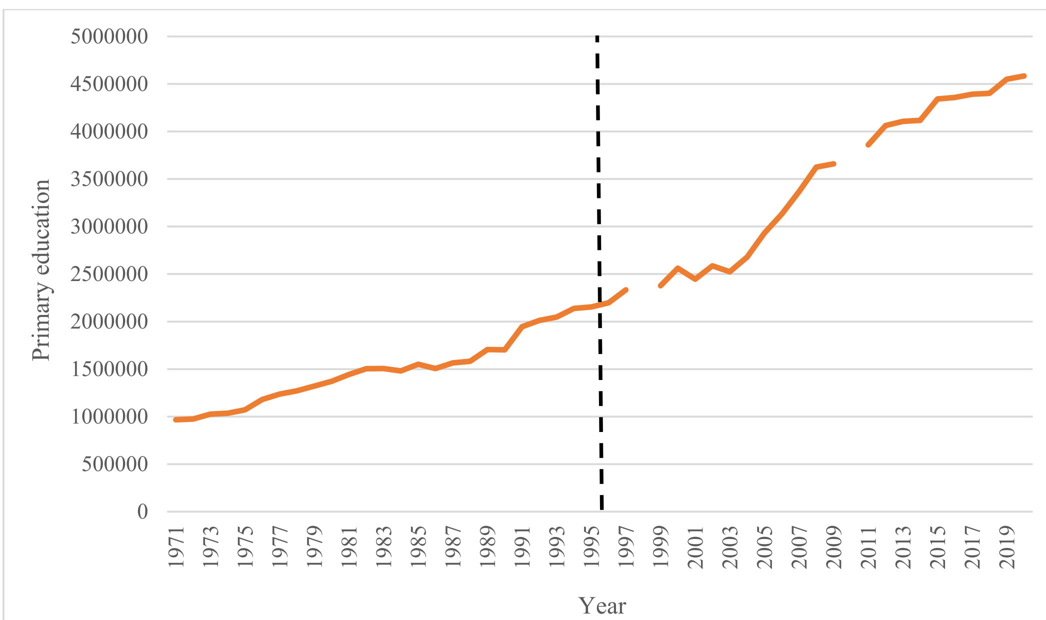

Fig. 2. Primary education, pupils in Ghana, 1971–2020 Source: World Data Bank, 2023 (https://data.worldbank.org/indicator/SE.PRM.ENRL?locations=GH).

long hours on-farm to control the spread of the shocks. The long hours in paid and unpaid work may likely affect school attendance.

The intersectoral trade-off is particularly severe among income-poor households with few assets and less available labor, which may affect food security, child nutrition, health, and education (Kes and Swaminathan 2006). To minimize crop losses, household labor may be shifted towards agricultural production. It is typical among farming households that children have limited or no decision-making power when it comes to the use of their time or labor; such decisions are taken by parents or adult household members. Thus, children may be directed to carry out farm work, which reduces their school attendance or hours spent in school. However, within the framework, the school domain can induce child labour effect. For example, children in rural schools are likely to engage in hard physical work (toiling on school farm, fetching water and sand for school construction project) which may be hazardous and thus reduce learning outcomes (Dunne and Humphreys, 2022). The combined effects of these arduous physical work in school and the burden of domestic and farm works can reduce school attendance and learning outcomes. Our study focuses on a partial analysis of the framework and test two main hypotheses: (1) ecological shocks reduce children's school attendance and (2) ecological shocks increase children's workload.

4. Data and descriptive statistics

4.1. Data

We used the seventh round of the Ghana Living Standards Survey (GLSS), a nationally representative household-level dataset that assesses

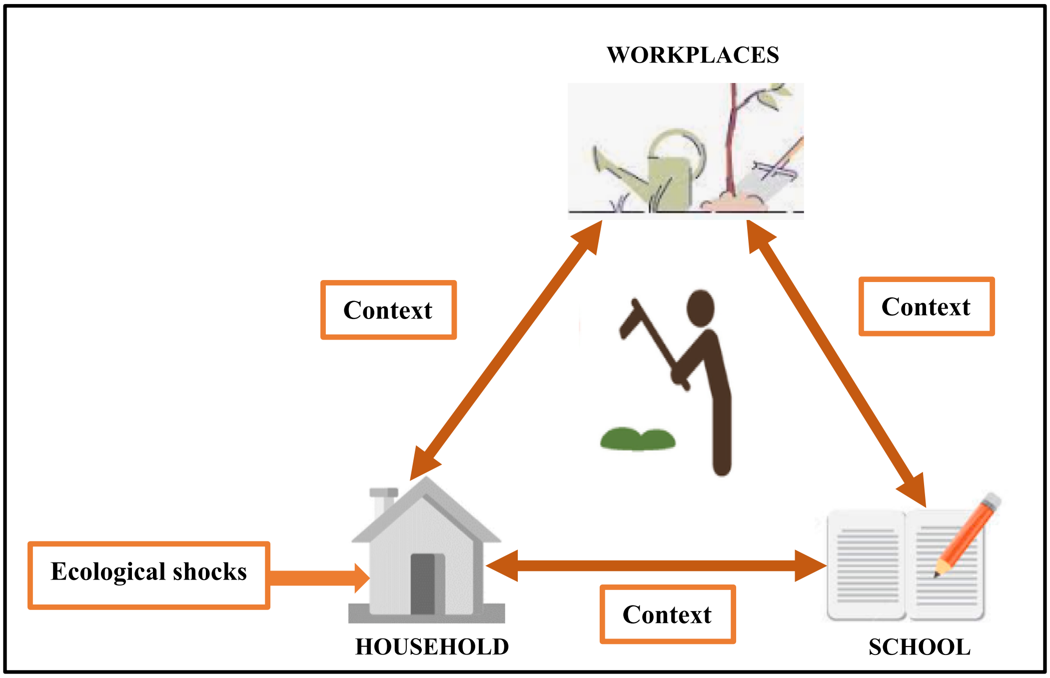

Fig. 3. Conceptual model of ecological shock, schooling, and child work Source: Adapted from Dunne and Humphreys, (2022).

the living standards of Ghanaians. The data was collected between 22 October 2016 and 17 October 2017. Details of the sampling approach are adequately described in the GLSS 7 main report (Ghana Statisitical Service [GSS], 2018). Our analysis focused on farm households in the Northern, Upper East and Upper West Regions, which together constitute northern Ghana.[8] The total sample used for the analysis is 3,251 households.

Our study focuses on the section of the data that captures household demographics, socioeconomics, assests, child education, child farm work, as well as institutional and geographic controls. Finally, we computed ecological shocks based on incidence of weed or pest invasion on farmers' farms within the year preceding data collection.

4.1.1. Ecological shocks

Our primary measure of ecological shocks is insect pest infestation and invasion of a parasitic weed. The most dominant invasive weed in northern Ghana is *Striga hermonthica* (witchweed): a parasitic weed that thrives in moisture and limited fertilizer/organic matter content as well as when when poor crop management practicies are undertaken. Maize grown in Striga-prevalent soils has a yield loss potential of up to 100% when improperly managed or controlled (David et al, 2022; Teka, 2014; Atera et al., 2013). Monocropping, relative to rotation and intercropping systems, increases the prevalence of Striga in smallholder farming systems (Badu-Apraku & Fakorede 2017). The farming system in northern Ghana is characterized by continuous cropping with little or no fallow: a practice that increases *Striga* invasion in most soils, leading to farmers abandoning their fields.

Pests are biotic stressors that increase crop losses (Oerke, 2006). Pest attacks occur at different stages of crop growth (stem, leaves, flowers) with varying levels of economic damage (Day et al., 2017). Studies have shown that a fall armyworm (FAW) attack can lead to 100% destruction of crops (Kasoma et al., 2021). In Ethiopia and Ghana, FAW may lead to 30% and 45% yield reduction, respectively (Assefa & Ayalew, 2019; Day et al., 2017). The climate of Ghana provides favorable conditions for several pests with considerable crop loss (Obeng-Ofori & Amiteye, 2005). Weevils are common pests that attack crops both on the field and in storage with an estimated damage of 8–15% (Williams 2010). Our study focuses on weevil and FAW infestation.

The data shows that farmers who experienced only pest invasion and only weed invasion spend about GHS 123 (USD 29)[9] and GHS 120 (USD 28) annually to control the shocks, respectively. Farmers who experienced both pest and weed invasion spend GHS 204 (USD 48) annually to control the shocks.

4.1.2. Children's school attendance and farm work

In this study, we consider children below 15 years of age to be at the basic school level. School attendance is measured as the number of children in a household attending school (private and public), which is a form of human capital accumulation (Martey et al., 2021). We separated private and public school as they reflect differences in the resource outlays of parents. Children's farm working hours are computed as the number of hours children spend working on a farm either alone or together with household members.

4.2. Descriptive statistics

Fig. 4 shows the relationship between ecological shocks and working hours. Consistent with the conceptual framework, pest and weed shocks are positively associated with working hours. Farmers who experienced both weed and pest invasion worked the most hours followed by farmers who experienced only weed and only pest invasion. Fig. 5 highlights the relationship between shocks and school attendance and child working hours. With reference to child working hours, farmers who experienced both pest and weed invasion recorded the highest child working hours followed by farmers who experienced only weed invasion and only pest invasion. However, the relationship between shocks and school attendance is mixed. Farmers who experienced both weed and pest invasion recorded the highest school attendance followed by farmers who experienced only pest invasion and only weed invasion. Compared with

[8] Northern Ghana is now made up of Northern, North East, Savannah, Upper East and Upper West Regions. The GLSS 7 data was captured before the administrative restructuring of the regions from three to five.

[9] The Bank of Ghana exchange rate at the time of the survey (2017) was GHS 4.271 to USD 1 at the end of January 2017.

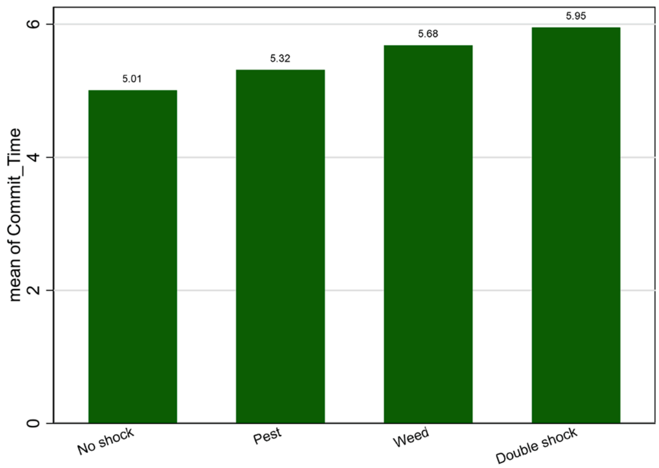

Fig. 4. Committed time by ecological shocks.

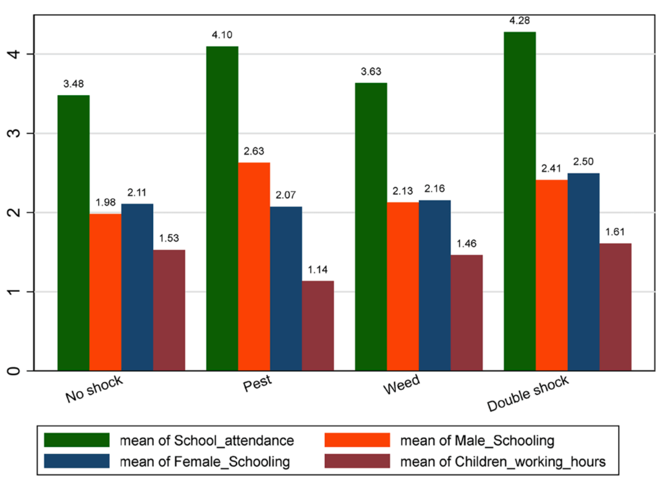

Fig. 5. School attendance and farm work by shocks Source: Authors' construct based on GLSS 7 data.

farmers who did not experience any of the ecological shocks, farmers who experienced pest invasion recorded a decline in female child school attendance.

Table 1 shows the proportion of ecological shocks experienced by sample farmers in Northern Ghana. The ecological shocks considered in this study include weed and pest invasion, which leads to four possible combinations of ecological shocks. For the total sample of 3,251 farmers, about 46% of the farmers did not experience any of the shocks, while 9% and 29% of the farmers experienced pest only and weed only, respectively. About 16% of the farmers experienced both pest and weed infestation.

Table 2 shows the descriptive statistics of the explanatory variables. About 18.3% of the sampled farming households in Northern Ghana are headed by females. The average age of farmers is 48 years with 2.39 years of formal education. The average number of years of education indicates that the sampled farmers have had minimal primary education. Regarding household characteristics, a farming household contains approximately six members. About 79% of household heads are married. On average, about 70.3% of the sample is employed and about 8.4% engage in some type of off-farm employment. A farming household in the study area owns about six livestock. Regarding access to institutional facilities, 32.4% of farmers had extension officers visiting their

Table 1
Ecological shock packages.

Choice (j)	Binary double package	Ecological shocks: Pest P_1	P_0	Weed W_0	W_1	Frequency (%)
1	P_0W_0		√	√		46.05
2	P_1W_0	√		√		8.92
3	P_0W_1		√		√	28.55
4	P_1W_1	√			√	16.49

Notes: The binary double package represents the possible ecological shock combinations. Each element in the shock package is a binary variable for ecological shocks (pests (P) and weeds (W)). The subscript "1″ represents experience of shock and 0 if otherwise.

communities, approximately 9% had access to a credit facility, and about 69% of the farmers reported having access to a motorable road. Additionally, farmers have an average of about 26 neighbors within their network who have access to agricultural extension services, while only 6% of farmers had access to irrigation services. Also, about 41 neighbors of farmers experienced some form of ecological shock on their farms during the time of the study; and the majority (89.5%) of farmers are members of rural farming households. Regarding regional distribution, 31.8%, 34.4%, and 33.9% of the sampled farmers reside in the Northern, Upper East and Upper West Regions, respectively.

5. Empirical strategy

The study employed the multinomial endogenous switching regression (MESR) to model the effect of ecological shocks on children's school attendance and farm work. A farmer in our sample may have experienced a single or a combination of ecological shocks leading to four possible outcomes – no shock (P_0W_0), pest invasion (P_1W_0), weed invasion (P_0W_1), and a combination of pest and weed invasion (P_1W_1). Under the assumption of exogeneity of the ecological shocks, the ordinary least squares (OLS) method can be applied to generate a consistent estimate of the effect of shocks on the outcome variables. However, farm management practices may either reduce or increase the spread of the shocks. The management practices of farmers may be influenced by both observable and non-observable factors, which may be correlated with the error term of the outcome model. In such case, claim of strict exogeneity in ecological shock is not plausible, thus, leading to a biased estimate of children's school attendance and working hours. Second, we suspect a reverse causality between the shocks and the outcome variables. Ecological shocks may influence schooling and working hours. Alternatively, a reduction in farm working hours and increase in school attendance may reduce labor for farm work, which may contribute to the spread of the shocks.

The study addresses the endogeneity and selection bias issues by employing the multinomial endogenous switching regression (MESR) treatment effect based on the Dubin and McFadden (1984) and Bourguignon et al. (2007) approaches. The MESR allows for the evaluation of alternative combinations and individual shocks. The MESR corrects for the selection bias by computing an inverse Mills ratio (IMR) based on the theory of truncated normal distribution (Malikov and Kumbhakar, 2014; Bourguignon et al., 2007). Second, the MESR allows for the construction of a counterfactual based on returns to the characteristics of farmers with experienced shocks and those who did not experience any shock (Kassie et al., 2018). Third, the MESR allows for interaction between choices of alternative shocks (Wu and Babcock, 1998).

The MESR involves a two-stage simultaneous estimation technique where the first stage models farmers' experience of shock using a multinomial logit selection (MNLS) model and accounts for unobserved heterogeneity. The second stage is the outcome equation estimated with the OLS. The IMR computed from the first stage is included as an additional variable to account for selection bias from time-varying, unobserved heterogeneity.

5.1. First stage – Multinomial selection model

As stated previously, farmer i experiences a shock package j, over an alternative shock package, k, that influences outcomes (school attendance and working hours) such that $S_{ij} > S_{ik}$ $k \neq j$. The expected outcome S^*_{ij} derived by the farmer from experiencing shock package j is a latent variable determined by observed household, socio-demographic, institutional and location characteristics (X_i), and unobserved characteristics (ε_{ij}):

$$S^*_{ij} = X_i\beta_j + \varepsilon_{ij} \tag{2}$$

Following Khonje et al., (2018) and assuming G is an index that characterizes farmer's choice of package, the index can be expressed as:

$$\Omega = \begin{cases} 1 \text{ iff } \quad S^*_{i1} > \max\limits_{k\neq j}\left(S^*_{ik}\right) \text{ or } \pi_{i1} < 0 & \\ \quad\vdots & \forall\, k \neq j \\ J \text{ iff } S^*_{ij} > \max\limits_{k\neq j}\left(S^*_{ik}\right) \quad \text{or } \pi_{ij} < 0 & \end{cases} \tag{3}$$

where $\pi_{ij} = \max\limits_{k\neq j}(S^*_{ik} - S^*_{ij}) < 0$(Bourguignon et al., 2007).

Assuming that the household-specific heterogeneity or idiosyncratic error are independent and identically Gumbel-distributed across all ecological shock choice sets (Bourguignon et al., 2007), the probability (P_{ji}) that a farmer i will experience shock j can be expressed as:

$$P_{ij} = \Pr\left(\pi_{ij} < 0 | X_i\right) = \frac{\exp\left(X_i\beta_j\right)}{\sum_{k=1}^{J}\exp(X_i\beta_k)} \tag{4}$$

Equation (4) is the multinomial logit model (Mc-Fadden, 1973) estimated by maximum likelihood.

The second stage of the MESR shows the relationship between the outcome equation for each possible regime j (excluding farmers who did not experience any shock as a base category) with selection bias correction term:

$$\begin{cases} \text{Regime } 1: \; Y_{i1} = Z_i\vartheta_1 + \sigma_1\widehat{\lambda}_1 + \omega_{i1} \quad \text{if } P = 1 & \\ \quad\vdots & j = 2,\ 3,\ 4 \\ \text{Regime } J: \; Y_{iJ} = Z_i\vartheta_j + \sigma_j\widehat{\lambda}_j + \omega_{ij} \quad \text{if } P = J & \end{cases} \tag{5}$$

where Y_{jit} represents outcomes associated with the selected regime $j(j = 0, \cdots, J)$ and observed if only one of possible shocks is experienced, Z_i represents a vector of explanatory variables, σ is the covariance between εs (first stage) and μs (second stage), $\widehat{\lambda}_j$ is the IMR calculated from estimated probabilities in Equation (4) as:

$$\widehat{\lambda}_j = \sum_{k\neq j}^{J}\rho_j\left[\frac{\widehat{p}_{ik}\ln\left(\widehat{p}_{ik}\right)}{1-\widehat{p}_{ik}} + \ln\left(\widehat{p}_{ij}\right)\right] \tag{6}$$

where ρ is the correlation between εs and μs, and ωs are error terms with an expected value of 0. Based on the multinomial choice setting, there are $J - 1$ selection correction terms, one for each alternative package of shocks.

Following previous studies and drawing from the peer effect literature (Verkaart et al., 2017; Tessema et al., 2016; Magnan et al., 2015; Ward and Pede, 2015; Krishnan and Patnam, 2014; Wollni and Andersson, 2014; Conley and Udry, 2010), we computed the leave-out-mean of farmers who have experienced shocks as a potential instrument for ecological shocks. Based on the relevance condition, we propose that farmers are more likely to be influenced by weeds and pests if neighbors within the same community experience weed and pest invasion. The credibility of the instrument also relies on the fact that the shocks are invasive so the possibility of spreading across farms is highly possible. We conducted a falsification test following the approach of Di Falco et al. (2011). The results confirm that the excluded variable has a significant effect on weed and pest invasion (see Table A2 in the Online Appendix) but not the outcome variables (see Tables A3-A6 in the Online Appendix).

5.2. Estimation of average treatment effects

The average treatment effect is estimated by comparing the expected outcomes of farmers who experienced shock and those without shocks in actual and counterfactual scenarios. The actual expected outcomes of farmers who experienced shocks are expressed as:

Table 2
Definitions and summary statistics of the variables used in the analysis.

Variable	Description	Full sample Mean	SD
Socioeconomics			
Gender	1 if farmer is female, 0 if otherwise	0.183	0.387
Age	Age of farmer (years)	48.084	16.185
Education	Number of years of schooling (years)	2.386	4.335
Household size	Number of household members (number)	5.902	3.404
Marital status	1 if currently married, 0 if otherwise	0.788	0.409
Employment status	1 if employed, 0 if otherwise	0.703	0.457
Off-farm work	1 if engaged in off-farm work, 0 if otherwise	0.084	0.277
Household assets			
Livestock	Number of livestock owned	5.823	11.052
Institutional factors			
Extension visits	1 if extension visit community, 0 if otherwise	0.324	0.468
Access to credit	1 if access to credit, 0 if otherwise	0.088	0.284
Access to motorable road	1 if access to motorable road, 0 if otherwise	0.690	0.463
Network of extension access	Number of neighbors with extension access	26.223	20.588
Access to irrigation	1 if access to irrigation, 0 if otherwise	0.059	0.236
Instruments			
Neighbors experiencing shocks	Number of neighbors who experience ecological shock	41.076	21.037
Geographic controls			
Urban location	1 if residing in urban areas, 0 if otherwise	0.105	0.306
Northern	1 if residing in Northern Region, 0 if otherwise	0.318	0.466
Upper East	1 if residing in Upper East, 0 if otherwise	0.344	0.475
Upper West	1 if residing in Upper West, 0 if otherwise	0.339	0.473

Notes: SD is standard deviation.

$$\begin{cases} E(Y_{i2}|G=2) = Z_i\vartheta_2 + \sigma_2\widehat{\lambda}_2 \\ . \\ . \\ . \\ . \\ . \\ E(Y_{ij}|G=J) = Z_i\vartheta_1 + \sigma_1\widehat{\lambda}_j \end{cases} \tag{7}$$

The expected outcomes of adopters had they not experienced shock (counterfactual) is specified as:

$$\begin{cases} E(Y_{i1}|G=2) = Z_i\vartheta_1 + \sigma_1\widehat{\lambda}_2 \\ . \\ . \\ . \\ . \\ . \\ E(Y_{i1}|G=J) = Z_i\vartheta_1 + \sigma_1\widehat{\lambda}_j \end{cases} \tag{8}$$

The average treatment effect on the treated (ATT[10]) is computed as the difference between Equations (7) and (8):

$$ATT = E(Y_{i2}|G=2) - E(Y_{i1}|G=2) = Z_i(\vartheta_2 - \vartheta_1) + \widehat{\lambda}_2(\sigma_2 - \sigma_1) \tag{9}$$

The first term on the right-hand side of Equation (9) $(\vartheta_2 - \vartheta_1)$ captures the expected change in the mean outcome due to the differences in coefficients of the observed characteristics. The second term $(\sigma_2 - \sigma_1)$ corrects selection bias (Khonje et al., 2018).

5.3. Lewbel 2SLS regression

We complemented the MESR with Lewbel 2SLS (Lewbel, 2012) to check for the robustness of our estimates of children's school attendance and working hours. The Lewbel 2SLS is useful when valid external instruments are unavailable or considered potentially weak. This method exploits heteroskedasticity in the data to generate internal instruments that are used to address endogeneity.

6. Results and discussion

6.1. Determinants of pest and weed invasion

Table 3 shows the marginal effects from the multinomial logit estimates of ecological shocks. Farmers who did not experience any ecological shock constituted the base category. The Wald test shows that the explanatory variables included in the selection model provide a good explanation of pest and weed invasion. The number of neighbors experiencing shocks is significantly associated with ecological shocks. Consistent with the a priori expectation, the number of neighbors experiencing shocks increases the probability of a farmer experiencing weed invasion and experiencing both weed and pest invasion. However, we observed a negative effect on pest invasion.

The gender of the household head is positively associated with the likelihood of experiencing pest invasion (P_1W_0). The estimates indicated that, relative to male farmers, females are 4.3% more likely to experience pest invasion. Female farmers often cultivate relatively small farms due to constraints on land access and lack the financial resources necessary to invest in labor-saving technologies such as pesticides (Peterman et al., 2014). Age positively influences the invasion of pests but is negatively associated with weed invasion (P_0W_1), suggesting that a unit increase in the age of a farmer will lead to a 0.1% increase in P_1W_0 and a 0.1% decrease in P_0W_1. The results suggests that older household heads are more likely to experience P_1W_0 but less likely to experience P_0W_1. Older household heads are more likely to be supported by household members in the control of weeds but may lack the financial resources to invest in pesticides. An increase in formal education is associated with a 0.3% increase in P_1W_0 and a 0.3% decrease in P_0W_1. The result is consistent with Asfaw et al. (2019) who find that educated household heads tend to explore off-farm income generating activities with less commitment to farm activities, thus, leading to the high chance of pest invasion on crop farms. Alternatively, education leads to improved cognitive reasoning (Li et al., 2020; Khonje et al., 2018; Dahmann, 2017) that promotes the adoption of enhanced crop production strategies, which has the potential to reduce weed invasions.

The likelihood of weed invasion (P_0W_1) and double invasion of pests and weeds (P_1W_1) increases with household size. A unit increase in household size is associated with 0.5% increase in P_0W_1 and P_1W_1. Large household size denotes the existence of labor availability for farm work that encourages the cultivation of large areas. The cultivation of large areas exposes farmers to the risk of pest and weed invasion. Farmers that

Table 3
Marginal effects of ecological shock packages.

Variables	P_1W_0 Marginal effect (Std. Error)	P_0W_1 Marginal effect (Std. Error)	P_1W_1 Marginal effect (Std. Error)
Gender	0.043***	−0.007	−0.035
	(0.017)	(0.027)	(0.025)
Age	0.001**	−0.001***	−0.001
	(0.000)	(0.001)	(0.000)
Education	0.003***	−0.003*	0.002
	(0.001)	(0.002)	(0.002)
Household size	0.002	0.005**	0.005***
	(0.002)	(0.002)	(0.002)
Marital status	0.054***	−0.006	0.028
	(0.017)	(0.025)	(0.023)
Employment status	−0.001	0.071***	0.078***
	(0.011)	(0.018)	(0.017)
Off-farm work	0.038**	−0.035	−0.049*
	(0.017)	(0.030)	(0.026)
Livestock	0.001**	0.003***	0.002***
	(0.000)	(0.001)	(0.001)
Extension visits	0.011	0.017	0.031**
	(0.012)	(0.017)	(0.015)
Access to credit	−0.027	0.058**	−0.025
	(0.019)	(0.026)	(0.023)
Access to motorable road	−0.024**	−0.075***	0.034**
	(0.012)	(0.019)	(0.017)
Network of extension access	0.001***	0.001*	−0.004***
	(0.000)	(0.000)	(0.000)
Access to irrigation	−0.082**	0.097***	−0.101***
	(0.035)	(0.033)	(0.037)
Neighbors experiencing shocks	−0.001***	0.005***	0.002***
	(0.000)	(0.000)	(0.000)
Urban location	−0.021	−0.039	−0.012
	(0.017)	(0.026)	(0.021)
Region FE	Yes	Yes	Yes
Joint significance of instruments χ^2 (6)	275.16***		
Wald χ^2 (54)	882.94***		
Observations	3,251	3,251	3,251

Notes: The reference category is no shock (P_0W_0). P_1W_0– only pest shock; P_0W_1– only weed shock; P_1W_1– pest and weed shocks. *** Significant at the 1% level, ** significant at the 5% level, and * significant at the 10% level.

[10] The ATT is computed based on the post-estimation prediction of the actual and counterfactual expected value of the outcomes for a household that experienced shock j after estimating the MESR in Equation (6).

are gainfully employed are 7.1% and 7.8% more likely to experience P_0W_1 and P_1W_1, respectively. Employment outside the farm shifts farmers' committed time on the farm to the labor market, thereby, increasing the likelihood of weed and pest shocks. Similarly, households' engagement in off-farm activities is positively associated with P_0W_1 but negatively with P_1W_1. The result indicates that engagement in off-farm activities increases the likelihood of P_0W_1 by 3.8% but decreases P_1W_1 by approximately 5%. Ownership of livestock appears to compete with investments in crop farms, thus, increasing the risk of pest and weed invasion; whereas a unit increase in household total livestock increases the likelihood of P_1W_0, P_0W_1, and P_1W_1 invasion by 0.1%, 0.3% and 0.2% respectively.

Relative to farmers who did not receive extension service, farmers who received extension services are 3.1% more likely to experience P_1W_1. The increasing effect of extension service on pest and weed invasion can be attributed to lack of understanding of extension service advice and recommendations, non-application of extension advice, and inadequate extension visits. Households' access to credit increases the likelihood of P_0W_1 by 5.8%. Farm credit, often in the form of cash, may be diverted from its intended purpose of acquiring farm inputs to other non-farm activities, thereby, increasing the risk of P_0W_1. The findings confirm the result of Tabe-Ojong (2022) who finds a positive association between households' credit access and ecological shocks. Access to motorable roads increases households' likelihood of experiencing P_1W_0 and P_0W_1 invasion but decreases P_1W_1. Relative to households with impassable roads, households with access to motorable roads are 2.4% and 7.5% more likely to experience P_1W_0 and P_0W_1, respectively. Access to motorable roads enables farmers to access farm inputs that minimize their exposure to ecological shocks. In the specific case of double invasion, access to motorable roads had a positive association with P_1W_1 indicating that households that have access to motorable roads are 3.4% more likely to experience both pest and weed invasion. Hu et al. (2019) explained that good roads increase farmers' likelihood of working off-farm, thereby, neglecting agricultural production and leading to exposure to ecological shocks.

Network of extension access is associated with a 0.1% increase in the likelihood of experiencing P_1W_0 and P_0W_1 invasion. On the contrary, network of extension access decreases both pest and weed invasion by 0.4%. The result projects the importance of peer effects and social learning in terms of adoption of agricultural technologies and risk-mitigation strategies. Access to irrigation has varying effects on P_1W_0, P_0W_1, and P_1W_1. The likelihood of P_1W_0 and P_1W_1 decreased by 8.2% and 10.1%, respectively, for households with access to irrigation facilities. However, for P_0W_1, access to irrigation facilities provides a conducive environment for the growth and spread of weeds increasing their likelihood of farm invasion. The result demonstrates that access to irrigation facilities increases farmers' likelihood of experiencing weed invasion by 9.7%. Farming households whose neighbors experienced shocks are 0.1% less likely to experience P_1W_0. Although marginal, the negative effect can be explained by the fact that the invasion of pests in neighbors' farms compelled neighbors to adopt control measures to prevent the spread of pests. On the contrary, farming households whose neighbors experienced shocks are more likely to experience weeds and both pest and weed invasions. The positive result is consistent with the a priori expectation that ecological shocks tend to spread within geographical areas.

6.2. *Average adoption effects for a combination of ecological shocks*

This section highlights the effects of ecological shocks on the number of children attending school, public school, private school, and children's farm work under actual and counterfactual conditions after controlling for selection bias. The second stage results are presented in the Appendix of the supplementary material. Table A2 in the supplementary material reports the unconditional average effects of ecological shocks on outcome variables derived from the actual and counterfactual distributions. The results of the study show that on average, farmers who experienced shocks realize lower school attendance (public and private) and children's farm working hours for all the shocks than farmers who did not experience any shock. However, the results are only indicative of the effects of ecological shocks. The results could be misleading because they do not account for observed and unobserved factors (selection bias) that may influence the outcome variables.

Table 4 presents the conditional average effects of the ecological shocks. The estimation of the impact of pest and weed invasion under conditional and unconditional average effects is based on the predicted outcomes from the MESR. Consistent across all the packages of shocks, we observed a decline in the number of children attending school and public-school attendance. Farmers who experienced only weed invasion recorded the highest decline in the number of children attending school (by 0.88) followed by farmers who experienced both pest and weed invasion (0.75), and those who experienced only pest invasion (0.43).

Regarding public school attendance, our results show that farmers whose farm plots were invaded decreased their number of children attending public school. Comparing the results across the shocks, we find that farmers who have experienced double invasion of pests and weeds recorded the highest decline in the number of children attending public school (by 0.74) followed by farmers who only experienced weed invasion (0.68) and only pest invasion (0.44). In reference to private school attendance, farmers whose fields were invaded by pests recorded an increase in the number of children attending private school (by 0.02). The result is contrary to the a priori expectation that ecological shock reduces farm household income and subsequently reduces the ability of households to accommodate the high cost of private school attendance. However, weed invasion and double invasion of weeds and pests reduce the number of children attending private school by 0.03 and 0.04, respectively. Consistent with the results on public school attendance, double invasion of pests and weeds had the highest effect on private school attendance. The result corroborates the findings of Martey et al.

Table 4
The average effect of ecological shock package using multinomial ESR.

Outcomes	Shock choice (j)	Shock status: Shock ($j = 1, 2, 3$)	Shock status: No shock ($j = 0$)	Average Treatment Effect
Children attending school (number)	P_1W_0	3.39 (0.14)	3.82 (0.25)	−0.43*** (0.12)
	P_0W_1	3.23 (0.08)	4.10 (0.23)	−0.88*** (0.15)
	P_1W_1	3.64 (0.14)	4.39 (0.28)	−0.75*** (0.15)
Public school attendance	P_1W_0	2.99 (0.11)	3.43 (0.21)	−0.44*** (0.12)
	P_0W_1	2.96 (0.07)	3.65 (0.19)	−0.68*** (0.13)
	P_1W_1	3.16 (0.10)	3.89 (0.23)	−0.74*** (0.14)
Private school attendance	P_1W_0	1.19 (0.01)	1.17 (0.01)	0.02** (0.01)
	P_0W_1	1.14 (0.01)	1.17 (0.01)	−0.03*** (0.01)
	P_1W_1	1.13 (0.01)	1.17 (0.01)	−0.04*** (0.01)
Child farm work	P_1W_0	1.08 (0.01)	1.16 (0.01)	−0.08*** (0.01)
	P_0W_1	1.28 (0.01)	1,24 (0.01)	0.04*** (0.01)
	P_1W_1	1.27 (0.01)	1.23 (0.01)	0.05*** (0.01)

Notes: P_1W_0– only pest shock; P_0W_1– only weed shock; P_1W_1– pest and weed shocks. ***Significant at the 1% level.

(2021). The results of their study show that food hardship reduces the number of children attending school and private school attendance. In another study by Martey et al. (2021), they found that time poverty reduces the number of children attending public school. A similar study on shocks by Agamile and Lawson (2021) in Uganda shows that exposure to negative rainfall shocks significantly reduces children's school attendance by almost 10%. Using longitudinal rural household survey data in Ethiopia, Randell and Gray (2016), find that greater summer rainfall is associated with school completion and attendance at the time of the survey.

The results further show a positive relationship between shocks and children's working hours except for farmers who have experienced pest invasion on their farm plots. As indicated by the results, pest invasion reduces children's farm work by 0.08 h. In contrast, weed invasion increases children's farm work by 0.04 h, while farmers who experienced both pest and weed invasion increased children's farm work by 0.05 h. The negative effect of pest invasion on children's farm work may be because children play a reduced role in terms of pesticide application compared with the youth category of the household. The structure of the household, as highlighted by the conceptual framework, may be accounting for farm-committed time allocation among household members. The positive effect of weed and pest invasion on children's farm work indicates that weed invasion may be driving the increase in children's time spent working on the farm given that weed invasion had a higher school attendance reduction effect than pest invasion. Studies have shown that weed invasion (*Striga hermonthica*) can reduce yield by up to 100% (Yacoubou et al., 2021), so the household heads are more likely to mobilize household members to participate in on-farm activities to curtail the spread of the weed. The implication of the results is that if interventions that seek to reduce the amount of time children do farm work are not implemented, then the education and labor market outcomes of children in the future will be sacrificed. This situation further leads to intergenerational transmission of poverty (Kes and Swaminathan 2006).

We illustrate the effects of ecological shocks (pest and weed invasion) on children's school attendance and farm working hours using the kernel densities of the predicted school attendance and child farm work distributions by shock status (Figure A1 in the supplementary materials). The result is more informative than observed schooling and child work since the values are estimated after controlling for observed and unobserved factors.

6.3. Robustness check – Lewbel 2SLS estimation

To test the robustness of our estimates, we perform a sensitivity test using the Lewbel (2012) 2SLS method to examine the sensitivity of our MESR estimation of shocks on child schooling and farm work (Table 5). Comparatively, the magnitude of the effect is relatively higher for the Lewbel 2SLS than the MESR. The first stage results show that the number of neighbors who have experienced ecological shocks is highly correlated with farmers experiencing ecological shocks. Consistent with the MESR estimate, the Lewbel 2SLS estimation shows that pest invasion reduces the number of children attending public school and the working hours on the farm by 0.14 and 0.06 h, respectively. Weed invasion increases child farm working hours by 0.176 h while double ecological shocks reduce the number of children attending school and public-school attendance by 0.11 and 0.09, respectively, and increased child farm working hours by 0.13 h.

The results of the Lewbel 2SLS shows the robustness of our estimates on the effect of shocks on children's school attendance and farm work. The implication of the findings is that children's school attendance can be improved with investment in labor-saving technologies or the subsidization of chemicals for pest and weed control.

Table 5
Lewbel 2SLS estimates for ecological shocks and child outcomes.

Outcomes	Schooling			Public			Private			Child farm work		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	P_1W_0	P_0W_1	P_1W_1	P_1W_0	P_0W_1	P_1W_1	P_1W_0	P_0W_1	P_1W_1	P_1W_0	P_0W_1	P_1W_1
Pest	−0.061			−0.139*			0.076			−0.057*		
	(0.070)			(0.077)			(0.050)			(0.034)		
Weed		−0.058			−0.010			−0.046			0.176***	
		(0.052)			(0.055)			(0.039)			(0.045)	
Pest and weed			−0.111**			−0.092*			−0.042			0.129***
			(0.049)			(0.051)			(0.034)			(0.039)
All controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First stage												
Neighbors shocks	0.001***	0.007***	0.004***	0.001***	0.007***	0.004***	0.001***	0.007***	0.004***	0.001***	0.007***	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
F-Statistic	13.77	26.70	44.62	13.77	26.70	44.62	13.77	26.70	44.62	13.77	26.70	44.62
J p-value	0.435	0.164	0.203	0.786	0.571	0.605	0.518	0.060	0.880	0.314	6.7e-07	0.089
Observations	1,787	2,425	2,033	1,787	2,425	2,033	1,787	2,425	2,033	1,787	2,425	2,033
R-squared	0.542	0.510	0.558	0.484	0.473	0.515	0.118	0.119	0.115	0.065	0.064	0.068

Notes: P_1W_0– only pest shock; P_0W_1– only weed shock; P_1W_1– pest and weed shocks. ***Significant at the 1% level, ** significant at the 5% level, and *significant at the 10% level.

7. Conclusion

Several studies have examined the impact of agricultural shocks on welfare outcomes. However, there is a dearth of studies examining the effect of ecological shocks on children's school attendance and farm working hours. This study fills the knowledge gap by employing a partial analysis of the edu-workscape framework using data from the seventh round of the Ghana Living Standards Survey, a nationally representative data set. We employed the multinomial endogenous switching regression (MESR) to establish the link and used the Lewbel 2SLS estimation technique as a robustness check.

The results from the multinomial logit selection model indicate that the likelihood of experiencing an ecological shock is significantly influenced by sex, age, household size, marital status, employment status, off-farm work, number of livestock owned, extension visits, credit access, access to motorable road, network of extension access, irrigation access, and number of neighbors experiencing shocks. The findings from this study provide the basis for formulating policies to guide development practitioners to address the social factors accounting for pest and weed invasion. The significant role of peer effect suggests the need to build the capacity of farmers on effective pest and weed control to reduce their spread.

The results of MESR show that double invasion (pests and weeds) reduced the number of children attending school (both public and private) and increased children's on-farm working hours. Farmers who experienced only pest invasion witnessed a decline in the number of children attending public schools, but an increase in the number of children attending private schools. Children's working hours on the farm declined for farm households that experienced only pest invasion. Weed invasion reduced the number of children attending school (public and private) but increased children's on-farm working hours. Comparatively, double ecological shocks had the most negative effect on public and private school attendance and the highest positive effect on children's working hours on the farm.

The findings of the study fits within the broader edu-workscape framework and have three main implications. First, the negative effect of ecological shocks on children's school attendance implies that children's human capital formation is likely to be sacrificed in the presence of ecological shocks. This may impact children's school performance and future labor outcomes. Given that the cost of hired labor is relatively high, household heads may principally rely on family labor for most agricultural activities. To avert this situation, there is the need to promote labor-saving technologies to reduce human drudgery and channel households' saved time into other productive activities. Second, an increase in children's working hours on the farm implies a trade-off between present gains and intergenerational transfer of poverty. Improving the current input subsidy programs to include pesticides and weedicides will have a far-reaching impact on reducing children's time spent doing farm work and subsequently improve their wellbeing. Further investment in nature-based solutions and bio-control innovations will yield sustainability benefits in the long run. Third, development practitioners must consciously sensitize farmers on the deteriorative effects of continuous cropping and encourage them to embrace crop rotation, crop diversification, fallowing and other crop management practices to limit pest and weed invasion on their farms. In conclusion, our results fit within the educ-workscape framework which highlights the interaction between household, child work, and schooling and has implications for other countries with similar challenges.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Acknowledgement

This study is made possible through data support from the Ghana Statistical Service (SSS). The authors are grateful for financial support received by the GSS from the Government of Ghana, Department for International Development (DFID) and the Dutch Government through the International Development Assistance (IDA) and the Statistics for Results Facility Catalytic Fund (SRF-CF) which was managed by the World Bank under the Ghana Statistical Development Program (GSDP). The authors express their appreciation for the administrative support offered by the CSIR-Savanna Agricultural Research Institute. Finally, we wish to express our profound gratitude to the anonymous reviewers whose contribution has led to a major improvement of this manuscript.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.wdp.2023.100529.

References

Adonteng-Kissi, O. (2018). Parental perceptions of child labour and human rights: A comparative study of rural and urban Ghana. *Child Abuse & Neglect, 84*, 34–44.

Agamile, P., & Lawson, D. (2021). Rainfall shocks and children's school attendance: Evidence from Uganda. *Oxford Development Studies, 49*(3), 291–309.

Ananga, E. (2011). *Dropping Out of School in Southern Ghana: The Push-Out and Pull-Out Factors*. Research Monograph No 55: CREATE Pathways to Access.

Afoakwah, C., & Koomson, I. (2021). How does school travel time impact children's learning outcomes in a developing country? *Review of Economics of the Household*, 1–21.

Akyeampong, K. (2009). Revisiting free compulsory universal basic education (FCUBE) in Ghana. *Comparative Education, 45*(2), 175–195.

Assefa, F., & Ayalew, D. (2019). Status and control measures of fall armyworm (Spodoptera frugiperda) infestations in maize fields in Ethiopia: A review. *Cogent Food & Agriculture, 5*(1), 1641902.

Asfaw, S., Scognamillo, A., Di Caprera, G., Sitko, N., & Ignaciuk, A. (2019). Heterogeneous impact of livelihood diversification on household welfare: Cross-country evidence from Sub-Saharan Africa. *World Development, 117*, 278–295.

Atera, E. A., Ishii, T., Onyango, J. C., Itoh, K., & Azuma, T. (2013). Striga infestation in Kenya: status, distribution and management options.

Badu-Apraku, B., & Fakorede, M. A. B. (2017). Maize in Sub-Saharan Africa: Importance and production constraints. In *Advances in genetic enhancement of early and extra-early maize for Sub-Saharan Africa* (pp. 3–10). Cham: Springer.

Bakari, S. (2013). Making gender sense on schools: Nigeria. Unpublished report (2nd edition) based on the Commonwealth study for E. Page & J. Jha (2009) *Exploring the bias: gender and stereotyping in schools*. London: Commonwealth Secretariat.

Baker, R. B., Blanchette, J., & Eriksson, K. (2020). Long-run impacts of agricultural shocks on educational attainment: evidence from the boll weevil. *The Journal of Economic History, 80*(1), 136–174.

Bandara, A., Dehejia, R., & Lavie-Rouse, S. (2015). The impact of income and non-income shocks on child labor: Evidence from a panel survey of Tanzania. *World development, 67*, 218–237.

Bandyopadhyay, S., & Skoufias, E. (2015). Rainfall variability, occupational choice, and welfare in rural Bangladesh. *Review of Economics of the Household, 13*(3), 589–634.

Björkman-Nyqvist, M. (2013). Income shocks and gender gaps in education: Evidence from Uganda. *Journal of Development Economics, 105*, 237–253.

Boateng, A., & Dako-Gyeke, M. (2022). Child Labor in Ghana: Current Policy, Research, and Practice Efforts. *Child Behavioral Health in Sub-Saharan Africa: Towards Evidence Generation and Policy Development*, 265-281.

Boissiere, M. (2004). *Determinants of primary education outcomes in developing countries*. Independent Evaluation Group (IEG), Washington, DC: World Bank.

Bourdillon, M., Crivello, G., & Pankhurst, A. (2015). Introduction: Children's work and current debates. In M. Bourdillon, G. Crivello, & A. Pankhurst (Eds.), *Children's Work and Labour in East Africa: Social Context and Implications for Policy* (pp. 1–19). Addis Ababa: Organisation for Social Science Research in Eastern & Southern Africa.

Boyden, J., Porter, C., & Zharkevich, I. (2021). Balancing school and work with new opportunities: Changes in children's gendered time use in Ethiopia (2006–2013). *Children's Geographies, 19*(1), 74–87.

Bourguignon, F., Fournier, M., & Gurgand, M. (2007). Selection bias corrections based on the multinomial logit model: Monte-Carlo comparisons. *Journal of Economic Surveys, 21*, 174–205.

Chanimbe, T., & Dankwah, K. O. (2021). The 'new'Free Senior High School policy in Ghana: emergent issues and challenges of implementation in schools. *Interchange, 52*(4), 599–630.

Child Labour: Global Estimates (2020), Trends and the Road Forward," United Nations Children's Fund, Accessed February 21, 2023, https://data.unicef.org/resources/child-labour-2020-global-estimates-trends-and-the-road-forward/.
Conley, T. G., & Udry, C. R. (2010). Learning about a new technology: Pineapple in Ghana. *American Economic Review, 100*(1), 35–69.
Dahmann, S. C. (2017). How does education improve cognitive skills? Instructional time versus timing of instruction. *Labour Economics, 47*, 35–47.
David, O. G., Ayangbenro, A. S., Odhiambo, J. J., & Babalola, O. O. (2022). Striga hermonthica: A highly destructive pathogen in maize production. Environmental. *Challenges, 100590*.
Dawud, M. A., Angarawai, I. I., Tongoona, P. B., Ofori, K., Eleblu, J. S., & Lfie, B. E. (2017). Farmers' production constraints, knowledge of striga and preferred traits of pearl millet in Jigawa state, Nigeria. *Global Journal of Science Frontier Research: D Agriculture and Veterinary, 17*(3), 1–7.
Day, R., Abrahams, P., Bateman, M., Beale, T., Clottey, V., Cock, M., et al. (2017). Fall armyworm: Impacts and implications for Africa. *Outlooks on Pest Management, 28*(5), 196–201.
DeJaeghere, J. G., Chapman, D. W., & Mulkeen, A. (2006). Increasing the supply of secondary teachers in sub-Saharan Africa: A stakeholder assessment of policy options in six countries. *Journal of Education Policy, 21*(5), 515–533.
Di Falco, S., Veronesi, M., & Yesuf, M. (2011). Does Adaptation to Climate Change Provide Food Security? A Micro-Perspective from Ethiopia. *American Journal of Agricultural Economics., 93*(3), 829–846.
Dimova, R., Gangopadhyay, S., Michaelowa, K., & Weber, A. (2015). Off-farm labor supply and correlated shocks: New theoretical insights and evidence from Malawi. *Economic Development and Cultural Change, 63*(2), 361–391.
Dubin, J., & McFadden, D. (1984). *An econometric analysis of residential electric appliance holdings and consumption., I*(52), 345–362.
Dunne, M., & Ananga, E. D. (2013). Dropping out: Identity conflict in and out of school in Ghana. *International Journal of Educational Development, 33*(2), 196–205.
Dunne, M., & Humphreys, S. (2022). The edu-workscape: Re-conceptualizing the relationship between work and education in rural children's lives in Sub-Saharan Africa. *World Development Perspectives, 27*, Article 100443.
Dunne, M., Humphreys, S., & Szyp, C. (2021). *Education and Work: Children's Lives in Rusal Sub-Saharan Africa. ACHA Working Paper 9*. Brighton: ACHA, Institute of Development Studies.
Dunne, M., Leach, F., Chilisa, B., Maudeni, T., Tabulawa, R., Kutor, N., et al. (2005). *Gendered school experiences: The impact on retention and achievement in Botswana and Ghana*. London: DfID.
Duryea, S., Lam, D., & Levison, D. (2007). Effects of economic shocks on children's employment and schooling in Brazil. *Journal of development economics, 84*(1), 188–214.
Ghana Population. (2022) (Live). World Population Review, Accessed February 21, 2023, https://worldpopulationreview.com/countries/ghana-population.
Glick, P. J., Sahn, D. E., & Walker, T. F. (2016). Household shocks and education investments in Madagascar. *Oxford Bulletin of Economics and Statistics, 78*(6), 792–813.
Gowda, M., Makumbi, D., Das, B., Nyaga, C., Kosgei, T., Crossa, J., et al. (2021). Genetic dissection of Striga hermonthica (Del.) Benth. resistance via genome-wide association and genomic prediction in tropical maize germplasm. *Theoretical and Applied Genetics, 134*, 941–958.
Hamenoo, E. S., Dwomoh, E. A., & Dako-Gyeke, M. (2018). Child labour in Ghana: Implications for children's education and health. *Children and Youth Services Review, 93*, 248–254.
Hu, Y., Li, B., Zhang, Z., & Wang, J. (2019). Farm size and agricultural technology progress: Evidence from China. *Journal of Rural Studies*. https://doi.org/10.1016/j.jrurstud.2019.01.009
Humphreys, S., Moses, D., Kaibo, J., & Dunne, M. (2015). Counted in and being out: Fluctuations in primary school and classroom attendance in northern Nigeria. *International Journal of Educational Development, 44*, 134–143.
International Labour Organization. (2018). Decent Work and the Sustainable Development Goals: A Guidebook on SDG Labour Market Indicators, Department of Statistics (STATISTICS), Geneva. https://www.ilo.org/ilostatfles/Documents/Guidebook-SDG-En.pdf. Accessed February 23 2023.
Jonah, O. T., & Abebe, T. (2019). Tensions and controversies regarding child labor in small-scale gold mining in Ghana. *African Geographical Review, 38*(4), 361–373.
Kasoma, C., Shimelis, H., & Laing, M. D. (2021). Fall armyworm invasion in Africa: Implications for maize production and breeding. *Journal of Crop Improvement, 35*(1), 111–146.
Kassie, M., Stage, J., Diiro, G., Muriithi, B., Muricho, G., Ledermann, S. T., et al. (2018). Push–pull farming system in Kenya: Implications for economic and social welfare. *Land Use Policy, 77*, 186–198.
Kes, A., & Swaminathan, H. (2006). Gender and time poverty in sub-Saharan Africa. Gender, time use, and poverty in sub-Saharan Africa, 13.
Khonje, M. G., Manda, J., Mkandawire, P., Tufa, A. H., & Alene, A. D. (2018). Adoption and welfare impacts of multiple agricultural technologies: evidence from eastern Zambia. *Agricultural Economics, 49*(5), 599–609.
Krauss, A. (2013). Understanding child labor beyond poverty: the structure of the economy, social norms, and no returns to rural basic education. *World Bank Policy Research Working Paper*, (6513).
Krishnan, P., & Patnam, M. (2014). Neighbors and extension agents in Ethiopia: Who matters more for technology adoption? *American Journal of Agricultural Economics, 96*(1), 308–327.
Lewbel, A. (2012). Using heteroscedasticity to identify and estimate mismeasured and endogenous regressor models. *Journal of Business & Economic Statistics, 30*(1), 67–80.
Li, L., Gow, A. D. I., & Zhou, J. (2020). The role of positive emotions in education: A neuroscience perspective. *Mind, Brain, and Education, 14*(3), 220–234.
Magnan, N., Spielman, D. J., Lybbert, T. J., & Gulati, K. (2015). Leveling with friends: Social networks and Indian farmers' demand for a technology with heterogeneous benefits. *Journal of Development Economics, 116*, 223–251.
Malikov, E., & Kumbhakar, S. C. (2014). A generalized panel data switching regression model. *Economics Letters, 124*(3), 353–357.
Martey, E., & Armah, R. (2021). Welfare effect of international migration on the left-behind in Ghana: Evidence from machine learning. *Migration Studies, 9*(3), 872–895.
Martey, E., Etwire, P. M., & Atinga, D. (2021). To attend or not to attend: Examining the relationship between food hardship, school attendance and education expenditure. *International Journal of Educational Development, 80*, Article 102304.
Masih, I., Maskey, S., Mussá, F. E. F., & Trambauer, P. (2014). A review of droughts on the African continent: A geospatial and long-term perspective. *Hydrology and Earth System Sciences, 18*(9), 3635–3649.
Mathenge, M. K., & Tschirley, D. L. (2015). Off-farm labor market decisions and agricultural shocks among rural households in Kenya. *Agricultural economics, 46*(5), 603–616.
Mc-Fadden, D. (1973). Conditional logit analysis of qualitative choice behavior. In P. Zarembka (Ed.), *Frontiers in Econometrics 1973* (pp. 105–142). New York: Academic Press.
Moreira, C. N., Rabenevanana, M. W., & Picard, D. (2017). Boys go fishing, girls work at home: Gender roles, poverty and unequal school access among semi- nomadic fishing communities in South Western Madagascar. *Compare, 47*(4), 499–511. https://doi.org/10.1080/03057925.2016.1253456
Obeng-Ofori, D., & Amiteye, S. (2005). Efficacy of mixing vegetable oils with pirimiphos-methyl against the maize weevil, Sitophilus zeamais Motschulsky in stored maize. *Journal of Stored Products Research, 41*(1), 57–66.
Oerke, E. C. (2006). Crop losses to pests. *The Journal of Agricultural Science, 144*(1), 31–43.
Oliveira, C. M., Auad, A. M., Mendes, S. M., & Frizzas, M. R. (2014). Crop losses and the economic impact of insect pests on Brazilian agriculture. *Crop Protection, 56*, 50–54.
Ortiz-Ospina, E., & Roser, M. (2016). Child labor. *Our World in Data*. Accessed February 21, 2023. https://ourworldindata.org/child-labor.
Peterman, A., Behrman, J. A., & Quisumbing, A. R. (2014). A review of empirical evidence on gender differences in nonland agricultural inputs, technology, and services in developing countries. *Gender in agriculture*, 145–186.
Randell, H., & Gray, C. (2016). Climate variability and educational attainment: Evidence from rural Ethiopia. *Global environmental change, 41*, 111–123.
Robson, E., Ansell, N., Huber, U. S., Gould, W. T., & van Blerk, L. (2006). Young caregivers in the context of the HIV/AIDS pandemic in sub-Saharan Africa. *Population, space and place, 12*(2), 93–111.
Rose, P. M., & Dyer, C. (2008). Chronic poverty and education: A review of literature. *Chronic Poverty Research Centre Working Paper, 131*.
Salifu, I., Boateng, J. K., & Kunduzore, S. S. (2018). Achieving free compulsory universal basic education through school feeding programme: Evidence from a deprived rural community in northern Ghana. *Cogent Education, 5*(1), 1509429.
Serdeczny, O., Adams, S., Baarsch, F., Coumou, D., Robinson, A., Hare, W., et al. (2017). Climate change impacts in Sub-Saharan Africa: From physical changes to their social repercussions. *Regional Environmental Change, 17*, 1585–1600.
Tabe-Ojong, M. P., Jr (2022). Ecological shocks and non-cognitive skills: Evidence from Kenya. *Ecological Economics, 194*(C).
Tabe-Ojong, M. P., Jr, Heckelei, T., & Baylis, K. (2021). Aspiration formation and ecological shocks in rural Kenya. *The European Journal of Development Research, 33*(4), 833–860.
Tadele, Z. (2017). Raising crop productivity in Africa through intensification. *Agronomy, 7*(1), 22.
Tafere, Y. (2014). *Children's experiences of household poverty dynamics in Ethiopia*. Young Lives.
Tafere, Y., & Pankhurst, A. (2015). Children combining work and school in Ethiopian communities. *Children's Work and Labour in East Africa: Social Context and Implications for Policy, Addis Ababa: Organization for Social Science Research in Eastern and Southern Africa (accessed 29 January 2021)*.
Teka, H. B. (2014). Advance research on Striga control: A review. *African journal of plant science, 8*(11), 492–506.
Tessema, Y. M., Asafu-Adjaye, J., Kassie, M., & Mallawaarachchi, T. (2016). Do neighbours matter in technology adoption? The case of conservation tillage in northwest Ethiopia. African. *Journal of Agricultural and Resource Economics, 11*(311–2016-5659), 211–225.
Thorsen, D., & Yeboah, T. (2021). Mobility and the rural landscape of opportunity. In *Youth and the rural economy in Africa: hard work and hazard* (pp. 78–91). Wallingford UK: CABI.
Unicef. (2022). United Nations Children's Fund Accessed February 21, 2023, https://www.unicef.org/about-unicef.
United Nations. (2015). *Transforming our world by 2030: A new agenda for global action Zero. Draft of the outcome document for the UN Summit to adopt the Post-2015 Development Agenda*. New York: United Nations.
Verkaart, S., Munyua, B. G., Mausch, K., & Michler, J. D. (2017). Welfare impacts of improved chickpea adoption: A pathway for rural development in Ethiopia? *Food Policy, 66*, 50–61.
Ward, P. S., & Pede, V. O. (2015). Capturing social network effects in technology adoption: the spatial diffusion of hybrid rice in Bangladesh. *Australian Journal of Agricultural and Resource Economics, 59*(2), 225–241.
Williams, I. H. (2010). The major insect pests of oilseed rape in Europe and their management: an overview. *Biocontrol-based integrated management of oilseed rape pests*, 1–43.

Wollni, M., & Andersson, C. (2014). Spatial patterns of organic agriculture adoption: Evidence from Honduras. *Ecological Economics, 97*, 120–128.
Wu, J., & Babcock, B. A. (1998). The choice of tillage, rotation, and soil testing practices: Economic and environmental implications. *American Journal of Agricultural Economics, 80*(3), 494–511.
Yacoubou, A. M., Zoumarou Wallis, N., Menkir, A., Zinsou, V. A., Onzo, A., Garcia-Oliveira, A. L., et al. (2021). Breeding maize (Zea mays) for Striga resistance: Past, current and prospects in sub-saharan Africa. *Plant Breeding, 140*(2), 195–210.
Zimdahl, R. L. (2018). *Fundamentals of weed science*. Academic press.