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Abstract
Mental distress is a growing contributor to the global burden of disease. In low-income agrarian contexts, climate change and seasonal unpredictability erode the environmental knowledge that smallholder farmers rely upon, generating uncertainty and psychological vulnerability. Across sub-Saharan Africa, smallholder farming communities confront compounding climate and livelihood stressors that heighten psychological vulnerability. However, empirical evidence connecting the structural conditions of agrarian life to psychological distress remains limited. The majority of this evidence comes from high-income countries, in populations who are largely insulated from climate impacts. To better understand this relationship in the context of smallholder farmers in western Uganda, we use mixed-methods analyses and environmental justice and social-ecological systems frameworks. We found that the high prevalence of mental distress was associated with food insecurity, climate uncertainty, and lower household-head educational attainment, rather than individual characteristics of farmers alone. Food insecurity was the strongest and most consistent predictor across all model specifications. Wildlife-related crop damage was also associated with greater continuous symptom burden. These findings suggest that mental distress in climate-vulnerable agrarian communities is patterned by broader livelihood and environmental conditions and may require integrated policy responses across food insecurity and climate adaptation efforts.

I. Introduction

Rural communities in sub-Saharan Africa (SSA) that are highly dependent on agriculture are exceptionally vulnerable to mental distress due to their tight coupling of livelihoods with environmental conditions and natural resource availability [1, 2, 3, 4]. In western Uganda, climatic stressors affecting smallholder livelihoods are primarily experienced through an increase in climatic variation such as increases in both maximum and minimum temperatures and shifts in the timing of the onset and cessation of rainy seasons, [5, 6]. The success of smallholders' yields relies on the ability to anticipate seasonal rhythms. It is this worsening climatic unpredictability, not a single acute or extreme event, that drives impacts on psychological wellbeing [7, 8, 9]. Additionally, climate variability and seasonal unpredictability erode the environmental knowledge that smallholder farmers diligently rely upon to plan and manage agricultural risk [7, 8, 9]. These challenges are intensified by population growth and increased demand for food, which places additional demands on agrarian systems to sustain agricultural production and food security [10]. In response, pesticide use has increased as a strategy for protecting crops as well as bolstering expanding yields when seasonal conditions can no longer be relied upon, adding financial expenditure to an existing precarious livelihood [11].

In this context, environmental shocks worsen food security and are among the most robustly reported determinants of poor mental health globally [12, 13, 14]. Households that struggle to secure sufficient food experience intense uncertainty, anxiety, shame, and physiological stress [15, 16, 17, 18]. In western Uganda, these climate pressures are intensified by proximity to protected forest areas, where human-wildlife conflict constitutes a persistent livelihood stressor [6, 19]. Crop raiding by wildlife, including elephants *(Loxodonta africana*), monkeys (various spp.), and baboons (*Papio anubis*), further threaten crop yields and food security [20]. As a result, smallholders devote additional time and resources to protect crops. These costs compete with other necessities such as school fees and food provisioning. Households find themselves making psychological trade-offs of essential needs. The variety of stressors illustrate how adapting to climate change disproportionately falls on those least responsible for the drivers of that change, a dynamic that is characterized as

environmental injustice [21].

Empirical environmental justice (EJ) work has consistently demonstrated that health outcomes reflect the aggregate weight of compounding physical, social, and structural stressors operating simultaneously [22]. An EJ framework provides an underutilized analytical lens for interrupting these dynamics. EJ posits that ecological risks, hazards, and burdens are not distributed equally. Marginalized communities with limited social, economic, and political capital face disproportionate exposure to environmental harms while possessing the fewest resources to adapt or recover [35]. Climate justice extends this framework by situating these disparities within the context of anthropogenic climate change, asking who is most exposed and who has contributed least to the crisis bearing its greatest costs [23]. These burdens fall most heavily on residents of low- and middle-income countries with the least adaptive capacity [24, 25]; evidence from agrarian communities in the Global South corroborates this pattern, with climate-driven disruptions producing measurable consequences for rural livelihoods and wellbeing [26]. In SSA specifically, structural neglect of smallholder farmers places the burden of environmental risk disproportionately on those least responsible for creating it [27].

Understanding how social and climatic stressors produce psychological harm requires a framework capable of capturing the complexity of rural agrarian systems. Ostrom's social-ecological systems (SES) framework provides an analytical architecture that conceptualizes resource-dependent communities as systems in which governance, resources, users, and ecological dynamics interact to shape livelihood outcomes [28]. Adapting the SES framework for mental health reveals how psychological distress emerges from the cumulative interaction of ecological shocks, institutional constraints, and household-level vulnerabilities. Ultimately, we challenge that individuals' isolated exposures alone contribute to significant psychological distress. Together, these frameworks situate mental distress within the structural conditions that produce it. In this study, we integrate an EJ and SES framework to examine how climate-driven stressors operate through food systems, agricultural production, and human-wildlife conflict to generate unequal psychological burdens among smallholder farming households in western Uganda.

Despite increasing recognition of the social ecological dynamics of mental distress [29], empirical evidence regarding the mental health status of farming populations in SSA remains remarkably limited [30, 31, 32]. Most SSA rural health studies focus on infectious diseases, maternal health, or physical malnutrition, ignoring the hidden psychological burden of agrarian livelihoods [33]. Where rural mental health studies do exist, they tend to examine individual risk factors in isolation, instead of within the structural and ecological systems that influence it [34].

This study addresses this gap in the climate mental health literature by combining quantitative survey analysis with in-depth qualitative interviews, enabling an understanding of the prevalence and predictors of mental distress and the lived mechanisms through which stressors are experienced. Situating these dynamics within an integrated climate justice and SES framework, we contribute empirical evidence from a severely climate-vulnerable agrarian context; we foreground how the structure of the SES, rather than individual circumstances, determine who bears the greatest psychological cost of climate disruption.

II. Methods

Study Design and Conceptual Framework

This study employed a sequential explanatory mixed-methods design, running quantitative household surveys that informed topics in qualitative semi-structured, in-depth interviews.

Quantitative and qualitative findings were integrated during the design and interpretation phase to achieve statistical breadth and narrative depth.

The study's design and variable grouping were guided by Ostrom's adapted framework, Social-Ecological Systems (SES), which was embedded within an environmental justice paradigm, mapping how macro-level ecological realities translate into household-level psychological outcomes [28]. A climate justice lens shows how socioeconomic marginalization determines differential exposure and adaptive capacity within the same ecological system [35, 54]. This framework guided variable selection, sampling stratification, and the integration of quantitative and qualitative findings, ensuring that both statistical patterns and lived experiences are interpreted within a coherent structural logic.

Study Area

Data collection was conducted across five districts in western Uganda: Bunyangabu, Kabarole, Kamwenge, Kasese, and Kyenjojo (Figure 1). This region is predominantly agricultural and is characterized by distinct environmental vulnerabilities, including steep topography that intensifies soil erosion, high climate variability, and proximity to major protected areas (e.g., Kibale National Park, Queen Elizabeth National Park), which creates pronounced human-wildlife tension [5, 6, 36]. Ecological and climatic details regarding the study area have been described by our previous study [37].

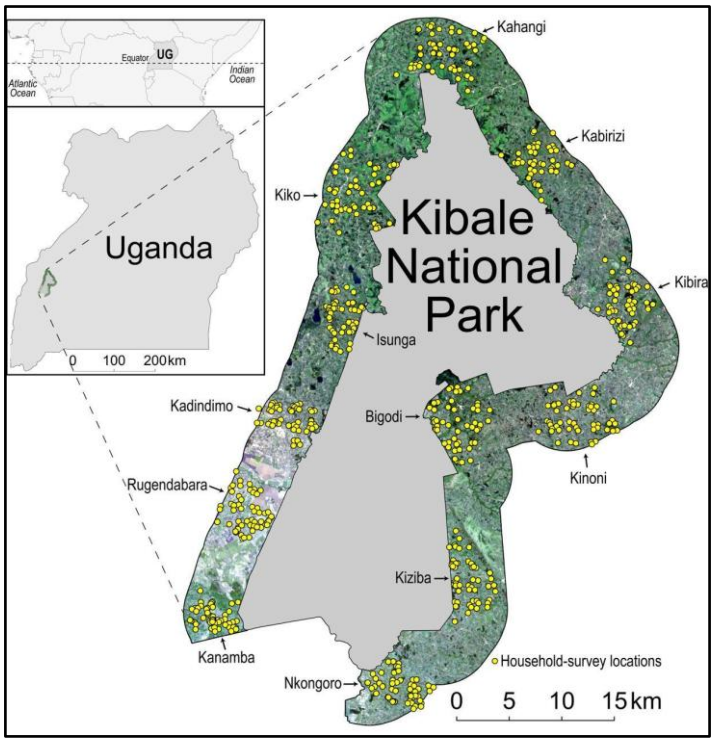


Figure 1. Description: Location of the Kibale National Park (KNP) study area in western Uganda. The study area comprises all land within 5 km of the KNP boundary, excluding Queen Elizabeth National Park to the south. The background is a true-color composite derived from Landsat 9 imagery acquired on 17 July 2023. Household survey locations are shown, with arrows labeling the parish associated with each cluster of surveyed households.

Sampling and Data Collection

Participants for the quantitative and qualitative components were selected using complementary sampling strategies. A multi-stage cluster sampling design was utilized to

select 638 farming households for the quantitative component. Complete-case multivariable analyses included 576 households with working-age household members. Missing data were low and primarily related to incomplete responses for one or more explanatory variables.

To complement the quantitative survey, 30 in-depth interviews (IDIs) were conducted in Kiko parish, Kabarole district, selected purposively for elevated mental distress prevalence. All participants were drawn from the survey population and randomly selected within Kiko parish, with sampling stratified to ensure variation in sex, age, and food security status. Interviews explored lived experiences related to food insecurity, climate variability, wildlife-related crop losses, agricultural livelihoods, social support systems, and mental well-being. Interviews were conducted by trained research assistants in local languages commonly spoken in the study area, including Rutooro, Runyankole, and Lukonzo. All interviews were audio-recorded with participant consent and subsequently transcribed verbatim. Transcripts were translated into English and reviewed for completeness and accuracy before analysis.

Outcome Variables

Mental distress was assessed using an adapted 11-item version of the World Health Organization's Self-Reporting Questionnaire (SRQ-20) (Do et al., 2023). The instrument measures symptoms of anxiety, depression, and somatic distress experienced during the preceding 30 days. Total scores ranged from 0 to 11, with higher scores indicating greater psychological distress. Consistent with validation studies conducted in similar SSA settings, a score of ≥4 was used to classify respondents as experiencing symptomatic mental distress. To comprehensively examine the outcome, mental distress was operationalized in three ways: (i) as a binary outcome (SRQ <4 vs. ≥4), (ii) as a continuous symptom score (0–11), and (iii) as an ordinal measure of severity categorized as Minimal/None (0–2), Mild-to-Moderate (3–5), and Severe (6–11).

Explanatory Variables

Potential determinants of mental distress were grouped into four conceptual domains informed by socio-ecological and environmental health frameworks. The first domain, agricultural stressors, included household pesticide use (yes/no). This indicates whether chemical pesticides were applied during the previous agricultural season. Wildlife damage severity was measured using a composite index (range: 0–3) based on self-reported crop losses attributed to wildlife across major crop types, with higher scores indicating greater severity of crop damage.

The second domain comprised environmental stressors and human–wildlife interactions. Environmental stressors included concern about climate change (yes/no), assessed by asking respondents whether they were concerned about the effects of climate change on their household or farming activities. Human–wildlife interactions were operationalized as whether the first recorded land unit bordered Kibale National Park (KNP) (yes/no) and if the household experienced wildlife conflict (e.g., crop raiding).

The third domain assessed food security. Household food insecurity was measured using a composite index (range: 0–3) based on concerns regarding food availability, reductions in dietary quality, and experiences of hunger due to insufficient food access. Higher scores indicated greater food insecurity.

The fourth domain included socio-demographic characteristics, comprising respondent age (years), sex (male/female), household-head educational attainment (primary education or less versus secondary education or higher), household size, and household dependency ratio.

Quantitative Data Analysis

Quantitative data were cleaned and analyzed using R (R Core Team, 2025). Mental distress was examined using three complementary outcome specifications to capture different dimensions of psychological burden. First, multivariable binary logistic regression estimated the adjusted odds of meeting the screening threshold for symptomatic mental distress (SRQ score ≥4 versus <4). Second, linear regression modeled the total SRQ score (0–11) as a continuous outcome to assess variation in overall symptom burden. Third, proportional-odds ordinal logistic regression evaluated the odds of belonging to a higher mental-distress severity category—Minimal/None (0–2), Mild-to-Moderate (3–5), or Severe (6–11). Multivariable analyses used complete-case data (n = 576). To assess the incremental contribution of different predictor domains, binary logistic models were also constructed hierarchically, beginning with sociodemographic and agricultural factors, followed by food insecurity, social capital, and environmental stressors. Improvement in model fit between successive models was evaluated using likelihood-ratio tests, with Akaike Information Criterion and McFadden's pseudo-R^2 used to describe overall model performance.

Qualitative Data Analysis

Pseudonyms were assigned using commonly used Ugandan names that corresponded with participants' gender identities. Additional identifying details, including specific locations and personal characteristics, were modified or omitted to protect participant confidentiality and reduce the risk of deductive identification. Interview transcripts were de-identified prior to analysis. Themes were developed with local enumerators during data collection. Interview transcripts were analyzed using deductive thematic analysis and an EJ framework. Qualitative themes were cross-checked against quantitative regression outputs to identify areas of convergent validity and contextual nuance. Researchers independently reviewed transcripts and discussed coding discrepancies that were resolved through consensus. Representative quotations were selected to illustrate major themes and experiences as well as contextualize quantitative results.

Ethical considerations

Ethical approval for this study was obtained from the Makerere University School of Public Health Research and Ethics Committee (SPHREC; Protocol SPH-2024-635) and the Uganda National Council for Science and Technology (UNCST; Registration SS3710ES). Additional ethical oversight was provided by the University of Colorado Boulder Institutional Review Board (Protocol 24-0776). All research procedures were performed in accordance with relevant institutional, national, and international ethical guidelines and regulations. Administrative approval and clearance were obtained from participating districts, sub-counties, and villages. All participants provided informed consent before participation. Consent procedures were conducted in local languages using approved scripts. Participation was voluntary, and respondents were informed of their right to decline participation or withdraw at any time without consequence. Interview transcripts and survey data were de-identified and stored securely to protect participant confidentiality.

III. Results

Participant Characteristics and Prevalence of Mental Distress

This study was conducted among 638 smallholder farming households. Respondents had a mean age of 48.2 years (SD = 15.8), and 73.2% of household heads had attained primary education or less. Exposure to environmental stressors was widespread, with 90.9% of households reporting pesticide use, 98.9% reporting wildlife-related crop damage, and 92.8% expressing concern about climate variability. Food insecurity was common, affecting 77.6% of households. Overall, 68.8% of respondents (n=439) met the screening threshold for symptomatic mental distress (SRQ score ≥4), with a mean SRQ score of 5.03 (SD = 2.61). For the qualitative component, participants included 12 women and 18 men, with a mean age of 48.2 years (± 18.7 [20-87]). Table 1 provides more details.

Table 1. Characteristics of study participants and key exposure variables

Characteristic	Frequency (%) (N=638)
Sociodemographic Characteristics	
Age (years), mean (SD)	48.2 (15.8)
Female sex n (%)	302 (47.3%)
Household-head education level: Primary or less, n (%)	467 (73.2%)
Household size (persons), mean (SD)	4.2 (2.3)
Dependency ratio mean (SD)	1.26 (1.29)
Environmental and Agricultural Exposures	
Pesticide use (any), n (%)	580 (90.9%)
Wildlife damage (any), n (%)	631 (98.9%)
Wildlife severity score (0–3), mean (SD)	1.64 (0.78)
Climate change concern, n (%)	592 (92.8%)
First recorded land unit borders KNP, n (%)	119 (18.7%)
Food Security	
Food insecurity score (0–3), mean (SD)	1.50 (1.01)
No food insecurity (score 0), n (%)	143 (22.4%)
Low food insecurity (score 1), n (%)	140 (21.9%)
Moderate food insecurity (score 2), n (%)	251 (39.3%)
High food insecurity (score 3), n (%)	104 (16.3%)
Mental Health outcomes	
Symptomatic Mental Distress (SRQ ≥*4*), n (%)	439 (68.8%)
SRQ Score (0–11), mean (SD)	5.03 (2.61)

**Abbreviations: SRQ = Self-Reporting Questionnaire. Symptomatic mental distress defined as SRQ score ≥4. Values are presented as mean (SD) for continuous variables and n (%) for categorical variables. Dependency ratio was calculated as the number of household members aged below 18 years or above 65 years divided by the number aged 18–65 years.*

Characteristics by Mental Distress Severity (n=638)

Respondents with severe mental distress were older on average than those reporting minimal or no symptoms (50.0 versus 46.9 years; p = 0.042) and were more likely to be female (58.2%

vs. 34.4%, ($p < 0.001$) (Table 2). Household-head educational attainment was associated with distress severity, with no formal education among household heads reported for 29.9% of households in the severe distress group compared with only 10.7% in the minimal or no distress group ($p < 0.001$).

Table 2. Characteristics of respondents by mental distress severity category

Characteristic	Overall (N=638)	Minimal/None (N=122)	Mild–Moderate (N=248)	Severe (N=268)	p-value
Age, mean (SD)	48.2 (15.8)	46.9 (15.2)	46.8 (15.4)	50.0 (16.3)	0.042
Female sex, n (%)	302 (47.3)	42 (34.4)	104 (41.9)	156 (58.2)	<0.001
No formal education (household head), n (%)	124 (19.4)	13 (10.7)	31 (12.5)	80 (29.9)	<0.001
Married (household head), n (%)	471 (73.8)	97 (79.5)	195 (78.6)	179 (66.8)	0.003
District					0.007
Bunyangabu	52 (8.2)	12 (9.8)	14 (5.6)	26 (9.7)	
Kabarole	162 (25.4)	36 (29.5)	70 (28.2)	56 (20.9)	
Kamwenge	215 (33.7)	35 (28.7)	81 (32.7)	99 (36.9)	
Kasese	105 (16.5)	11 (9.0)	40 (16.1)	54 (20.1)	
Kyenjojo	104 (16.3)	28 (23.0)	43 (17.3)	33 (12.3)	
Pesticide application events per season, mean (SD)	713.8 (1383.7)	495.9 (1197.8)	895.7 (1493.5)	649.0 (1343.9)	0.021
Pesticide type diversity					0.001
1 type	71 (11.1)	24 (19.7)	30 (12.1)	17 (6.3)	
2 types	215 (33.7)	40 (32.8)	79 (31.9)	96 (35.8)	
3 types	89 (13.9)	14 (11.5)	44 (17.7)	31 (11.6)	
4 types	263 (41.2)	44 (36.1)	95 (38.3)	124 (46.3)	
Wildlife damage severity, mean (SD)	1.6 (0.8)	1.6 (0.8)	1.6 (0.7)	1.7 (0.8)	0.037

**Bivariate comparisons are descriptive; multivariable predictors were specified according to the study's conceptual framework rather than selected solely on the basis of bivariate statistical significance. Categorical variables are presented as n (% within each mental-distress severity category); percentages are column percentages.*

Qualitative interviews revealed that many participants viewed psychological distress as a consequence of worsening environmental and livelihood conditions. Agricultural decline was the most frequently cited proximate stressor. Reflecting on the temporal difference between past productivity and present scarcity, Alexander [male, 44] shared, *"Previously*

crops were yielding so much… but don't you see that rain is [now] disappearing?" Other participants alluded to experiencing distress as both an economic hardship and a rupture in an expected ecological relationship. Betty [female, 29] experienced this distress as anticipatory, she shares worry surrounding shifting weather patterns beyond current severity. She reflects, *"In the future the changing weather patterns will be worse than how it is today. I see that there is a difference compared to when I grew up."*

Food Insecurity as the Dominant Predictor of Mental Distress

Each one-unit increase in food insecurity was associated with a 76% increase in the odds of mental distress (AOR = 1.76, 95% CI: 1.45–2.14; p < 0.001). Climate change concern (AOR = 2.27, 95% CI: 1.12–4.60; p=0.023), household-head primary education or less (AOR = 1.59, 95% CI: 1.04–2.43, p=0.031), were also independently associated with higher odds of distress (Table 3).

Table 3. Multivariable logistic regression model predicting symptomatic mental distress (SRQ score ≥4)

Predictor Domain	Variable Specification	β (95% CI)	Adjusted Odds Ratio (95% CI)	p-value
Agricultural	Pesticide use (yes/ no)	-0.311 (-1.021, 0.399)	0.73 (0.36, 1.49)	0.391
	Wildlife severity (per unit)	0.102 (-0.146, 0.350)	1.11 (0.86, 1.42)	0.420
Environmental	Climate concern (yes/ no)	0.821 (0.115, 1.527)	2.27 (1.12, 4.60)	0.023*
	First recorded land unit borders KNP (yes/ no)	0.060 (-0.437, 0.558)	1.06 (0.65, 1.75)	0.812
Food Security	Food insecurity score (0–3)	0.564 (0.369, 0.759)	1.76 (1.45, 2.14)	<0.001***
Demographics	Age (per year)	0.003 (-0.009, 0.016)	1.00 (0.99, 1.02)	0.595
	Dependency ratio	-0.000 (-0.158, 0.158)	1.00 (0.85, 1.17)	0.999
	Household-head education (Primary or less)	0.467 (0.043, 0.890)	1.59 (1.04, 2.43)	0.031*
	Household size	-0.002 (-0.090, 0.085)	1.00 (0.91, 1.09)	0.960
	Sex (Female vs. Male)	0.356 (-0.028, 0.740)	1.43 (0.97, 2.10)	0.069

Qualitative interviews revealed that food insecurity was experienced as a persistent threat to social roles, household stability, and relational peace. Participants described the inability to provide food as a source of shame, conflict, and withdrawal. Andrew [male, 72] situated this dynamic within the confines of a single day. Andrew explained,

Yesterday you may have spent the whole day without food, maybe the wife

doesn't have the energy to look for it or there is no money to buy. If you go to the bar and come back home happily, you find the children are not happy or comfortably sleeping because they thought you would come with food yet you have nothing. That means that there will be no peace that night.

Francis [male, 81] frames a similar experience of distress around his capacity to work, *"What disturbs me is when I'm too weak to work. But if I don't work I have nothing to eat. I want to eat something good but if you have not worked, you can't.*" His account captures a cycle in which hunger diminishes the physical capacity required to escape hunger. This feedback loop sustains both food insecurity and psychological burden simultaneously.

Joseph [male, 21] describes observing neighboring households in which poor harvests produced parental withdrawal, substance use, and domestic aggression. He explains,

Sometimes you find that the father wants to escape so he goes to drink alcohol and when he comes back he's shouting at everyone at home. When you're the neighbor you hear all that, most of the time, it's because of the bad harvest and he's blaming everyone to [better] look after the crops, but most of the time it's because of bad weather.

These accounts indicate the influence of food insecurity on mental well-being through multiple pathways, such as hunger, physical depletion, and household relationships.

Climate Uncertainty and Psychological Distress

Respondents who reported concern about climate change had more than twice the odds of experiencing mental distress compared with those who did not express such concerns (AOR = 2.27, 95% CI: 1.12–4.60; p = 0.023).

Qualitative interviewees describe climate change as eroding traditional knowledge and techniques that smallholder farming has historically depended on. Participants express a collapse of the ability to decipher environmental cues and plan accordingly. Florence [female, 70] situated this loss within her planting decisions, *"We no longer know the exact seasons where you can plant and be sure that what you have planted will yield. So now it's only God with the plan but we humans don't have, we have to keep planting."* Denis [male, 40] extended this into somatic consequences, describing how the lack of control of weather outcomes only compounded psychological uncertainty into sleeplessness and even fatal stress,

Now, even if you discuss the weather patterns with your neighbors, what are you about to change? You will not change anything. If it wants to shine, it will shine, it hurts you and you don't sleep… before you know it, so-and-so has died due to stress, because the drought destroyed 5 acres of his maize, or you were expecting to get 100 bags of coffee from the garden and you got 5 bags. Do you think that you can sleep?

Wildlife Conflict and Environmental Stress

Wildlife-related crop damage demonstrated a more nuanced relationship with mental health outcomes. Although wildlife damage severity was not significantly associated with crossing the binary threshold for symptomatic mental distress in the adjusted logistic regression model (AOR = 1.11, 95% CI: 0.86–1.42; p = 0.420), it was significantly associated with higher continuous SRQ symptom scores in the sensitivity analysis (β = 0.33, 95% CI: 0.06–0.59; p = 0.015) (Supplementary Table 1).

In-depth interviews with individuals living near park boundaries revealed that participants associated wildlife conflict with psychological distress. Wildlife conflict was

described as requiring sustained vigilance and contributing to physical exhaustion. Henry [male, 36] described the precarity associated with anticipating loss, *“The wildlife does not come at a specific time. Sometimes, they spend the whole night [raiding]. We guard the gardens so that they don't spoil the bananas, that stresses me a lot.”* Isaac [male, 54] connected wildlife raiding to food insecurity, *“Elephants raided my garden and when they did, I don't have any food in my home to eat, I don’t have food that could help my children”* Wildlife conflict was similarly positioned as a driver of food insecurity, providing qualitative context for the broader relationship between livelihood stressors and psychological distress. Peter [male, 40] articulated the cumulative weight of this dynamic most explicitly, describing crop raiding as a process that consumed financial investment, productive labor, and psychological reserves in sequence,

> *Crop raiding brings me a lot of stress, because when I plant my crops, and put in a lot of money, I still fail to get a yield because the wild animals disturb a lot... You have to go through a lot of struggles, there is so much worry to the extent that you are at the extreme of emotional or mental strain*

Education and Social Vulnerability

In the adjusted logistic regression model, households whose heads had primary education or less had significantly greater odds of symptomatic mental distress compared with households whose heads had secondary education or higher (AOR = 1.59, 95% CI: 1.04–2.43; p = 0.031). This relationship remained consistent across sensitivity analyses, with lower household-head educational attainment associated with higher continuous symptom scores (β = 0.62, 95% CI: 0.16–1.09; p = 0.009) and increased odds of belonging to a more severe mental distress category (OR = 1.71, 95% CI: 1.18–2.46; p = 0.004).

While the quantitative model captures household-head educational attainment, qualitative interviews revealed a distinct dimension of educational vulnerability in which parents experience anxiety in the ability to educate one’s children. Instead of framing distress in terms of their own schooling relative to their peers, participants linked educational stress to the financial pressure of school fees and the opportunities that diminish when education is not pursued. John situated the first of these stressors as a component of daily life, describing school fee obligations as a source of sleeplessness and sustained preoccupation. John shares, *"The education of my children stresses me a lot. My money is not enough and gives me sleepless nights. How will my children attain education? I want them to study and that stresses me a lot to be honest."* His account illustrates how the aspiration to educate children, which is itself a strategy for reducing future vulnerability, became an immediate source of psychological burden when income was insufficient to sustain it.

Denis [male, 40] highlights this stressor from the perspective of a child, describing the distress produced when a student is turned away from school for non-payment, "*When a person is asking what she needs and you are not able to provide it, even for your child, you send him to school to study and they chase him away. Do you think that that child will be happy? No, he won't be happy."* He suggests that the psychological costs of educational exclusion were experienced by multiple members of the family. Across interviews, participants emphasized that limited educational attainment narrowed access to non-agricultural employment, deepening dependence on increasingly unpredictable farming livelihoods. These findings suggest that educational attainment functions as a socioeconomic marker and a critical adaptive resource. The absence of education concentrated both economic and psychological risk within households least equipped to absorb environmental shocks.

IV. Discussion

This study found a high prevalence of mental distress among smallholder farming households in western Uganda, with more than two-thirds of respondents meeting the threshold for symptomatic distress. This rate exceeds the pooled prevalence of depression (30%) reported across Ugandan populations [38] and general rural common mental disorder estimates (10-11%) across repeated population-based surveys in Kenya [39, 40]. While differences in screening instruments, cut-off thresholds, and population characteristics limit direct comparison, the elevated prevalence observed here is consistent with evidence that farming communities operating under compounding environmental and livelihood stressors carry adverse psychological burdens relative to Ugandan or similar rural populations (Proctor & Hopkins, 2023; Kaggwa et al., 2022; [39, 40].

Food insecurity emerged as the most consistent predictor of mental distress. Climate change concern and lower household-head educational attainment were associated with symptomatic mental distress in the primary adjusted model. Female sex and wildlife-related crop damage showed association in the secondary analyses. Taken together, these findings indicate that psychological distress among smallholder farming households is a socioecological outcome [41]. In this context, mental distress is produced by the compounding interaction of food insecurity, climate uncertainty, livelihood precarity, and structural inequality operating within a system that distributes these burdens unevenly across socioeconomic position.

Environmental and socioeconomic stressors appear to influence mental wellbeing, most strongly through food insecurity, which was consistent with evidence from rural Africa low- and middle-income countries [14, 42]. Qualitative findings revealed that food insecurity operated through at least three psychosocial pathways: the erosion of parental and spousal identity; a compounding cycle in which hunger diminished the physical capacity required to earn food; and the displacement of distress into alcohol use and household conflict. These mechanisms suggest that food insecurity functions as a nutritional deficit and as a livelihood disruptor [43, 44]. Within an SES framework, these findings illustrate how environmental shocks (e.g., erratic rainfall, wildlife-related crop losses, seasonal unpredictability) deplete the natural and financial capital upon which food security depends. This highlights how ecological disruption acts as household-level psychological harm. From an EJ perspective, vulnerable rural populations may experience disproportionately high rates of psychological consequences as a result of livelihood insecurity [41].

Growing literature has documented climate-related distress, ecological grief, and climate anxiety across diverse settings [45]. The majority of this evidence originates from high-income countries, in populations who are largely insulated from climate impacts [46]. In contrast, our participants described distress produced by the erosion of ecological knowledge and agricultural predictability. For instance, participants described how community deliberation may have once acted as a buffer to environmental distress, but due to present weather unpredictability this is no longer an adequate form of adaptation. By recognizing that discussing changing conditions with neighbors could produce no actionable change, this powerlessness itself was framed as a source of sustained psychological burden and a barrier to social well-being.

Research from western Uganda has demonstrated that farmers who maintain high-fidelity tracking of intra-annual rainfall patterns, specifically in the timing of seasonal onset and cessation, achieve better crop yields than those whose recall diverges from measured rainfall patterns [7]. As scientific evidence points to increasing climate variability, the anticipation of future hardship may become an increasingly important determinant of psychological wellbeing

among farming communities. This finding highlights the importance of integrating psychological considerations into climate adaptation initiatives [41, 47].

This study did not collect measures of soil quality, which is a known contributor of declining yields in the region [6] and may confound participants' attributions of yield loss and rainfall change. Future work should integrate soil fertility assessments alongside climate and livelihood data.

Lower household-head educational attainment was associated with poorer mental health outcomes across multiple analyses. Similar findings have been reported in studies examining the social determinants of mental health, where education is recognized as a protective resource [48, 49]. Qualitative findings extend this interpretation by revealing that educational aspiration itself was a source of distress, when unmet. Participants described sleeplessness and sustained worry towards school fees, and the experience of children being turned away from school for non-payment. These findings are consistent with research from communities bordering Kibale National Park that demonstrate proximity to protected areas and wildlife guarding directly reduce school attendance. These findings suggest that education functions as a protective factor and an intergenerational investment, in which lack of education amplifies the psychological consequences of livelihood insecurity [41, 50].

Wildlife-related crop damage demonstrated a more nuanced relationship with mental health. Although wildlife damage was not independently associated with crossing the threshold for symptomatic mental distress, it was associated with greater symptom severity in the continuous analyses. This pattern suggests that wildlife conflict may function as a chronic stressor that contributes to accumulating psychological strain rather than acting as a discrete trigger of distress; this distinction has important implications for how conservation-adjacent communities are assessed and supported [51]. Acute stressor models may systematically under detect this kind of harm, in which no single event necessarily crosses a clinical threshold, but repeated exposures accumulate into sustained psychological burden. The binary structure of conventional mental distress screening is poorly suited to capturing this pattern, which may explain why wildlife damage severity emerged as a significant predictor in continuous models, but not binary specifications. Wildlife conflict in this setting appears to operate when crop losses recur across seasons and isolated events, and the overnight vigilance demanded of farming households produces sleep disruption and physical depletion that compounds across successive wildlife raids [52]. These pathways were sequential in which crop loss threatened household food supplies, food insecurity intensified anxiety, and the physical exhaustion of chronic guarding reduced the capacity to cope with either. Communities living adjacent to protected areas may consequently bear a disproportionate share of conservation-related burdens while possessing limited capacity to absorb associated losses, raising important EJ concerns that current wildlife management and compensation frameworks are not equipped to address [53].

Climate-related psychological distress and livelihood vulnerability may mutually reinforce each other in which environmental distress impairs cognitive engagement required for effective adaptation, yet failed adaptation deepens psychological distress. Thus, extension services, community weather monitoring, and the integration of local knowledge with scientific data may carry adaptive and psychological benefits.

Utilizing SES and climate justice frameworks, these findings advance the case that mental distress among smallholder farming households is best understood as an aspect of the SES, instead of an individual health outcome. Psychological distress in this context encompasses the cumulative weight of compounding stressors in a system that distributes burdens unequally. Thus, rural mental health should be considered alongside the structural

conditions of agrarian life. By integrating quantitative surveys with qualitative inquiry, this study shows that psychological distress is patterned by socioecological and livelihood conditions. Addressing mental health among smallholder farming populations will therefore require approaches that extend beyond clinical services to address the broader environmental and socioeconomic conditions that shape wellbeing. This requires integrating mental health into climate adaptation efforts, social protections, and agricultural extension policy. For instance, including psychological considerations in food security, agricultural literacy, and educational programs. As climate variability intensifies across sub-Saharan Africa, the psychological consequences of agrarian precarity are likely to deepen. This mental distress will remain systematically underrecognized unless mental health is positioned as a central concern within climate adaptation, food security, and conservation frameworks.

V. Conclusions

Mental distress was highly prevalent among smallholder farming households in agrarian Uganda, with food insecurity emerging as the strongest and most consistent correlate across analyses. Climate change concern and lower household-head educational attainment were also associated with symptomatic mental distress, while female sex and wildlife-related crop damage showed outcome-specific associations in secondary analyses. Qualitative findings revealed that distress was experienced as a rational response to livelihood precarity, environmental unpredictability, and the erosion of resources (e.g., agricultural, social, economic) upon which household survival depends. Our findings indicate that mental health among rural farming populations cannot be meaningfully separated from the structural conditions of agrarian life under environmental change, and that addressing it will require structural interventions. Given the strength and consistency of the association between food insecurity and mental distress, interventions that improve household food access, buffer agricultural income against environmental shocks, and reduce dependence on climate-sensitive production may yield measurable mental health and well-being improvements.

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Additional Information

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Author Contributions Statement

K.S. contributed to conceptualization, data curation, formal analysis, investigation, methodology, validation, and writing of the original draft and review and editing of the manuscript. J.M. contributed to data curation, formal analysis, methodology, software, validation, and writing of the original draft and review and editing of the manuscript. M.W. contributed to funding acquisition, methodology, resources, and review and editing of the manuscript. R.N. and A.N. contributed to data curation, investigation, translation, validation, and review and editing of the manuscript. R.M. contributed to data curation, investigation, and project administration. S.N. contributed to investigation, methodology, and validation. J.E.D. contributed to funding acquisition, methodology, visualization, and review and editing of the manuscript. J.H. contributed to funding acquisition and review and editing of the manuscript. K.B. contributed to funding acquisition, methodology, project administration, and review and editing of the manuscript.

Competing Interests Statement

The author(s) declare no competing interests.

Data Availability Statement

The qualitative data are not publicly available due to ethical restrictions and strict confidentiality agreements approved by Makerere University School of Public Health Research and Ethics Committee (SPHREC; Protocol SPH-2024-635), Uganda National Council for Science and Technology (UNCST; Registration SS3710ES), and University of Colorado Boulder Institutional Review Board (Protocol 24-0776). De-identified qualitative excerpts and quantitative datasets may be obtained upon request, subject to institutional review board approval and data use agreements.

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