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WATER STRESS AND ITS SYNERGISTIC EFFECTS ON PEST AND DISEASE DYNAMICS IN SMALLHOLDER IRRIGATED AGRICULTURE: -EVIDENCE FROM CENTRAL REGION OF GHANA

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Abstract: Water stress—manifesting as either drought or waterlogging—poses significant challenges to irrigated agriculture by disrupting plant physiological defenses and creating favorable conditions for pest and pathogen proliferation. This study examines the complex interactions between water stress, crop health, and pest–disease dynamics in the Somnyamekodur community, Twifo Hemang Lower Denkyira District, Central Region, Ghana.A quantitative survey approach was adopted, involving 100 randomly selected farmers engaged in irrigated agriculture. Data were collected using structured questionnaires covering farmer demographics, irrigation practices, effects of water stress, management strategies, and economic outcomes.Results indicated that the farming population is predominantly older (60% above 46 years) and characterized by low formal education levels (84% with primary or no education), which limits technology adoption. Traditional irrigation methods dominated (92%), while adoption of efficient systems such as drip (2%) and sprinkler (3%) irrigation remained low.
Water stress dramatically increased fungal infections (68%) and insect pest infestations (90%), resulting in severe yield reductions, with 96% of farmers reporting high negative impacts and 72% experiencing income losses exceeding 50%. Despite 98% acknowledging that sustainable practices could mitigate water stress, only 10% implemented water-saving measures like mulching, primarily due to financial constraints (44%) and knowledge gaps (30%).

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The study demonstrates that water stress creates synergistic pest-pathogen-plant interactions that disproportionately affect smallholder farmers lacking access to modern irrigation technologies and extension services. Climate change was identified as the primary driver (92%), yet technology adoption remained low (76% unwilling) due to cost barriers. These findings underscore the urgent need for integrated approaches combining affordable irrigation technologies, targeted farmer training, financial incentives, and collaborative water management strategies to enhance resilience in climate-vulnerable agricultural systems.

Keywords: *Water stress, irrigated agriculture, pest-disease dynamics, smallholder farmers, climate change adaptation, Ghana*

INTRODUCTION

Global food security faces unprecedented challenges from climate variability, with water stress emerging as a principal constraint to agricultural productivity, particularly in smallholder farming systems that constitute the backbone of food production in developing nations[1], [2]. Water stress, encompassing both deficit (drought) and excess (waterlogging) conditions, fundamentally alters plant physiological processes, compromises defense mechanisms, and creates ecological conditions that favor pest and pathogen proliferation [3], [4]. These biotic-abiotic stress interactions generate synergistic effects that produce disproportionate yield losses compared to individual stressors acting in isolation, yet remain inadequately addressed in contemporary agricultural management paradigms.

Drought stress impairs stomatal conductance, reduces photosynthetic efficiency, and triggers resource reallocation from growth to survival mechanisms, consequently weakening plant resistance to biotic challenges [5], [6]. Simultaneously, water-stressed plants accumulate elevated concentrations of soluble sugars and amino acids in phloem tissues, rendering them preferential hosts for sap-feeding insects including aphids and whiteflies [7], [8]. This nutritional enhancement paradoxically occurs alongside suppressed jasmonic acid and salicylic acid signaling pathways, creating windows of vulnerability for pathogen invasion, particularly vascular wilt organisms such as *Fusarium* and *Verticillium* species [9], [10]. Conversely, waterlogging establishes anaerobic soil conditions that suppress beneficial microbial communities while favoring root rot pathogens including *Pythium* and *Phytophthora*, simultaneously disrupting root oxygen supply and undermining systemic plant immunity [11], [12].

Climate change amplifies these challenges through increased frequency and intensity of extreme weather events, creating environments where plants experience sequential or cumulative stresses that exponentially increase disease and pest vulnerability [13], [14]. Historical evidence demonstrates the catastrophic potential of such interactions: the 2012 United States Midwest drought facilitated unprecedented spider mite infestations and *Fusarium* infections that devastated maize yields [15].

Despite advances in irrigation technology and crop improvement, existing management strategies rarely account for complex water stress-pest-pathogen interactions.

Precision irrigation techniques can reduce disease pressure through controlled leaf wetness and soil moisture [16], [17], yet inappropriate scheduling may inadvertently stress plants and enhance pest attractiveness [18]. Similarly, crop breeding programs typically target individual stressors, leaving protection gaps against combined abiotic-biotic challenges due to growth-defense trade-offs and antagonistic regulatory pathways [19], [20].

In Sub-Saharan Africa, where smallholder farmers dominate agricultural landscapes and climate vulnerability is acute, these knowledge and practice gaps have profound implications for food security and rural livelihoods [21], [22], [23], [24]. The Central Region of Ghana exemplifies this vulnerability, experiencing increasing climate variability that intensifies both drought episodes and waterlogging risks within single growing seasons. However, empirical understanding of how water stress modulates pest-disease dynamics in this context, and how farmers perceive and respond to these challenges, remains limited.

This study addresses critical knowledge gaps by investigating water stress impacts on pest and disease dynamics in Somnyamekodur community, examining farmer perceptions, management practices, and economic consequences. The research novelty lies in its holistic integration of plant physiological responses, pest-pathogen ecology, farmer indigenous knowledge, and socioeconomic constraints within a climate-vulnerable smallholder system. Specific objectives include: (1) characterizing farmer demographics and irrigation practices; (2) assessing water stress impacts on crop health and farming practices; (3) exploring management strategies for mitigating water stress effects; and (4) analyzing economic impacts on farming livelihoods. Findings will inform targeted interventions combining water management optimization with integrated pest-disease management strategies tailored to resource-constrained farming systems facing escalating climate pressures.

MATERIALS AND METHDOS

2.1 Study Area Characteristics

The research was conducted in Somnyamekodur community, Twifo Hemang Lower Denkyira District, Central Region, Ghana (Figure 1), located between latitudes 5°50'N-5°51'N and longitudes 1°50'W-1°10'W at elevations of 60-200 meters above sea level. The area experiences a semi-equatorial climate characterized by bimodal rainfall distribution with peaks in June and October, mean annual precipitation of 1,750 mm, and relatively uniform temperatures ranging from 26°C (August) to 30°C (March). Relative humidity remains consistently high throughout the year (70-80% during dry season, 75-80% during wet season). The natural vegetation comprises semi-deciduous forest, substantially modified by anthropogenic activities including agriculture, logging, and mining. Soils developed over granite parent material exhibit free-draining characteristics, respond favorably to phosphorus fertilization, and support diverse cropping systems including tree crops (cocoa, oil palm, citrus) and annual food crops (plantain, cocoyam, banana, cassava).

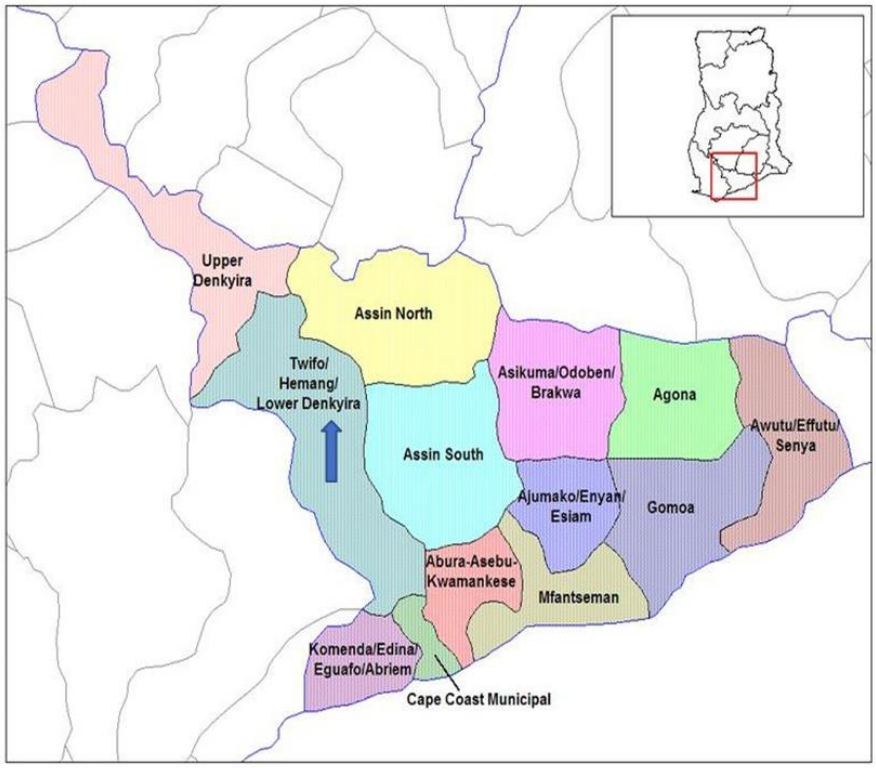


Figure 1. Map of the study area

Research Design and Sampling

The study employed a quantitative cross-sectional survey design to assess farmer understanding of irrigation practices and water stress impacts on agricultural productivity. A sample size of 100 farmers was determined adequate for capturing variability in practices and perceptions within the community while remaining logistically feasible. Participants were selected through simple random sampling to ensure representativeness across age groups, gender, farm sizes, and cropping systems. Inclusion criteria required active engagement in irrigated agriculture during the preceding growing season. The sampling frame was developed in collaboration with local agricultural extension officers who maintained farmer registries.

Data Collection Procedures

Primary data collection utilized structured questionnaires administered through face-to-face interviews conducted in local dialects to facilitate comprehension and ensure response accuracy. The questionnaire instrument comprised five thematic sections: (1) sociodemographic characteristics (age, education, farming experience); (2) irrigation practices and water sources; (3) water stress experiences and impacts on crop health; (4) pest and disease incidence patterns; and (5) management strategies and economic consequences.

Questions employed multiple response formats including closed-ended categorical items, Likert scales for perception assessment, and semi-structured items allowing elaboration on specific experiences.
Interviews were conducted at participants' farms and households between planting and harvest periods to capture real-time observations of crop conditions and ongoing management practices. Behavioral observations during interviews provided contextual insights into farmer knowledge and attitudes. Each interview lasted approximately 45-60 minutes. To enhance data quality, questionnaires were pre-tested with 10 farmers outside the study area, and modifications were made based on feedback regarding question clarity and cultural appropriateness.

Ethical Considerations
The research protocol adhered to established ethical standards for agricultural social science research. All participants provided informed verbal consent after receiving clear explanations regarding study objectives, voluntary participation, right to withdraw without consequences, and confidentiality protections. No identifying information was recorded; respondents were assigned numerical codes to maintain anonymity. Data were used exclusively for academic research purposes, with results presented in aggregate form preventing individual identification. The study design prioritized beneficence and non-maleficence, avoiding questions that could cause psychological discomfort or social harm. Findings aim to generate actionable knowledge benefiting agricultural communities through improved water and pest management strategies.

Data Analysis
Quantitative data were processed and analyzed using IBM SPSS Statistics version 24. Descriptive statistics including frequencies, percentages, means, and standard deviations were computed for all variables to characterize the sample and summarize response distributions. Cross-tabulations examined relationships between demographic characteristics and adoption of water-saving practices. Chi-square tests assessed associations between categorical variables where appropriate. Graphical presentations including bar charts and pie diagrams were generated using Microsoft Excel to visualize key findings. Tables were formatted in Microsoft Word to present multivariate results systematically. Analysis focused on identifying patterns, constraints, and opportunities related to water stress management in the study population, with findings interpreted in the context of existing literature on smallholder agriculture, climate adaptation, and integrated pest management.

RESULTS AND DISCUSSION

3.1 Farmer Demographics and Irrigation Practices
Demographic analysis revealed a predominantly aging farmer population, with 60% of participants aged 46 years and above (Table 1).

Table 1. Farmers' age groups, educational level and their years of farming.

Demographic	Frequency(N)	Percentage (%)
Age Group		
26-35 years	14	14
36-45 years	26	26
46-55 years	30	30
56 and above	30	30
Educational Level		
Higher education	3	3
No formal education	33	33
Primary	51	51
Secondary	12	12
Years Of Farming		
11-20 years	28	28
5-10 years	12	12
Less than 5 years	3	3
More than 20 years	57	57

This age distribution, showing 30% in each of the 46-55 and 56+ categories, reflects a global trend where agriculture increasingly depends on older practitioners, raising concerns about knowledge transfer and innovation adoption capacity [25], [26]. Educational attainment proved severely limited, with 84% having either primary education (51%) or no formal schooling (33%), while only 3% achieved higher education. This educational deficit constrains farmers' ability to comprehend technical information, evaluate technological risks and benefits, and adopt complex innovations—a pattern consistently documented in developing-country agricultural systems [27]. Farming experience was extensive, with 57% cultivating for over 20 years and an additional 28% practicing for 11-20 years, suggesting strong reliance on indigenous knowledge but potentially limited exposure to modern practices.

Crop selection patterns (Figure 2) demonstrated that vegetables dominated production (46%), followed by cereals (35%), fruits (11%), and pulses (8%).

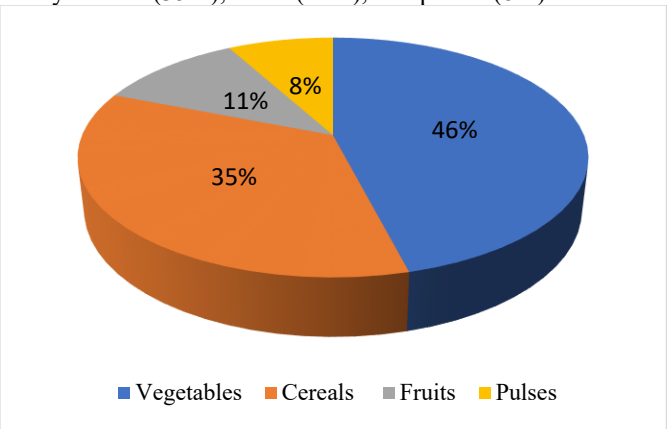


Figure 2. Types of Crops Grown by the Farmers

The preference for vegetables and cereals reflects their dual importance for household food security and market income generation, characteristics particularly valuable for resource-constrained smallholders requiring short-cycle, high-turnover crops.
However, these crop categories exhibit high water demands and sensitivity to moisture stress, intensifying vulnerability to water scarcity.
Irrigation practices revealed severe technological underdevelopment, with 92% of farmers employing rudimentary methods including watering cans, buckets, and informal channels (Figure 3).

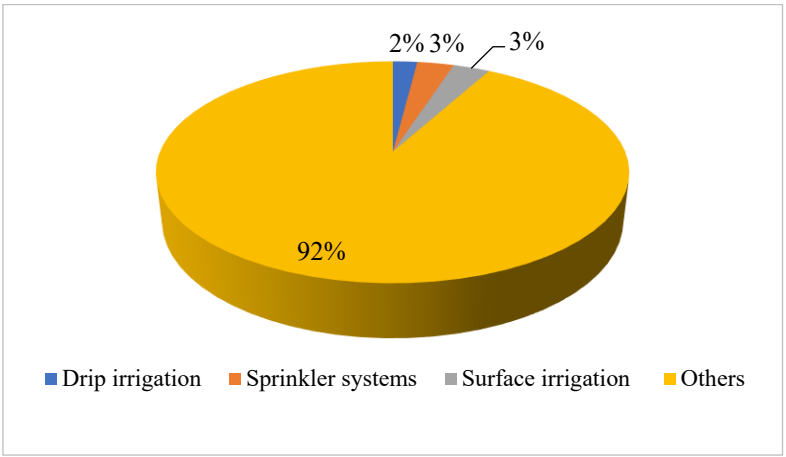


Figure 3. Irrigation Practices Used by the Farmers

Modern efficient technologies showed minimal penetration: drip irrigation (2%), sprinkler systems (3%), and surface irrigation (3%). This overwhelming reliance on traditional methods, while minimizing capital requirements, results in substantial water losses through evaporation and poor application efficiency. Similar patterns characterize smallholder systems throughout Sub-Saharan Africa, where high installation costs, limited technical expertise, weak extension support, and credit constraints prevent adoption of water-efficient technologies [28], [29]. The dominance of water-intensive vegetables and cereals combined with inefficient irrigation creates acute vulnerability to water stress episodes.

Water Stress Impacts on Crop Health and Pest-Disease Dynamics

Water stress generated severe biotic challenges, with fungal infections affecting 68% of farmers (Figure 4), followed by viral diseases (20%) and bacterial infections (4%).

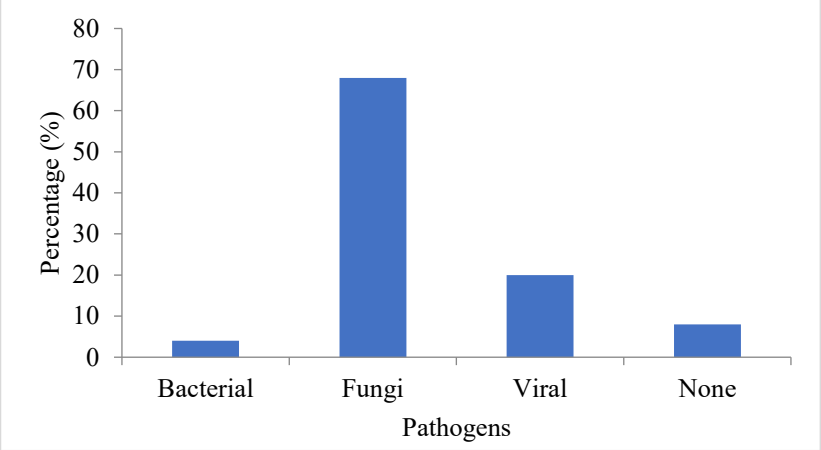


Figure 4. Types of Pathogens Encountered by Farmers as a Result of Water Stress.

The fungal disease predominance aligns with established physiological mechanisms: water stress creates microclimate fluctuations and compromises plant defense signalling, particularly salicylic acid pathways crucial for fungal resistance [30], [31], [32]. Alternating drought and irrigation cycles generate humidity conducive to fungal spore germination and mycelial growth, while stressed plants exhibit reduced capacity for synthesizing antifungal compounds [33], [34], [35]. The relatively lower bacterial incidence likely reflects reduced free water availability for bacterial movement and infection establishment during drought periods, though waterlogging episodes can dramatically elevate bacterial diseases [36], [37]. Insect pest pressures proved even more severe, with 90% of farmers reporting significant problems (Figure 5), while rodents and weeds each affected 4%.

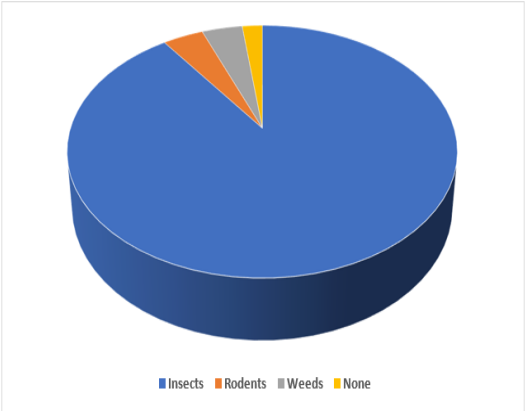


Figure 5. Problematic Pests Faced by Farmers as a Result of Water Stress.

This overwhelming insect predominance reflects well-documented stress-induced changes in host plant suitability. Water-stressed plants accumulate elevated phloem concentrations of soluble sugars and amino acids, enhancing nutritional quality for sap-feeding insects including aphids, whiteflies, and planthoppers [38], [39].

Simultaneously, drought often suppresses jasmonic acid-mediated anti-herbivore defenses while plants prioritize abscisic acid-regulated stress tolerance, creating physiological trade-offs that compromise pest resistance [40], [41]. Additionally, stressed plants emit altered volatile organic compound profiles that can attract rather than repel herbivorous insects [42], [43].

Yield impacts proved catastrophic, with 96% of farmers reporting high negative effects from water stress and only 1% documenting increases (Table 2).

Table 2. Impact of Water Stress on Crop Yield and Pests Infestation

Water Stress on Crop Yield	Frequency(N)	Percentage (%)
High Impact	96	96
Moderate Impact	4	4
Increase In Crop Yield Due Water Stress		
Yes	1	1
No	99	99
Pest Infestation Changed Due to Water Stress		
Increased	99	99
Decreased	1	1

Income losses reflected this productivity collapse, with 72% losing over half their farm income and 93% experiencing decreased earnings (Table 3).

Table 3. Economic Impact of Water Stress on Overall Farm Income.

How Has Water Stress Affected Your Overall Farm Income	Frequency(N)	Percentage (%)
Decreased	93	93
Increased	7	7
Percentage of Income Affected		
0-10%	2	2
11 - 25%	2	2
26-50%	23	23
More than 50%	72	72
Additional Resources Invested?		
No	16	16
Yes	84	84
If Yes, What Resources Have You Invested In?		
Irrigation system	23	23
Other	77	77
Perception on Long- term Economic Viability of Farming under Water Stress		
Not viable	68	68
Somewhat viable	6	6
Very viable	26	26

Contin. Table 3.

How Concerned are you about Future Water Availability for Agriculture		
Somewhat concerned	3	3
Very concerned	97	97
Importance on Collaboration on Water Management Strategies		
Not important	8	8
Somewhat important	29	29
Very important	63	63

These severe economic consequences align with global evidence demonstrating water scarcity as a primary driver of smallholder yield losses, particularly in rainfed and poorly-managed irrigated systems [44], [45]. Pest infestations intensified under water stress for 99% of farmers, confirming synergistic interactions where abiotic stress simultaneously reduces plant defenses while enhancing pest population growth and damage potential.

Management Strategies and Adoption Barriers

Adaptive management proved severely limited despite urgent need. Only 10% of farmers implemented water-saving practices like mulching, while 90% employed no formal conservation measures **(**Table 4**).**

Table 4. Strategies Used by Farmers to Mitigate Water Stress

STRATEGIES TO CONSERVE WATER	Frequency(N)	Percentage (%)
Efficient irrigation practices		
mulching	10	10
None	90	90
EFFECTIVENESS OF THE STRATEGIES		
Crop rotation		
Not effective	86	86
Somewhat effectiveness	6	6
Very effective	8	8
TRAINING ON WATER MANAGEMENT TECHNIQUES		
No	26	26
Yes, occasionally	65	65
yes, regularly	9	9
INFORMATION SOURCE		
Agricultural extension	21	21
Online resources	5	5
Peer farmers	21	21
None	53	53

This minimal adoption occurs despite mulching's effectiveness for moisture retention, temperature moderation, and weed suppression at relatively low cost [46], [47].
The adoption deficit reflects multiple interacting constraints documented across smallholder systems globally [48], [49].
Farmer perceptions of existing strategies proved largely negative, with 86% rating crop rotation as ineffective against water stress. While rotation provides benefits for nutrient cycling and certain pest management objectives, its limited direct impact on water availability explains this perception. More concerning, only 9% received regular training in water management techniques, while 65% obtained occasional training and 26% received none. This extension service weakness leaves farmers dependent on informal knowledge sources: 53% had no reliable information access, 21% relied on peer farmers, 21% on agricultural extension when available, and only 5% on online resources. Such information poverty severely constrains technology adoption and practice improvement.
Barriers to implementing water-saving practices (Figure 6) were dominated by financial constraints (44%) and knowledge gaps (30%), with limited technology access contributing 20%.

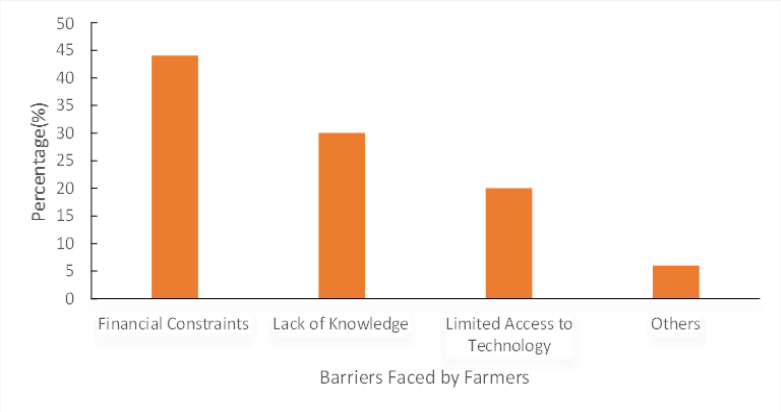


Figure 6. Barriers Faced by Farmers to Implement Water Saving practices.

These findings mirror patterns across developing-country agriculture where capital requirements for irrigation infrastructure exceed smallholder capacity, while inadequate extension services prevent effective utilization even of affordable technologies [50], [51].
The financial barrier manifests despite 84% of farmers investing additional resources to cope with water stress, indicating that available capital remains insufficient for transformative changes. When asked about adoption motivations (Table 5), 55% emphasized financial incentives including subsidies, credit, and insurance, compared to 25% citing peer recommendations and 18% proven effectiveness.

Table 5. Role of Climate Change, Motivations, Adoption of New Technologies, Sustainable Farming Practices to Mitigate Water Stress

Role of Climate Change in Water Stress	Frequency(N)	Percentage (%)
Major role	92	92
Moderate role	8	8

Contin. Table 5.

Adopt New Technologies for Managing Water Stress		
Not likely	76	76
Somewhat likely	15	15
Very likely	9	9
Motivation in Adopting New Technologies		
Recommendations from peers	25	25
Proven effectiveness	18	18
Financial incentives	55	55
Others	2	2
Can Sustainable Farming Practices help Mitigate Water Stress?		
Yes	98	98
No	2	2

Economic Consequences and Future Viability

Water stress generated severe economic hardship extending beyond immediate yield losses. While 93% experienced income declines, the magnitude proved extreme, with 72% losing over half their income and an additional 23% losing 26-50% (Table 3). Such dramatic economic shocks directly threaten household food security, asset accumulation, and intergenerational welfare—consequences extensively documented in climate vulnerability literature [52], [53]. Despite majority investment in coping resources (84%), farmers predominantly perceived long-term farming under water stress as non-viable (68%), with only 26% viewing it as very viable and 6% as somewhat viable. This pessimistic outlook reflects accumulated experience with escalating climate variability overwhelming adaptive capacity.

Climate change attribution proved near-universal, with 92% identifying it as playing a major role in water stress intensification (Table 5), consistent with scientific understanding of anthropogenic climate impacts on regional hydrology [54], [55]. Future water availability concerns were nearly unanimous (97% very concerned), while 63% rated collaborative water management strategies as very important, suggesting recognition that individual farmer actions prove insufficient. However, willingness to adopt new technologies remained low (76% not likely), primarily due to cost and uncertainty despite 98% agreeing that sustainable practices could help mitigate stress.

Water source dependencies (Figure 7) revealed reliance on rivers (36%), groundwater (30%), and various combinations, with only 10% depending solely on rainfall.

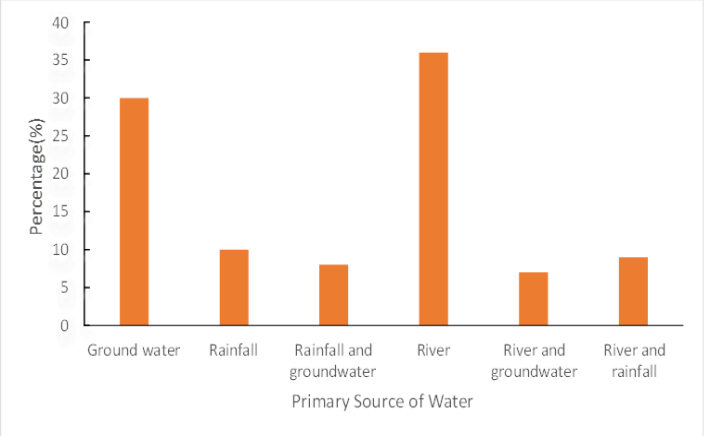


Figure 7. Primary source of water Used by Farmers.

This diversity suggests vulnerability to both surface water variability and groundwater depletion. Farm sizes proved predominantly small (91% under 10 acres), limiting individual investment capacity and economies of scale—a pattern reinforcing the need for collective approaches through cooperatives or water user associations [56], [57], [58]. Legal water rights concerns remained minimal (10%), possibly reflecting weak enforcement or communal access traditions, though emerging scarcity may intensify future competition.

Table 6. Legal Issues and Concerned Regarding Water Usage, and Farm Size.

Legal Issues Regarding Water Right and Usage	Frequency(N)	Percentage (%)
No	90	90
Yes	10	10
Biggest Concerned Regarding Water Right and Usage		
Access to water	7	7
Competition with other users	3	3
other	90	90
Farm Size		
10 to 20 acres	7	7
20 to 30 acres	2	2
Less than 10 acres	91	91

Critical factors for addressing water stress (Figure 8) prioritized technological innovation (50%) and farmer education (40%), with community engagement (9%) and policy changes (1%) receiving less emphasis.

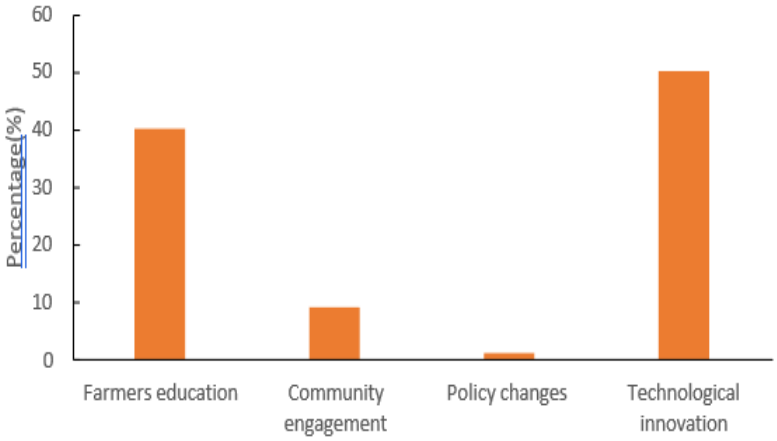


Figure 8. Critical Factors for Addressing Water Stress in Agriculture.

This prioritization reflects practical farmer orientation toward tangible solutions over institutional reforms, though successful intervention requires integrated approaches combining all elements.

Support needs (Figure 9) emphasized financial assistance (48%), technical training (30%), and resource access (20%), reinforcing that effective adaptation requires simultaneously addressing capital, knowledge, and infrastructure constraints rather than isolated interventions.

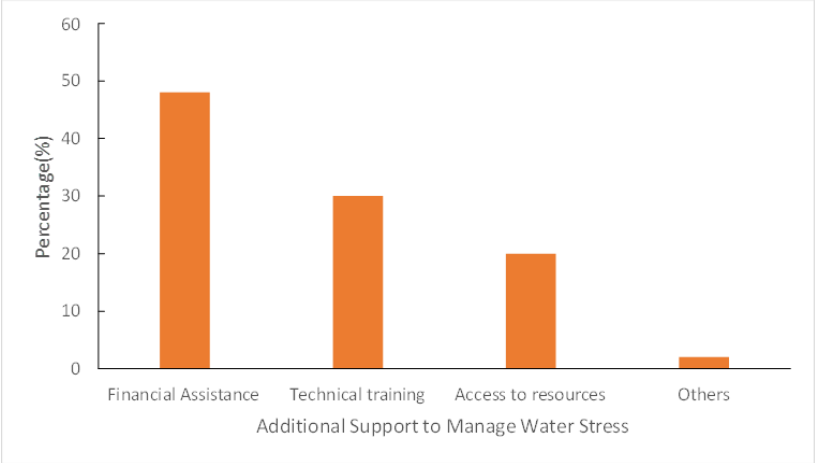


Figure 9: Additional support needed to manage water stress more effectively.

The Way Forward: Integrated Pathways for Sustainable Water-Stress Management

Addressing water stress impacts on pest-disease dynamics in Ghana's smallholder farming systems requires integrated, multi-dimensional interventions that simultaneously tackle technological, institutional, financial, and knowledge constraints identified in this study.

Technological transformation must follow a phased approach, beginning with low-cost interventions like mulching (currently adopted by only 10% despite proven effectiveness) before progressing to capital-intensive systems.

Community-based procurement models can reduce drip irrigation costs by 40-60% through collective purchasing, as demonstrated in Kenya where cooperative arrangements increased adoption from 3% to 28% within five years [59]. Smart irrigation technologies integrating low-cost sensors with mobile phone connectivity offer frontier opportunities for precision water management that simultaneously reduces pest-disease risks [60], [61], [62].

Capacity building represents perhaps the most critical intervention, given that 53% of farmers lack reliable information sources and only 9% receive regular training. Pluralistic extension approaches combining video-mediated learning, farmer-to-farmer networks, and lead farmer models have achieved 30-40% higher technology adoption rates compared to conventional extension in similar contexts [63], [64]. Training curricula must integrate pest-disease-water stress interactions rather than addressing these factors in isolation, enabling farmers to implement coordinated management responses.

Financial mechanisms beyond traditional credit are essential, as 44% of farmers cited cost as the primary adoption barrier. Index-based weather insurance bundled with irrigation loans reduced default rates from 18% to 4% in Kenya's Kilimo Salama program [65], while performance-based subsidies conditioning support on verified adoption of integrated practices achieved 45% higher water productivity in Mexico [66], [67]. Pay-as-you-go financing models leveraging mobile money platforms offer additional pathways for overcoming upfront cost barriers.

Germplasm improvement through participatory breeding integrating drought tolerance, pest resistance, and pathogen defense addresses the synergistic stress interactions documented. Marker-assisted selection enables simultaneous tracking of multiple favourable traits, while participatory varietal selection ensures varieties meet farmers' multiple production constraints, achieving 30% adoption rates versus under 10% for conventionally-released varieties [68], [69], [70].

Institutional reforms establishing water user associations and farmer producer organizations enable collective action critical for smallholders farming 91% of land below 10 acres. Successful associations in Morocco reduced water losses from 45% to 22% through participatory management [71], [72]. Policy coherence across fragmented institutional landscapes requires cross-sectoral coordination mechanisms integrating agriculture, water, climate, and rural development agencies.

Climate information services translating seasonal forecasts into actionable irrigation and pest management recommendations can reduce climate-related losses by 15-30% [73], [74]. Integrating soil moisture monitoring with pest surveillance enables anticipatory interventions, as demonstrated by Ghana's fall armyworm early warning systems that reduced crop damage from 35% to 12%.

Integrated pest-disease management must explicitly account for water stress interactions through precision irrigation scheduling, biological control agents showing enhanced efficacy under stress conditions, and push-pull strategies simultaneously addressing pest pressure and soil water retention [75], [76]. Implementation requires robust participatory monitoring systems enabling adaptive learning and continuous program refinement based on farmer experiences and emerging evidence.

Success demands simultaneous progress across all dimensions rather than isolated interventions, recognizing that technological solutions alone prove insufficient without complementary investments in human capacity, financial access, institutional development, and enabling policy environments.

CONCLUSIONS

This study provides comprehensive evidence that water stress creates synergistic pest-disease-plant interactions generating disproportionate impacts on smallholder irrigated agriculture in the Central Region of Ghana. The predominantly aging, minimally educated farmer population employing rudimentary irrigation methods proves highly vulnerable to climate-driven water stress intensification. Water scarcity simultaneously compromises plant physiological defenses while creating favorable conditions for fungal pathogens and insect pests, resulting in severe yield losses affecting 96% of farmers and income reductions exceeding 50% for 72% of participants. Despite near-universal recognition that sustainable practices could mitigate impacts (98%), adoption remains minimal (10%) due to intersecting financial constraints (44%) and knowledge gaps (30%), compounded by weak extension services leaving 53% without reliable information access.

The research demonstrates that addressing water stress-pest-disease dynamics requires integrated interventions combining affordable irrigation technologies, targeted farmer capacity building, financial incentives, and collaborative governance structures.

Priority actions include: expanding access to efficient irrigation systems through subsidies and credit mechanisms; strengthening extension services to deliver practical training in water-efficient practices and integrated pest management; establishing farmer field schools enabling peer learning and technology demonstration; developing climate-informed early warning systems linking water stress forecasts with pest-disease risk alerts; promoting water user associations facilitating collective resource management; and breeding crop varieties combining water stress tolerance with pest-disease resistance to mitigate physiological trade-offs.

Future research should investigate specific mechanisms underlying water stress-pest-pathogen interactions in locally important crops, evaluate cost-effectiveness of alternative irrigation technologies under smallholder constraints, and assess policy instruments for incentivizing adoption. Long-term monitoring of climate adaptation trajectories will prove essential for understanding how farming systems evolve under intensifying environmental pressures and identifying pathways toward sustainable resilience.

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VODNI STRES I NJEGOVI SINERGIJSKI EFEKTI NA DINAMIKU ŠTETOČINA I BOLESTI U POLJOPRIVREDI NA MALOM POSEDU SA PRIMENOM NAVODNJAVANJA: -DOKAZI IZ CENTRALNOG REGIONA GANE

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Apstrakt. Vodni stres, koji se manifestuje u obliku suše ili zadržavanja vode u zemljištu, predstavlja ozbiljan izazov za poljoprivredu zasnovanu na primeni navodnjavanja, jer narušava fiziološke odbrambene mehanizme biljaka i stvara povoljne uslove za razmnožavanje štetočina i patogena.
Ovaj rad ispituje složene međusobne odnose između vodnog stresa, zdravstvenog stanja useva i dinamike štetočina i bolesti u zajednici Somnjamekodur, okruzima Tvifo Hemang i Donji Denkjira, u centralnom regionu Gane.
Istraživanje je sprovedeno primenom kvantitativnog pristupa, pri čemu je anketirano 100 nasumično odabranih poljoprivrednika koji se bave proizvodnjom sa sistemom za navodnjavanje.
Podaci su prikupljeni pomoću struktuiranog upitnika koji je obuhvatio demografske karakteristike ispitanika, prakse navodnjavanja, efekte vodnog stresa, primene mera upravljanja i ekonomske posledice.
Rezultati su pokazali da je većina poljoprivrednika starijeg životnog doba (60% ima preko 46 godina) i sa niskim nivoom formalnog obrazovanja (84% ima osnovno obrazovanje ili uopšte nema osnovno obrazovanje), što ograničava mogućnost usvajanja savremenih tehnologija.
Tradicionalni sistemi navodnjavanja dominiraju (92%), dok su savremeni i efikasniji sistemi poput tehni;kog Sistema kap po kap (2%) i Sistema prskalica (3%) izuzetno slabo zastupljeni.
Vodni stres značajno povećava pojavu gljivičnih infekcija (68%) i napade insekata (90%), što dovodi do velikih gubitaka prinosa — čak 96% ispitanih poljoprivrednika prijavilo je izražene negativne efekte, a 72% gubitke prihoda veće od 50%.

I ako 98% poljoprivrednika smatra da održive poljoprivredne prakse mogu ublažiti efekte vodnog stresa, samo 10% zaista primenjuje mere poput malčiranja.
Kao ključne prepreke istaknute su: finansijska ograničenja (44%) i nedostatak stručnog znanja (30%). Klimatske promene su identifikovane kao glavni uzročnik (92%), ali čak 76% ispitanika negativno iskazuje usvajanje savremene tehnologije zbog visokih troškova.
Rezultati istraživanja ukazuju, da, vodni stres prouzrokuje sinergijske interakcije između biljaka, štetočina i patogena, koje nesrazmerno pogađaju poljoprivrednike sa malim posedima, koji nemaju pristup savremenim tehnikama navodnjavanja i poljoprivrednim savetodavnim službama.
Ovaj rad naglašava hitnu potrebu za integrisanim pristupom koji bi objedinio pristupačne tehnike navodnjavanja, edukaciju poljoprivrednika, finansijsku podršku i kolektivno upravljanje vodnim resursima u cilju povećanja otpornosti poljoprivredne proizvodnje na klimatske promene.

Ključne reči: *Vodni stres, navodnjavana poljoprivreda, dinamika štetočina i bolesti, poljoprivrednici na malom posedu, prilagođavanje klimatskim promenama, Gana*

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