AGRICULTURE FOR THE FUTURE

ETHICS, COOPERATION AND RESOURCE MANAGEMENT

EDITOR

Clement Okechukwu ATTAMAH

AGRICULTURE FOR THE FUTURE: ETHICS, COOPERATION AND RESOURCE MANAGEMENT-2025

ISBN: 978-625-92866-0-0

DOI: 10.5281/zenodo.17671223

Edited By

Clement Okechukwu ATTAMAH

November / 2025

İstanbul, Türkiye

Date: 21.11.2025

Halic Publishing House
İstanbul, Türkiye
www.halicyayinevi.com

adopted by Esma AKSAKAL
ISBN: 978-625-92866-0-0

AGRICULTURE FOR THE FUTURE: ETHICS, COOPERATION AND RESOURCE MANAGEMENT

EDITOR

Clement Okechukwu ATTAMAH

AUTHORS

Dr. Joy Chizaram Iro UKOHA
Ogochukwu Gabriella ONAH
Clement Okechukwu ATTAMAH
Innocent Achonam ENWELU
Charles Ekene UDOYE
Onyinyechi Ifeanyi NNADI
Chukwuemeka Chiebonam ONYIA
Ikechukwu Remigius OZIOKO
Chiebonam Justina AYOGU
Mohamed Rami BERBACHE
Chaima CHETIOUI
Ameur ZAGHOUANI
Amina HAMMADI
Kawther BOUREZZANE
Soumia FADHLAOUI
Ayoub HADJEB

TABLE OF CONTENTS

PREFACE

This collection of chapters offers a timely and critical exploration of agricultural development through diverse lenses of governance, sustainability, and education. The first chapter confronts the persistent challenges of corruption and unethical practices in Nigeria's agricultural sector, proposing actionable strategies to strengthen transparency and institutional integrity.

The second and third chapters shift focus to climate resilience and regional development. One highlights the role of cooperatives in advancing climate-smart agriculture and enhancing food security, while the other examines the agricultural potential and limitations in Algeria's Sétif Province, revealing the complex interplay between natural resources and socio-economic constraints.

The final chapter presents foundational insights into extension teaching—its concepts, procedures, and guiding principles—underscoring the importance of knowledge transfer and capacity building in agricultural progress. Together, these chapters illuminate pathways toward more equitable, sustainable, and informed agricultural systems.

Editoral Team
November 21, 2025
Türkiye

CHAPTER 1
APPROACHES FOR CURBING CORRUPTION AND UNETHICAL CONDUCT IN NIGERIAN AGRICULTURAL SECTOR

[1]Clement Okechukwu ATTAMAH
[2]Innocent Achonam ENWELU
[3]Charles Ekene UDOYE

[1]Department of Agricultural Extension, University of Nigeria, clement.attamah@unn.edu.ng, ORCID ID: 0000-0002-1343-7987
[2]Department of Agricultural Extension, Nnamdi Azikiwe University, ia.enwelu@unizik.edu.ng, ORCID ID: 0000-0001-8712-5444
[3]Department of Agricultural Extension, University of Nigeria, charles.udoye@unn.edu.ng ORCID ID: 0000-0003-0868-1624

INTRODUCTION

Ethics is typically regarded as a subfield of philosophy that examines how individuals should live by merging ideas of what constitutes "good" behaviour and what constitutes "just" or "right" behaviour. Social mores are a source of laws concerning what is proper and wrong. It is because of this that ethics has been referred to as a "moral philosophy" (Pojman, 1990).

According to Adewunmi (1998), ethics refers to the principles or standards of conduct by which we want to live, work, and interact with one another. Ethical behaviour occurs when one acts in a way that is equitable, fair, and unbiased and respects the rights of others. In other words, ethical behaviour occurs when one does what is morally correct.

Agricultural ethics can be characterized as systemic thinking about the values and norms linked with the food system, including farming, resource management, food processing, distribution, commerce, and consumption. Agricultural ethics combines components of philosophical ethical analysis with issues that occur concerning the food system (Council for Agricultural Science and Technology, 1994). Unethical conduct happens when decisions enable a person or organization to profit at the cost of the larger public (Ogunleye, 2000). The agricultural sector in Nigeria has suffered over time as a result of unethical practices.

According to the Food and Agricultural Organization (2001), the persistence of hunger is the biggest ethical problem with food production, consumption, and trade. Humans need food to survive, and hunger is a result of violations of this basic human right. Every culture assumes that it is necessary to give the physically capable the means to seek food and to allow those who are unable to feed themselves to receive food directly. This is true of both formal ethical systems and ethical practices. The removal of hunger and malnutrition is considered kind, whereas failing to do so is considered an injustice and unethical conduct. The main way unethical behaviour manifests itself is through corruption.

Transparency International (2015a) defines corruption as the misuse of authority for personal benefit. It erodes society's foundation and erodes trust in institutions, leaders, and political and economic systems. People may lose their lives, freedom, health, finances, and sometimes even their lives.

The Centre for Democracy and Governance (1999) also noted that the misuse of public office for personal benefit is a social-human component that contributes to corruption. It includes unilateral wrongdoing by public officials like embezzlement and nepotism as well as wrongdoing involving both public and private actors such as bribery, extortion, peddling, fraud, etc.

1. PROBLEM STATEMENT

Agriculture plays a key role in the economy of Nigeria, hence it should be free of any irregularities like unethical behaviour and corruption-related activities. Because agriculture is characterized by behaviours that engage both social and ecological systems, ethical questions in the field have gained significance. According to Grimm (2005), the mismatch between global food supplies and human nutritional needs, the effect of agribusiness on rural employment, the implications of contemporary agricultural biotechnologies for human and animal welfare, and the effects of intensive production systems on the sustainability of the global environment are all reasons why agriculture has become a matter of moral concern.

The global fight against unethical behaviour and corruption has made tremendous strides, demonstrating that the issue has recently received much more attention (United States Agency for International Development, 2005). This tendency is further supported by the rise in the number of international agreements and state laws prohibiting corruption as well as the transformation of Transparency International from a local NGO to a worldwide movement with over 100 chapters throughout the world (Fadairo & Ladele, 2014). Although there is evidence that corruption still exists as a serious issue and a major development barrier, diplomatic, donor, and private sector engagement in the battle against unethical behaviour and corruption has increased as well (USAID, 2005; Anand, 2006; Sarmiento, 2006). Although corruption is not a new phenomenon, its scope and forms are worryingly expanded. Its influence has reached every aspect of national life. It is one of the main dangers to Nigeria's growth and development (Ades & Di Tella, 1996).

What is more regrettable today is the rising acceptance of corruption as a necessary evil and an essential component of civil society (Anand, 2006).

If it isn't stopped, governments and individuals will pay a very high price for the unstable economic fluctuations that would ensue from reduced earnings, fewer investments, and less development (Olopoenia, 1998). According to the United States Agency for International Development (2005), corruption stifles democracy, threatens social, political, and economic development, and slows economic growth. Further, according to USAID, ignoring widespread corruption ultimately weakens all development initiatives, with small and medium-sized businesses suffering disproportionately. And the majority of farmers fall into this category, which is small scale.

An anti-corruption and ethically sound system is critical for the agricultural industry. Anticorruption initiatives are expected to aid in the accomplishment of objectives in the agriculture sector by increasing the productivity of public spending, identifying and decreasing leakage, and strengthening citizen monitoring. In a similar spirit, Anand (2006) claimed that instead of wailing uncontrollably over corruption's pervasive negative impacts, we should instead take proactive steps to stop its growth. Therefore, according to Anand's viewpoint, the people themselves are largely responsible for finding a solution. Similarly, Spector (2005) claimed that sector-specific solutions can be pursued concurrently with or even in the absence of political support for more systemic reforms, even though comprehensive government reforms to eliminate chronic corruption may be necessary. In light of this, the following questions were investigated in the study: What are the unethical and corrupt practices in the agricultural industry? And what approaches can be adopted in curbing corruption and unethical conduct in the Nigerian agricultural sector?

2. ETHICAL ISSUES IN AGRICULTURE

Agriculture raises a lot of ethical questions. One aspect of this is the overall corruption of regulators and legislators, as well as issues with food safety, animal welfare, pollution, and environmental sustainability.

There are two different types of ethical problems, according to Nash (1990). Type I difficulties or problems are the first category. These involve moral dilemmas where the "ethical" course of action is up for debate.

Examples in agriculture include debates about the use of biotechnology in food production, the genetic modification of crop plants, and the use of animals in biomedical research. Because they are contentious, Type I ethical issues are serious. The pertinent issue that ethicists must answer when seeking to settle Type I ethical difficulties is, "What is the appropriate norm or standard in this matter?" Argument and moral discussion are used to settle Type I ethical difficulties, which involve value conflicts. Type II problems can be used to describe the second group (Nash, 1990). These involve situations where there is agreement on the proper action, standard, or norm but there are incentives for people to go against it. Examples in agriculture include dumping toxic waste into a public water system, growers and processors breaking food safety laws, and bribing government officials to get a favourable farm policy or decision. Due to the incentives for people to disregard ethical standards, type II ethical concerns are substantial. The pertinent question that ethicists must address when seeking to settle Type II ethical difficulties is, "We know what the appropriate ethical norm is in this matter, but why do some individuals violate that norm?" Changes in the institutional environment are made to provide people or organizations with incentives to adhere to generally accepted ethical norms (or at the very least, so that they do not have incentives to act unethically), which is how Type II ethical problems, caused by perverse institutional incentives, are resolved.

3. CORRUPTION AND UNETHICAL CONDUCT IN AGRICULTURE

According to the Philippine Civil Service Commission, a violation of the law is considered unethical behaviour. Thus, actions that are not ethically deserving or that are against the law would be considered unethical. Corrupt practices, mail and wire fraud, discrimination and harassment, insider trading, conflicts of interest, inappropriate use of company assets, bribery and kickbacks, compliance procedures, disciplinary action, fraud, illegal business donations, patent infringement, and product liability are just a few of the behaviours that fall under this classification (Barrcus & Near, 1991).

Events like the Watergate Scandal, the Lockheed Scandal, the 1972 US presidential election, illicit business donations, and bribery of foreign officials to encourage business abroad are examples of unethical behaviour that sparked interest in ethics (Carroll, 1978). The most prevalent ones currently are deceitful communication, collusion, conflicts of interest, gifts and bribes, unfair practices, insider trading, discrimination and harassment, and embezzlement.

According to Fadairo and Ladele (2014), corruption and unethical conduct-related activities in the Nigerian agricultural sector includes; misappropriation of agricultural subsidies, nepotism, patronage, pork-barrelling, bribery, influence peddling, bureaucratic conflict of interest, impropriety, abuse of office, private use of public resources, etc. Agriculture-related corruption and unethical behaviour affect issues like land usage and title, credit supply and availability, supply quality, water allocation, product standards and certification, marketing, agricultural regulations, and the growth of agribusinesses (Fink, 2002). What then is the way forward?

Transparency International's study report states that sub-Saharan Africa confronts a significant challenge in eliminating corruption. The survey found that one of the best methods to prevent corruption is to report instances of bribery. According to Transparency International (2015b), many people fail to disclose bribery because they fear facing punishment and believe that the systems in place are inadequate.

Although prosecuting corrupt people is crucial to show that corruption is not allowed and that neither the highest-ranking government official nor the wealthiest businessperson is exempt from prosecution, anti-corruption efforts go beyond simply punishing the guilty. A comprehensive strategy to combat corruption, however, goes beyond criminalization and prosecution. It also includes prevention, which entails creating transparent, accountable systems of governance, enhancing the capacity of civil society and the media, enhancing public integrity, enhancing the personal ethics of public and private officials, and perhaps even challenging social norms that support corruption (www.u4.no/articles/the-basics-).

4. ETHICS AND GOVERNANCE

Ethical governance is described as a government's ongoing efforts to establish trustworthy and transparent leadership to justify its existence. Indicators like the fight against corruption serve as proof of this. The subject of ethical governance in Nigeria can be analysed against the backdrop of inconsistency and hypocrisy in the government's implementation of the law and the fight against corruption. All corrupt practices and power abuse must end for accountability and transparency to be guaranteed in the government of any sector, including agriculture.

Rule of law, openness, and accountability in government, in Femi's opinion (2007), serve as essential elements of effective governance as well as tools for combating corruption. The fruits of freedom and prosperity can be fully shared by all when political will is formed by and drawn from the will of the people. Strong checks and balances are necessary to institutionalize government accountability, and they can be provided, for instance, through independent media and inclusive and participatory governance by citizens. However, when political will is absent, corruption has the power to subvert democracy and undermine the rule of law. This is particularly true in Nigeria, where millions of people are calling on their government to end the cycle of corruption and unethical behaviour, to enact real reform and accountability, and to provide them with a higher standard of living.

5. APPROACHES TO CURBING CORRUPT AND UNETHICAL CONDUCTS

According to Douglas (2012), the following are seven approaches to overcoming corrupt and unethical conduct in the workplace;

- **Put up correct policies and practices:** Organizations must conduct research, create rules and procedures, and then document how to define, spot, and report ethical transgressions. These guidelines should be stated in the employee handbook, and those who bring up ethical concerns should be given protection. Nevertheless, having a policy is insufficient. You must put your words into action.
- **Hire the right people:** The ethics of your company can be greatly improved by choosing quality employees from the start.

Some businesses run background checks, spend money on screening devices, or ask candidates to explain an instance in which they acted morally while going against social or cultural expectations.

- **Develop personnel's understanding of ethical issues and their implications:** The majority of human resource specialists will tell you that teaching employees to act "ethically" won't have much of an impact, but creating a procedure for reporting ethics infractions and educating personnel about ethical expectations is crucial.
- **Encourage and promote the right behaviours:** Leaders in the agricultural industry must take into account if a new policy fosters the kinds of acts that are cherished by the stakeholders before implementing it. It is crucial to discuss the checks and balances that will be implemented to ensure that improper behaviour is dealt with effectively if there is a possibility of impropriety. A reward should also be given where necessary.
- **Put control measures in place:** Risk management experts will tell you that despite having all the necessary policies and procedures in place and a staff that is aware of them, it is still advisable to carry out routine audits to help reduce opportunities for unethical behaviour, persuade people who might act unethically to reconsider, find problems that have arisen accidentally, and mitigate risk generally.
- **Build a culture of transparency, openness, and robust communication:** It is challenging to manage cultures. People must be able to see, hear, and feel what is happening as well as feel confident speaking up when something goes wrong to achieve actual success when it comes to organisational ethics.
- **Leadership must walk the talk:** All day long, leaders can emphasize the value of rules and procedures, rewards, communication, and openness, but if they conduct unethically in their day-to-day operations, it could be like tossing a big stone into the stillness of ethics. The same logic applies to elevating personnel who have acted unethically. Such as a staff who does not have regard for time.

- Staff members at all organisational levels quickly pick up on a leader's lack of ethical behaviour when they talk the talk but don't do the does.This may sow disbelief and erode trust. In addition, Goldfield (2015) suggested the following four proactive approaches to addressing unethical behaviour in the workplace;

5.1 Develop A Code of Ethics

By developing an ethics code, you may set the standard for behaviour at work. A code of ethics lays forth the principles that are significant to a company and establishes a framework for everyone to understand the limits of the organization, such as the Ministry of Agriculture. While being brief enough to fit in a values statement, codes of ethics should be stated in general, aspirational words to convey the ministry's ethical vision. Include ethical standards in the mission statement and employee manuals of the ministry if it makes sense to do so. These documents should cover the ministry's dos and don'ts. When creating and formalizing the code of ethics, make sure to include important personnel. This will guarantee that leaders agree with and are dedicated to the ideals. A document outlining everything that a field extension agent is supposed to do is an example of a code of ethics.

5.2 Establish An Ethical Protocol

A guideline on how to report unethical behaviour should be included in your code of ethics. Establish a clear reporting procedure, such as asking for a private appointment with the relevant manager or supervisor, as well as an anonymous ethical hotline. In addition, make sure the individual assigned to reply is the farthest away from the reported issue or violation if the business lacks internal human resources. As far away from the situation as you can delegate establishes a tone that the issue will be addressed seriously and fosters confidence in your organization's capacity to handle it equitably. Consider investing in a third-party external HR partner who can provide objectivity to the process if keeping an acceptable internal employee is not a possibility.

5.3 Empower Employees with the Right Knowledge and Skills

Give employees the right knowledge and skills they need to spot and deal with ethical infractions. To boost the effectiveness of the code, accomplish this by conducting ethics-training programs for all new and current personnel. Books and other written materials, as well as online, private, or live instruction training, are all options for ethics courses. To further boost the code's relevance to employees, you may even decide to link it to certain financial incentives, like a bonus at the end of the year or additional paid time off.

5.4. Continuously Evaluate and Review the Code of Ethics

Updating the code is a crucial part of maintaining an organization's commitment to ethics. Every year, distribute copies of the code of ethics to all agricultural industry participants. You can also discuss it in workshops, seminars, or conferences. For instance, a conference of stakeholders in the Nigerian agricultural sector such as ministries of agriculture, ADP, faculties of agriculture in universities, agricultural research institutes, private agro enterprises, etc. can be organised where issues regarding corruption and unethical conduct can be deliberated on and code of conduct made available to all. Every stakeholder may be required to validate their comprehension of the code by later signing an acknowledgment form. These will proactively create an environment that supports the stated principles and is supported by both formal and informal means. Any attempt to downplay the significance of creating an ethical culture may lead to legal action, low turnover, low morale, and even the organization's extinction. A shrewd leader would support a formal code of ethics from the start, set up procedures, and regularly review and promote the rules. This will demonstrate to employees the importance of fostering a positive and moral workplace. It is equally important to set expectations that are detailed, clear, and easy for everyone to grasp. The results will ultimately lead to better services, happier and more secure employees, and a more prosperous business.

According to Transparency International (2015b), more needs to be done to safeguard whistle-blowers from reprisal attacks, enhance the efficiency of reporting avenues, and educate the general public about how and where they can report corruption to successfully combat it in sub-Saharan Africa.

The organization also emphasized how several nations in the region have experienced threats and acts of violence against civil society, making it risky to conduct business and challenging to hold governments accountable. Governments must guarantee the operational and physical freedom of such organizations and must provide secure environments for civil society to carry out its anti-corruption efforts.

CONCLUSION

The kind of approach adopted in the fight against corruption and unethical conduct in any sector, such as agriculture, goes a long way to determining the level of success that can be recorded.

The study reveals that the most widely used approach in the fight against corruption and unethical conduct are those revolving around making sound policies, creating of code of ethics, hiring the right person for a job, encouraging the right behaviours, building sound human relations, employee capacity building in the area of ethics and transparency in service delivery, living an exemplary life, the establishment of protocol, protection of whistleblowers from retribution, improvement of reporting channels, raising of public awareness about how and where to report corruption and unethical cases, criminalisation and prosecution of corrupt individuals.

Recommendations

With all these approaches that have been in place in many private and public establishments, corruption and unethical conduct are still rampaging the country's economy. Hence, the study recommends that;

- The body championing the fight against corruption should be strengthened and made more transparent for all to see;
- The consequences of corruption and unethical conduct should be taught in such a way that all will appreciate its damaging effects;
- Every citizen should be empowered through the rule of law to fight against corruption and unethical conduct;
- There should be a vigorous nationwide campaign against corruption and unethical conduct;

- Institutions such as family, education, economic and legal bodies should be cleansed of every corrupt and unethical conduct-related activity via proper and coherent education and sanctions;
- There should be a change in the value and reward system from a materialistic point of view to a character point of view (integrity, discipline, hard work, etc.).

REFERENCES

Ades, A. & Di Tella, R. (1996). The causes and consequences of corruption: A review of recent empirical contributions. IDS Bulletin: Liberalization and the New Corruption, 27(2), 6-11.

Adewunmi, W. (1992). Ethics and Professionalism in Nigeria Banking Industry. CBN publication

Anand, A.S. (2006). Effects of corruption on good governance and human rights. Welcome Address delivered at National Conference on Effects of Corruption on Good Governance and Human Rights held in New Delhi on 9th May 2006. http://www.jansamachar.net

Baucus, M. S. & Near, T. J. P. (1991). Can illegal corporate behaviour be predicted? An event history analysis. Academy of Management Journal, 34(1), 9-36.

Carroll, A. B. (1978). Linking business ethics to behaviour in organizations. SAM Advanced Management Journal. 4-11.

Centre for Democracy and Governance. (1999). A handbook on fighting corruption, Technical Publication Series, Bureau for Global Programs. United States Agency for International Development, Washington, DC., pp: 5-18.

Council for Agricultural Science and Technology (CAST). (1994). How Much Land Can Ten Billion People Spare for Nature? TaskForce Report 121. Council for Agricultural Science and Technology, Ames, Iowa.

Douglas, E. (2012). 7 Practices to Prevent Unethical Behaviour. Top school jobs, Educational Week.

Fadairo, O. and Ladele, A. (2014). Attitudes and perception of corrupt practices among public officials in the agricultural sector in South-western Nigeria. Developing Country Studies,4(8). ISSN 2224-607X (Paper) ISSN 2225-0565. www.iiste.org

Femi, F. (2007). Ethics and governance, the rule of law and anti-corruption: A Nigerian dilemma. Sahara reporters.

Fink, R. (2002). Corruption and the agricultural sector. Sectoral perspectives on corruption prepared by MSI, sponsored by USAID, DCHA/DG. Contract no. AEP+00-00-00009-00. Rapid Response Task.

Food and Agricultural Organisation. (2001). Ethical issues in food and agriculture, Rome, 2001. This article summarizes the ethical aspects (values) in agriculture.

Goldfield, B. (2015). A Proactive Approach to Addressing Unethical Behavior in the Workplace. Entrepreneur. https://www.entrepreneur.com/growing-a-business/a-proactive-approach-to-addressing-unethical-behavior-in/241924

Grimm, H. (2005). Ethical Issues in Agriculture. Interdisciplinary and Sustainability Issues in Food and Agriculture, 1. https://www.academia.edu/42451166/Ethical_Issues_in_Agriculture

Nash, L. L. (1990). Good Intentions Aside: A Manager's Guide to Resolving Ethical Problems, (Boston, MA: Harvard Business School Press, 1990), pp. 122-128.

Ogunleye G.A. (2000). Ethics and professionalism in banking: Lessons from the recent distress in the Nigerian Banking System. NDIC Quarterly Journal, 10(1)

Olopoenia, R.A. (1998). A political economy of corruption and under-development. Faculty lecture delivered at the University of Ibadan on October 7, 1998. Vantage Publishers Ltd., Ibadan.

Pojman, L. I. (1990). Ethics: Discovering Right and Wrong. Belmont, CA: Wadsworth Publishing Company, 1990.

Sarmiento, P. (2000). Agriculture weighed down by corruption and waste. Philippine Center for Investigative Journalism. http://www.pcij.org/stories/2000/agri.html

Spector, B. I. (2005). Fighting corruption. In: Fighting Corruption in Developing Countries: Strategies and Analysis. Bloomfield, CT: Kumarian Press. pp.1–9.

Transparency International, (2015a). What is Corruption? Transparency International: The global coalition against corruption. https://www.transparency.org/en/what-is-corruption

Transparency International. (2015b). Corruption in Africa: 75 million people pay bribes. https://www.transparency.org/news/story/parents_nightmare

United States Agency for International Development. (2005). USAID Anticorruption Strategy. Washington DC.

CHAPTER 2
THE COOPERATIVE ADVANTAGE IN CLIMATE-SMART AGRICULTURE ADOPTION: IMPLICATIONS FOR FOOD SECURITY

[1]Ogochukwu Gabriella ONAH
[2]Onyinyechi Ifeanyi NNADI
[3]Chukwuemeka Chiebonam ONYIA
[4]Ikechukwu Remigius OZIOKO
[5]Chiebonam Justina AYOGU

[1]Department of Agricultural Economics, University of Nigeria, ogochi.onah@unn.edu.ng, ORCID ID: 0000-0002-9883-2109
[2]Department of Agricultural Extension, University of Nigeria, onyinyechi.ogbonna@unn.edu.ng, ORCID ID: 0000-0001-8990-947X
[3]Department of Agricultural Economics, University of Nigeria, ORCID ID: 0000-0002-9642-8209, chukwuemeka.onyia@unn.edu.ng
[4]Department of Agricultural Extension, University of Nigeria, ORCID ID:0000-0001-9180-0000remigius.ozioko@unn.edu.ng
[5]Department of Agricultural Extension, University of Nigeria, justina.ayogu@unn.edu.ng, ORCID ID: 0000-0002-7852-2226

INTRODUCTION

The threat of climate change to global food security necessitates a rapid transformation of agricultural systems. Climate-Smart Agriculture (CSA) offers a holistic framework to achieve this by integrating goals of increased productivity, enhanced resilience, and reduced greenhouse gas emissions. However, its widespread adoption, particularly among smallholder farmers who are most vulnerable yet crucial to global food supplies, remains critically low. This chapter suggests that agricultural cooperatives serve as a pivotal, yet underutilized, institutional mechanism to overcome the primary barriers to CSA adoption- economic constraints, knowledge deficits, risk aversion, and limited market access. Through a systematic review of contemporary literature and a detailed analysis of global case studies, this chapter delineates the multifaceted "cooperative advantage." It demonstrates how cooperatives leverage economies of scale for input access, create platforms for knowledge co-creation and social learning, pool risks to enable experimentation, and develop market linkages that incentivize sustainable production. The review further traces the direct implications of this cooperative-CSA synergy for all four dimensions of food security: availability, access, utilization, and stability thereby contributing to the achievement of the Sustainable Development Goals (SDGs), most notably SDG 2 (Zero Hunger), SDG 13 (Climate Action), and SDG 17 (Partnerships for the Goals). In conclusion, integrating robust support for agricultural cooperatives into national and international climate and agricultural policies is not merely beneficial but essential for building equitable and resilient food systems. Specific recommendations are offered for policymakers, development partners, and cooperative leaders to harness this potential effectively.

The Converging Crises of Climate Change and Food Insecurity

The global agricultural landscape is defined by a paradox: it must simultaneously become more productive to feed a growing population and more sustainable to operate within global boundaries. The Intergovernmental Panel on Climate Change (IPCC, 2022) stated with high assurance that anthropogenic climate change is already reducing agricultural productivity in many regions, exacerbating water scarcity, and increasing the frequency and intensity of extreme weather events.

These impacts directly undermine the foundation of global food security, threatening to reverse decades of progress in reducing hunger. The latest reports indicate that after years of decline, global hunger is on the rise again, with up to 828 million people facing chronic undernourishment, a crisis significantly amplified by climate variability and conflict (FAO et al., 2023). This convergence of climate and food crises demands not incremental change but a systemic transformation of how we produce, distribute, and consume food.

Climate-Smart Agriculture: A Conceptual Solution

In response to this urgent need, Climate-Smart Agriculture (CSA) has emerged as a dominant paradigm within global agricultural development discourse. Championed by the Food and Agriculture Organization (FAO) and other key institutions, CSA is defined by its pursuit of three intertwined objectives: (1) sustainably increasing agricultural productivity and farm incomes to support national food security and development goals; (2) adapting and building resilience of food systems and farming communities to climate change; and (3) reducing and/or removing greenhouse gas emissions from agriculture, where possible (FAO, 2013). It is crucial to understand that CSA is not a prescriptive set of practices but a context-specific approach that may include a diverse portfolio of technologies and management strategies, such as agroecology, conservation agriculture, agroforestry, integrated water management, precision farming, and improved livestock management. The ultimate goal is to transform agricultural systems into ones that are productive, resilient, and with low emission.

The Persistent Adoption Gap and the Institutional Vacuum

Despite its compelling rationale and proven technical potential, a significant gap exists between the promise of CSA and its widespread adoption on farms, particularly among the world's 500 million smallholder households. The barriers are multifaceted and well-documented. They include high upfront investment costs for new technologies and limited access to credit and insurance. Farmers also face insufficient technical knowledge and inadequate extension services, as well as high perceived risks of experimenting with new practices.

In addition, there is often a lack of market incentives or premium prices for sustainably produced goods (Lipper et al., 2018).For an individual smallholder farmer operating on a marginal economic footing, the perceived risk of adopting an unfamiliar practice often outweighs the potential long-term benefit. This adoption gap highlights a critical failure: a focus on technological solutions without a commensurate focus on the institutional mechanisms required to deliver them. The question is not merely "what works?" but "how can it be delivered effectively and at scale?".

1. CONCEPTUAL FRAMEWORK: INTERLACING COOPERATIVES INTO THE CSA-FOOD SECURITY NEXUS

A deep understanding of CSA is foundational. The three pillars are interdependent and synergistic (Zougmoré et al., 2018):

- Productivity: The goal is sustainable intensification. Practices must increase yields and incomes without degrading the natural resource base, ensuring that gains are not short-lived.
- Adaptation: This involves adjusting agricultural practices and systems to moderate or exploit the beneficial effects of climate change. It includes using drought-tolerant seeds, diversifying crops, implementing water-harvesting techniques, and adopting soil conservation measures.
- Mitigation: This refers to reducing the emission intensity of agricultural production (emissions per unit of output) or enhancing carbon sequestration in soils and biomass. Examples include improved manure management, reduced tillage, agroforestry, and efficient fertilizer application.

The power of CSA lies in practices that deliver "triple wins," advancing all three pillars simultaneously. For instance, agroforestry (integrating trees on farms) can sequester carbon (mitigation), provide shade and windbreaks to protect crops (adaptation), and yield fruit, timber, or fodder to boost incomes (productivity).

1.1 Agricultural Cooperatives: More Than Business Entities

Agricultural cooperatives are member-owned, member-controlled, and member-benefitting business enterprises. Their identity is defined by the International Cooperative Alliance's (ICA, 2023) seven principles, which include voluntary and open membership, democratic member control, member economic participation, autonomy and independence, education and training, cooperation among cooperatives, and concern for community. This principles-based structure makes them fundamentally different from investor-owned firms. Their dual nature as both economic enterprises and social organizations is key to their potential in promoting CSA. They are embedded within local social networks, fostering trust and social capital—a prerequisite for collective action on common challenges like climate change (Ostrom, 1990). They are motivated not solely by profit maximization but by improving the long-term well-being of their members and their communities, aligning perfectly with the intergenerational goals of sustainability.

1.2 Defining Food Security in a Climate-Stressed World

Food security exists "when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO, 2006). This definition rests on four pillars:

- Availability: sufficient quantities of food of appropriate quality, supplied through domestic production or imports.
- Access: having adequate resources (economic, physical) to obtain appropriate foods for a nutritious diet.
- Utilization: the ability to use food effectively through adequate diet, clean water, sanitation, and healthcare.
- Stability: consistent access to adequate food, without risk of losing it due to sudden shocks (e.g., climate, economic) or cyclical events.

Climate change directly threatens all four pillars, making stability and resilience central to modern food security concepts.

1.3 Synthesizing the Pathway: From Cooperative Action to Secure Food Systems

The proposed conceptual pathway integrates these components:

Climate change pressures increase production risks and variability, threatening food security. This creates a need for CSA, but adoption is blocked by significant barriers. Agricultural cooperatives, by their very structure and principles, act as a catalytic intermediary. They deploy specific mechanisms (economic pooling, knowledge sharing, etc.) to dismantle these barriers, thereby facilitating the adoption of CSA practices. The successful implementation of these practices leads to improved agricultural outcomes: higher and more stable yields (productivity), reduced vulnerability to shocks (adaptation), and a lower environmental footprint (mitigation). These improved outcomes, in turn, directly and positively impact the four dimensions of food security. This entire process contributes to the achievement of multiple SDGs, creating a sound cycle of sustainable development.

1.4 The Role of Social Capital and Trust in Cooperative-Led CSA

The effectiveness of cooperatives as instruments for CSA adoption is deeply rooted in the concept of social capital which is the networks of relationships, trust, and shared norms that enable collective action. Unlike top-down extension models, cooperatives leverage pre-existing social networks and build upon them. The repeated, face-to-face interactions within a cooperative foster trust (Fischer & Qaim, 2014), which is critical for overcoming the perceived risk of adopting new, unproven CSA practices. When a trusted peer shares a success story with conservation tillage or a new drought-resistant seed variety, it carries more weight than advice from an external agent. This high-trust environment reduces the "transaction costs" of cooperation, making it easier to organize collective actions such as managing shared watersheds, enforcing grazing agreements, or pooling resources for a bulk purchase. Furthermore, cooperatives often reinforce and build new norms around sustainable management, creating a culture where CSA adoption becomes the expected behavior rather than the exception.

This social infrastructure is an intangible yet vital asset that explains why the cooperative model can succeed where other institutional arrangements fail.

1.5 The Role of Social Capital and Trust in Cooperative-Led CSA

The effectiveness of cooperatives as instruments for CSA adoption is deeply rooted in the concept of social capital which is the systems of relationships, trust, and shared norms that enable collective action. Unlike top-down extension models, cooperatives leverage pre-existing social networks and build upon them. The repeated, face-to-face interactions within a cooperative foster trust (Fischer & Qaim, 2014), which is critical for overcoming the perceived risk of adopting new, unproven CSA practices. When a trusted peer shares a success story with conservation tillage or a new drought-resistant seed variety, it carries more weight than advice from an external agent. This high-trust environment reduces the "transaction costs" of cooperation, making it easier to organize collective actions such as managing shared watersheds, enforcing grazing agreements, or pooling resources for a bulk purchase. Furthermore, cooperatives often reinforce and build new norms around sustainable management, creating a culture where CSA adoption becomes the expected behavior rather than the exclusion. This social infrastructure is an intangible yet vital asset that explains why the cooperative model can succeed where other institutional arrangements fail.

2. THE MECHANISMS OF THE COOPERATIVE ADVANTAGE: A MULTIDIMENSIONAL ANALYSIS

The high initial investment required for many CSA technologies is a primary deterrent. Cooperatives overcome this through the fundamental principle of collective economics.

- **Bulk Purchasing:** By aggregating member demand, cooperatives can negotiate significant discounts on inputs like climate-resilient seeds, organic fertilizers, biopesticides, and efficient irrigation equipment (e.g., drip lines). This lowers the unit cost for each member, making adoption financially viable (Mojo et al., 2017).

- **Shared Asset Ownership:** Cooperatives can collectively invest in high-cost machinery that would be exorbitantly expensive for an individual smallholder farmer. For example, a cooperative can purchase a zero-till drill for conservation agriculture, a rice transplanter, or a solar-powered irrigation pump, making it available to members for a rental fee. This model dramatically reduces the capital barrier to accessing precision technology (Abebaw & Haile, 2013).
- **Access to Finance:** Individually, smallholder farmers are often considered high-risk and unbanked. A cooperative, with its collective assets and governance structure, can act as a financial intermediary. It can secure loans from formal financial institutions on behalf of its members, provide internal credit systems, or act as a guarantor for individual member loans. This unlocks crucial capital for investing in CSA infrastructure.

2.1 Facilitating Knowledge Co-Creation and Social Learning

Knowledge is not merely a lack of information but often a lack of contextually relevant, trusted advice.

- **Platform for Extension:** Cooperatives provide a cost-effective platform for government and NGO extension services. Training dozens of farmers through a single cooperative is far more efficient than visiting scattered individual farms. This amplifies the reach and impact of limited extension resources (Wollni & Fischer, 2019).
- **Peer-to-Peer Learning and Demonstration:** Perhaps more importantly, cooperatives facilitate social learning. Member-to-member knowledge transfer is often more trusted and effective than top-down advice. Successful early adopters within the cooperative can serve as role models, and their farms can become living laboratories for demonstration plots. This builds confidence and reduces the perceived risk of new practices.
- **Knowledge Co-creation:** Cooperatives can facilitate a process where external scientific knowledge is blended with indigenous knowledge held by members, leading to the development of locally adapted and more effective CSA innovations.

2.2 Risk Mitigation, Social Capital, and Collective Action

Agricultural innovation is inherently risky. Cooperatives provide a crucial risk-mitigation function.

- **Pooling and Sharing Risk:** Cooperatives can establish internal insurance or emergency funds to cushion members against potential losses from failed experiments with new CSA practices. This safety net encourages innovation.
- **Collective Action for Landscape Management:** Many CSA practices are more effective when implemented at a landscape scale rather than on individual plots. Examples include building shared water harvesting structures, managing communal grazing lands to prevent overgrazing, or coordinating integrated pest management across contiguous fields. Cooperatives provide the institutional platform to organize this collective action, overcoming the "tragedy of the commons" (Ostrom, 1990).
- **Building Social Capital:** The repeated interactions and shared identity within a cooperative build trust, reciprocity, and shared norms which is the essence of social capital. This social glue is essential for enforcing agreements, sharing information, and mobilizing collective action in response to climate shocks.

2.3 Market Power, Value Chain Integration, and Creating Green Premiums

Market incentives are a powerful driver of farmer behavior.

- **Aggregation and Market Access:** Individually, smallholder farners struggle to meet the volume, consistency, and quality requirements of large buyers. Cooperatives aggregate produce, enabling them to enter formal value chains, supply supermarkets, or access export markets that would be inaccessible to individuals.
- **Value Addition and "Green" Premiums:** Cooperatives can develop brands and obtain certifications (e.g., Organic, Fairtrade, Rainforest Alliance, Carbon Neutral) for their collectively produced goods. These certifications often command significant price premiums in increasingly conscious consumer markets.

By linking CSA adoption to these market incentives, cooperatives create a powerful economic feedback loop: sustainable production leads to higher and more stable incomes, which financially rewards and reinforces the continued use of CSA practices (Bijman & Wijers, 2019). This transforms CSA from a cost-bearing burden into a profit-generating strategy.

2.4 Gender Dynamics and Inclusivity: Ensuring Equitable Benefits

A critical analysis of the cooperative advantage must address the issue of inclusivity, particularly regarding gender. Women constitute a significant proportion of the agricultural workforce and are often custodians of traditional knowledge relevant to adaptation. However, they frequently face barriers to full participation in cooperatives, including limited access to land (a common membership requirement), time constraints due to unpaid care work, and cultural norms restricting their voice in public decision-making (SOFA Team & Doss, 2011). The benefits of cooperative-promoted CSA can therefore be unevenly distributed if these dynamics are ignored. For instance, a biogas unit saves women time spent on fuelwood collection and improves their health by reducing indoor air pollution, directly impacting food utilization. Conversely, a decision to invest in a male-dominated cash crop for export might marginalize women's food crops. Therefore, the "cooperative advantage" is only fully realized when governance structures actively promote women's membership, leadership, and participation in decision-making. Cooperatives that implement gender-sensitive policies such as providing childcare during meetings, offering training at convenient times, and ensuring women have equitable access to the benefits of new technologies not only become more fair but also more effective and resilient institutions.

3. GLOBAL EVIDENCE AND IN-DEPTH CASE STUDIES

In Kenya's dairy-intensive regions, manure management is a challenge, contributing to water pollution and methane emissions. The Githunguri Dairy Farmers Cooperative Society Ltd., one of the country's largest, has been instrumental in promoting household biogas digesters.

- Mechanisms Applied: The cooperative leveraged bulk purchasing to source affordable digester kits and components. It facilitated access to credit and technical training for installation and maintenance. It created a platform for members to share experiences and troubleshoot problems.
- CSA and Food Security Outcomes: The adoption of biogas technology delivers across all three CSA pillars. It mitigates GHG emissions by capturing methane for use as clean energy. It helps families adapt by providing a reliable energy source that is resilient to fuel price shocks and deforestation. The nutrient-rich bio-slurry byproduct is a potent organic fertilizer that improves soil health (increasing productivity) and reduces dependency on chemical fertilizers. For food security, benefits are multifold: saved income from reduced fuelwood/purchased energy costs improves economic access to food; time saved (mostly for women) in fuel collection can be redirected to food preparation, childcare, or income-generating activities, improving utilization; and improved soil health supports more stable yields, enhancing availability and stability (Ochieng et al., 2020). This creates a good circular economy on the farm.

3.1 Case Study 2: Cereal-Legume Value Chains and Conservation Agriculture in India

In the central drylands of India, smallholder farmers face soil degradation and water scarcity. The ARYA (Auraiya Rural Development Agency) Farmers' Cooperative in Uttar Pradesh promotes conservation agriculture (CA) and diversified cropping systems.

- **Mechanisms Applied:** The cooperative invested in shared CA machinery (zero-till drills, laser land levelers). It established a robust system of member training and on-farm demonstrations. Crucially, it integrated production with market incentives by aggregating and marketing the legumes (e.g., pigeon pea, chickpea) that are central to the diversified CA rotations.
- **CSA and Food Security Outcomes:** CA practices like zero-tillage and residue retention conserve soil moisture (adaptation), build soil organic carbon (mitigation), and reduce production costs, leading to higher net incomes (productivity).

Legume integration fixes nitrogen, improving soil fertility. The cooperative's market linkage ensures farmers get a good price for these legumes. This directly boosts household income (improving economic access to food) and improves household nutrition if legumes are consumed (improving dietary diversity and utilization). The system's enhanced water efficiency makes food production more stable under variable rainfall (Kumar et al., 2022).

3.2 Case Study 3: Specialty Coffee Cooperatives and Agroforestry in Peru

In the Peruvian Andes, coffee farmers are highly vulnerable to rising temperatures and changing rainfall patterns, which threaten Arabica coffee production.

- **Mechanisms Applied:** Cooperatives like CECOVASA have long focused on producing high-quality organic and Fairtrade certified coffee for export. To adapt to climate change, they are now actively promoting shade-grown agroforestry systems among their members. The cooperative provides technical assistance on selecting appropriate shade trees, manages the complex organic certification process, and markets the final product to international buyers who value environmental sustainability.
- **CSA and Food Security Outcomes:** Shade trees sequester significant amounts of carbon (mitigation). They buffer coffee plants from extreme heat and temperature fluctuations, reduce pest pressures, and improve soil moisture and health (adaptation). While shade can slightly reduce yields, the quality of the beans is often higher, and the cooperative secures a significant price premium in the specialty market, leading to higher and more stable net incomes (productivity). The trees also provide fruit, firewood, and timber, diversifying household income and food sources, which significantly enhances resilience and food security (Haggar et al., 2021).

3.3 Cross-Case Analysis and Synthesis of Success Factors

These cases, from different continents and commodities, reveal common success factors:

- Integrated Approach: The most successful cooperatives integrate input supply, knowledge transfer, and market access into a single, coherent package.
- Economic Incentives: CSA adoption is sustained when it is clearly linked to tangible economic benefits, either through cost reduction or market premiums.
- Strong Governance: Democratic control, transparency, and accountability are essential for maintaining member trust and ensuring equitable benefit distribution.
- Strategic Partnerships: Cooperatives rarely succeed alone; partnerships with NGOs, research institutions, government agencies, and private buyers are critical for accessing technology, knowledge, and markets.

4. IMPLICATIONS FOR THE FOUR DIMENSIONS OF FOOD SECURITY

The cooperative-CSA nexus strengthens all four pillars of food security:

By facilitating the adoption of yield-enhancing and resilience-building practices (e.g., improved seeds, water management, soil health), cooperatives help increase the total quantity of food produced locally. More importantly, by reducing yield variability caused by climate shocks (droughts, floods), they ensure a more stable and predictable food supply throughout the year, smoothing out the seasonal hunger periods that often affect farming communities.

4.1 Access: Enhancing Economic and Physical Entitlements

This is perhaps the most direct impact. Higher yields and lower production costs, combined with access to premium markets, significantly increase the net income of member households. This enhanced purchasing power directly improves their economic access to a greater quantity and diversity of food from the market.

Furthermore, by aggregating produce and linking to larger markets, cooperatives improve the physical access to markets for farmers in remote areas.

4.2 Utilization: Improving Nutritional Outcomes and Food Safety

Many CSA practices promoted by cooperatives have direct nutritional benefits. Crop diversification (e.g., integrating legumes, vegetables, fruit trees) leads to more diverse farm production, which translates into more diverse household diets. Practices like agroecology and organic farming reduce exposure to harmful pesticides, leading to safer food and a healthier local environment. The increased incomes also allow families to purchase more nutritious foods (e.g., animal proteins, fruits) that they do not produce themselves.

4.3 Stability: Building Systemic Resilience to Shocks

This is the overarching benefit. The primary goal of adaptation is to enhance stability. By making farming systems more resilient to climate variability, cooperatives help ensure that availability, access, and utilization are maintained even in the face of shocks. A household that has diversified its income sources (e.g., from coffee and fruit trees), has savings from higher incomes, and is part of a supportive cooperative community is far less likely to fall into food insecurity after a drought or flood than an individual farmer practicing monoculture.

4.4 The Multiplier Effect: Cooperative-CSA Synergies and Rural Development

The impact of the cooperative-CSA nexus extends beyond the farm gate, generating positive spillover effects that catalyze broader rural development. This multiplier effect operates through several channels. First, increased and more stable incomes for member households stimulate local economies. Higher disposable income is spent on local goods and services, supporting non-farm businesses and creating a stable cycle of economic activity.

Cooperatives often invest their surpluses in community projects such as building grain stores, improving rural infrastructure, or funding scholarships which enhance the overall quality of life and human capital in the region. By creating successful, visible models of sustainable production, cooperatives can influence the practices of non-member farmers in the surrounding area, leading to a landscape-level adoption of CSA practices. Finally, the organizational capacity built within successful cooperatives which is the ability to manage finances, negotiate with buyers, and advocate for members' interests becomes a powerful asset for community-driven development. This capacity allows rural communities to engage more effectively with external actors, from government agencies to private investors, thereby attracting further resources and opportunities for sustainable growth.

5. CHALLENGES AND LIMITATIONS OF COOPERATIVE

Cooperatives are faced with significant challenges.

- Elite Capture: A pervasive risk is that the benefits of the cooperative are captured by a few wealthy, powerful, or early joining members, to the exclusion of poorer farmers, women, and youth (Chambo, 2009). This can reinforce existing social inequalities.
- Weak Management: Many cooperatives suffer from poor financial management, inadequate record-keeping, and a lack of business acumen, leading to inefficiency and even collapse.
- Member Apathy: As cooperatives grow, members may become disengaged, failing to participate in governance and allowing leadership to become unaccountable.

5.1 External Constraints: Policy, Financing, and the Enabling Environment

- **Unsupportive Policies:** Legal frameworks may be outdated, overly bureaucratic, or fail to recognize the specific needs of cooperatives. Government programs may bypass cooperatives in favor of dealing with individual farmers or large corporations.

- **Limited Access to Long-Term Finance:** Cooperatives need long-term capital for investing in shared infrastructure and building their businesses. Such long-term, low-cost finance is often scarce.
- **Market Volatility:** Even with aggregation, cooperatives remain vulnerable to global commodity price fluctuations, which can undermine their financial stability and their ability to offer stable prices to members.

5.2 The Scalability Challenge: Moving from Isolated Success to Systemic Change

While the case studies presented demonstrate compelling successes, a significant challenge remains scaling these isolated victories to achieve transformative, systemic impact. Many thriving cooperatives operate as "islands of success" within the conventional practice. Scaling is not merely about increasing the number of cooperatives or their members; it is about creating an enabling ecosystem where the cooperative model can flourish widely. This involves addressing several interconnected constraints:

- **Sequencing of Support:** Successful scaling requires a nuanced understanding of the stages of cooperative development, from initial mobilization and trust-building to business planning and market engagement. Providing advanced market linkages to a new cooperative without first strengthening its internal governance can lead to failure.
- **Federation and Networks:** Scaling impact often requires cooperatives to federate at regional or national levels. These higher-level structures can provide specialized services (e.g., access to larger markets, policy advocacy, advanced training) that are beyond the capacity of individual primary cooperatives.
- **Context Sensitivity:** A model that works for dairy farmers in Kenya may not be directly transferable to rice farmers in Vietnam. Scaling strategies must avoid blueprints and instead focus on adapting the core principles of the cooperative model: democratic control, member economic participation, and concern for community, to local social, cultural, and agro-ecological contexts.

- **Long-term Capital and Engagement:** Building robust, member-controlled institutions is a slow process that contradicts the short-term funding cycles of many development projects. Truly scaling impact requires long-term, sustainable investment in institutional development, not just the delivery of technologies or inputs.

CONCLUSION

This chapter has demonstrated that agricultural cooperatives are far more than simple marketing clubs. They are complex, member-driven institutions whose principles and structure align powerfully with the challenges of promoting Climate-Smart Agriculture. By dismantling economic, knowledge, risk, and market barriers, they create an enabling environment for smallholder farmers to adopt sustainable practices. This adoption, in turn, generates a cascade of benefits that directly enhance food security by making systems more productive, resilient, and equitable. Supporting cooperatives is, therefore, a strategic investment in achieving the SDGs, particularly SDG 2 (Zero Hunger), SDG 13 (Climate Action), SDG 12 (Responsible Consumption and Production), and SDG 17 (Partnerships for the Goals).

A Multi-Stakeholder Action Plan

For Policymakers

- **Revise Legal Frameworks:** Develop and implement cooperative laws that promote good governance, transparency, and inclusivity.
- **Mainstream Cooperatives into Climate Policy:** Integrate cooperatives as key implementing agents in National Adaptation Plans (NAPs) and Nationally Determined Contributions (NDCs). Design climate finance mechanisms to be accessible to farmer collectives.
- **Provide Targeted Support:** Offer grants or concessional loans for cooperatives to invest in shared CSA infrastructure and technology.

For Development Agencies and NGOs:

- **Build Capacity:** Invest in long-term training programs for cooperative leaders and members on CSA techniques, business management, financial literacy, and inclusive governance.

- **Facilitate Market Linkages:** Act as honest brokers to connect cooperatives to buyers seeking sustainably produced goods and help them navigate certification processes.
- **Fund Research and Development:** Support action research within cooperatives to develop and test locally adapted CSA packages.

For Cooperative Leaders

- **Embrace Transparency:** Foster trust through open communication, democratic decision-making, and regular financial reporting to all members.
- **Prioritize Inclusivity:** Actively develop strategies to engage women, youth, and marginalized groups in leadership and ensure they benefit equitably.
- **Invest in the Future:** Allocate resources to member education and strategically invest in CSA technologies that will ensure the long-term resilience of the cooperative.

REFERENCES

Abebaw, D., & Haile, M. G. (2013). The impact of cooperatives on agricultural technology adoption: Empirical evidence from Ethiopia. Food Policy, 38, 82–91. https://doi.org/10.1016/j.foodpol.2012.10.003

Bernard, T., & Spielman, D. J. (2009). Reaching the rural poor through rural producer organizations? A study of agricultural marketing cooperatives in Ethiopia. Food Policy, 34(1), 60–69.

Bijman, J., & Wijers, G. (2019). What makes a cooperative a cooperative? The nature of the cooperative firm. In The Cooperative Firm (pp. 1-21). Springer, Cham.

Chambo, S. A. (2009). Agricultural cooperatives: Role in food security and rural development. Paper presented at the Expert Group Meeting on Cooperatives, New York.

FAO. (2006). Food security. Policy Brief, Issue 2. Food and Agriculture Organization of the United Nations.

FAO. (2013). Climate-smart agriculture sourcebook. Food and Agriculture Organization of the United Nations.

FAO, IFAD, UNICEF, WFP, & WHO. (2023). The State of Food Security and Nutrition in the World 2023. FAO. https://doi.org/10.4060/cc3017en

Haggar, J., Pons, D., Saenz, L., & Vides, M. (2021). The role of coffee cooperatives in the adoption of climate-smart agriculture in Peru. Journal of Agribusiness in Developing and Emerging Economies. https://doi.org/10.1108/JADEE-08-2020-0180

ICA. (2023). Cooperative identity, values & principles. International Cooperative Alliance.

IPCC. (2022). Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

Kumar, S., Prasad, K. V., Singh, V. K., & Maji, C. (2022). Role of farmer producer organizations in promoting climate-smart agriculture: Evidence from India. Journal of Agribusiness in Developing and Emerging Economies. Ahead-of-print. https://doi.org/10.1108/JADEE-05-2021-0123

Lipper, L., McCarthy, N., Zilberman, D., Asfaw, S., & Branca, G. (2018). Climate smart agriculture: Building resilience to climate change. Springer Nature.

Mojo, D., Fischer, C., & Degefa, T. (2017). The determinants and economic impacts of membership in coffee farmer cooperatives: recent evidence from rural Ethiopia. Journal of Rural Studies, 50, 84-94.

Ochieng, B. O., Ngigi, M., & Okello, J. J. (2020). The role of cooperatives in promoting biogas technology adoption among smallholder dairy farmers in Kenya. Climate and Development, 12(9), 851-862.

Ostrom, E. (1990). Governing the commons: The evolution of institutions for collective action. Cambridge University Press.

Ricciardi, V., Mehrabi, Z., Wittman, H., James, D., & Ramankutty, N. (2020). Higher yields and more biodiversity on smaller farms. Nature Food, 1(4), 255-262.

Wollni, M., & Fischer, E. (2019). Member-based organizations and agricultural technology adoption: Evidence from dairy cooperatives in Ethiopia. Food Policy, 86, 101729.

World Bank. (2021). Enabling the business of agriculture 2021. World Bank Group.

Zougmoré, R. B., Partey, S. T., Ouédraogo, M., Torquebiau, E., & Campbell, B. M. (2018). Facing climate variability in sub-Saharan Africa: perspectives for climate change agriculture. Agricultural Systems, 156, 165-174.

CHAPTER 3
NATURAL RESOURCES AND AGRICULTURAL DEVELOPMENT IN SÉTIF PROVINCE: BETWEEN POTENTIAL AND CONSTRAINTS

[1]Mohamed Rami BERBACHE
[2]Chaima CHETIOUI
[3]Ameur ZAGHOUANI
[4]Amina HAMMADI
[5]Kawther BOUREZZANE
[6]Soumia FADHLAOUI
[7]Ayoub HADJEB

[1]Laboratory of Diversity of Ecosystems and Dynamics of Agricultural Production Systems in Arid Zones (DEDSPAZA), Department of Agronomic Sciences, University of Biskra, mohamedrami.berbache@univ-biskra.dz, ORCID ID: 0000-0003-0751-463X

[2]Laboratory of Improvement and Development of Plant and Animal Production, Department of Agronomic Sciences, University of Sétif 1, chetioui_chaima@univ-setif.dz; ORCID ID: 0009-0007-9590-9581

[3]Laboratory of Diversity of Ecosystems and Dynamics of Agricultural Production Systems in Arid Zones (DEDSPAZA), Department of Agronomic Sciences, University of Biskra, ameur.zaghouani@univ-biskra.dz; ORCID ID: 0009-0009-4771-1938

[4]Laboratory of Improvement and Development of Plant and Animal Production, Department of Agronomic Sciences, University of Sétif ,hammadiamina@univ-setif.dz; ORCID ID: 0009-0004-4421-1982

[5]Laboratory of Diversity of Ecosystems and Dynamics of Agricultural Production Systems in Arid Zones (DEDSPAZA), Department of Agronomic Sciences, University of Biskra, kawther.bourezzane@univ-biskra.dz

[6]Technical Institute of Development of Saharian Agriculture (ITDAS), soumia.fadlaoui@univ-biskra.dz

[7]Laboratory of Diversity of Ecosystems and Dynamics of Agricultural Production Systems in Arid Zones (DEDSPAZA), Department of Agronomic Sciences, University of Biskra, ayoub.hadjeb@univ-biskra.dz, ORCID ID: 0000-0003-3981-5066

INTRODUCTION

Agriculture is one of the fundamental pillars of the Algerian economy, serving as a key source for achieving food security and for diversifying the productive base beyond an excessive reliance on energy resources. According to recent studies, Algeria's agriculture sector employs close to 20% of the country's working population and accounts for over 12% of its GDP (Bank, 2022; FAO, 2021). Notwithstanding its significance, agricultural activities continue to encounter difficulties due to widely fluctuating weather patterns, notable regional differences in natural resources, and infrastructure deficiencies in some places.

Given its geographic location inside the High Plateaus and its diverse environment, Sétif Province stands out as one of Algeria's most significant agricultural districts. Because it produces so many cereals, especially durum wheat, the province has been referred to as the "breadbasket of Algeria" for many years. According to official figures (Dsa, 2016), the total area under use is more than 360,000 hectares, of which more than 190,000 hectares are used for cereals, horticulture, arboriculture, and cattle production.

However, a number of structural and natural constraints limit this significant potential. With an annual precipitation of only 322 to 453 mm, the region has a semi-arid Mediterranean climate with continental influences, with cold, rainy winters and hot, dry summers (Menadi et al., 2022). Even while some plains have reasonably productive soils, they are still prone to erosion and structural instability. In addition, there is a shortage of water resources because there are still few irrigated regions and agriculture is mostly dependent on rainfall. Together, these elements lead to poor and erratic agricultural output, especially in the production of cereals, where average yields during the previous ten years were roughly 13 quintals per hectare (Dsa, 2016).

The research community has focused a lot on learning about farming changes in the Algerian High Plateaus, especially in Sétif. (Abbas, 2012) pointed out that the local farming method mixes growing grains with raising sheep, which leads to a combination of different types of production. (Meroni et al., 2021) noted that crop yields are still largely affected by the amount of rainfall, especially since there aren’t good irrigation systems in place.

More recent research by (Rouabhi et al., 2019) found that using conservation tillage, which means not turning the soil, can help increase crop yields and lower farming costs. This opens up new ways for more sustainable farming. At the same time, studies on improving plant genetics by (Benchelali et al., 2022) have shown that some local and bred plant varieties can handle dry conditions, making them good options for tackling the issues of climate change.

Based on what was discovered, this study brings up an important question: How can Sétif Province make the most of its natural and human resources to improve farming despite challenges like weather, water supply, and other issues? To answer this question, we need to look at how the natural resources available, like climate, soil, and water, connect with the farming methods used there, such as growing grains, fruit trees, and raising animals. We also need to check out the weaknesses and problems, including changing weather, low crop yields, and limited farming techniques.

Therefore, this research has the goal of:

- Describing the natural characteristics of Sétif Province, including its position, landscape, weather, soil, and water sources, and how these aspects relate to how productive farming is.
- Looking into the current situation of farming in the area regarding how land is used, what crops are most common, and how animals are spread out.
- Investigating how cereal farming has changed over time as the main type of activity and exploring how it connects with weather and farming techniques.
- Assessing current methods for managing farming and water resources, while also looking for other ways to make agriculture more sustainable in the region.

Exploring farming in Sétif Province is more than just looking at how things are now. It aims to find out how the strengths and challenges interact, so we can suggest better ways to grow crops that are good for the environment. This makes the research both useful and scientifically important.

1. GEOGRAPHICAL SITUATION

Setif Province is strategically positioned in the northeastern region of Algeria, situated on the high plains at an altitude of approximately 1,100 meters above sea level (A. Fellahi et al., 2021; Ghorab et al., 2023; Khallef et al., 2025). The province covers an area ranging from 6,504 to 6,666 km² according to different sources, representing about 0.27% of Algeria's total area (Bouchareb & Morad, 2023; Khallef et al., 2025; Menadi et al., 2022). Located approximately 300 kilometers from the capital city of Algiers, Setif serves as an important administrative center with an estimated population of nearly 1.5 million inhabitants (A. Fellahi et al., 2021).

The province is bordered by several neighboring regions: Bejaia and Jijel to the north, M'Sila and Batna to the south, Mila to the east, and Bordj Bou-Arriridj to the west (A. Fellahi et al., 2021; Khallef et al., 2025). Setif's topography is notably diverse, characterized by significant altitudinal variations ranging from 297 meters to 2,004 meters at Jebel Babor, with the relief divided into distinct zones including northern mountains, central plains, and southern low areas (A. Fellahi et al., 2021; Khallef et al., 2025).

The region experiences a semi-arid Mediterranean climate with distinct seasonal patterns, featuring cold, rainy winters and hot, dry summers (A. Fellahi et al., 2021; Khallef et al., 2025; Menadi et al., 2022). This climate pattern, combined with the province's varied topography and agricultural potential of approximately 67,400 hectares of agricultural land, makes Setif an important region for understanding Algeria's geographic and environmental characteristics (Bouchareb & Morad, 2023).

1.1 Presentation of the Physical Setting

Setif Province is precisely positioned at latitude 36°11'N and longitude 5°25'E, situated in the eastern Algerian highlands between parallels 35°36'58" and 36°35'45" north and meridians 4°43'52" and 6°1'37" east (Haddad et al., 2004; Khallef et al., 2025). The province forms part of Algeria's High Tablelands, a strategic geographical position that places it within the central part of Algeria's northern region (Aieb et al., 2020; Haddad et al., 2004).

The geographical situation of Setif is notably influenced by its position within the Soummam watershed, one of Algeria's 17 major watersheds covering 9,125 km² with irregular boundaries (Aieb et al., 2020). This watershed placement connects Setif to the broader regional geography, extending from the Djurdjura mountain range in the north to the Hodna Mountains in the south.

Setif's location is characterized by its relationship to several prominent mountain ranges that create natural geographical boundaries. The Djurdjura mountains rise to the southeast, approximately 60 km from the city center, reaching altitudes of 2,300 meters with the highest peak Lalla Khedidja at 2,308 meters (Aieb et al., 2020; Haddad et al., 2004). The Bibans mountains are positioned 40 km to the southwest with elevations reaching 1,417 meters, while the Babors mountains lie 30 km to the northeast, achieving heights of 2,004 meters at Jebel Babor (Haddad et al., 2004; Khallef et al., 2025).

This mountainous geography creates a natural amphitheater effect around Setif, positioning the province as a central plateau within the eastern Algerian highlands. The province's location on these high plains, combined with its proximity to major transportation routes including the RN 9 highway, establishes Setif as a significant geographical junction between Algeria's northern coastal regions and its southern interior (Lacheheb & Ballout, 2015).

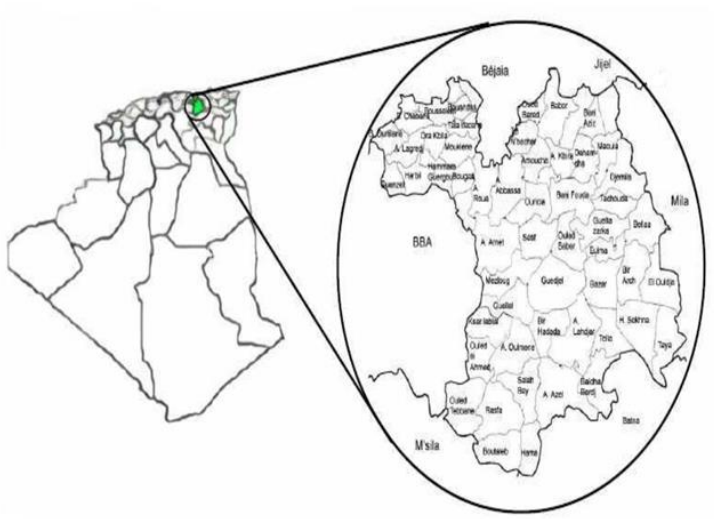

Figure 1. Location of the Sétif region in Algeria

1.2 The Reliefs

The relief structure of Setif Province is characterized by dramatic topographical diversity organized into three distinct zones: northern mountainous areas, central plains, and southern low regions (A. Fellahi et al., 2021). The province exhibits significant altitudinal variations ranging from 297 meters at its lowest points to 2,004 meters at Jebel Babor, creating a complex mountainous landscape (Khallef et al., 2025).

The detailed topographical composition reveals that northern mountains constitute 31.33% of the province's area, while plains occupy 20.03%, agropastoral zones cover 28.56%, piedmonts account for 12.10%, and southern mountainous zones represent 7.98% of the total terrain (Bouchareb & Morad, 2023). This distribution creates a varied landscape that significantly influences transportation routes and land use patterns throughout the region.

Setif's relief system forms part of the broader alpine orogen, which serves as the structural backbone for all of northern Algeria's mountainous terrain (Bachir et al., 2021). The province belongs to the Maghreb-Alpine chain and represents part of the peri-Mediterranean Alpine region of Tertiary age, specifically within the Tellian series that characterizes the external zones of northern Algeria's geological structure (Samir & Khemissi, 2022).

The surrounding mountainous barriers create natural geographical boundaries, with the Djurdjura mountains rising 60 km southeast to altitudes of 2,300 meters, the Bibans mountains positioned 40 km southwest reaching 1,417 meters, and the Babors mountains located 30 km northeast achieving the region's highest elevation of 2,004 meters (Haddad et al., 2004). The terrain is notably rugged, with slopes typically ranging between 10 and 40%, particularly in forested areas like Tamentout, where southern zones are characterized by summits largely devoid of vegetation (Yaici et al., 2020).

The regional relief pattern includes several major plains that define the area's agricultural potential, including the plains of Bordj Bou Arreridj, Setif, Oued El Othmania, and El Khroub at Constantine, with additional plains at Mila in the north and Touffana and Batna in the south, generally dominated by very low slopes ranging from 0-5% (Bachir et al., 2021).

Figure 2. Map of the areas of the wilaya of Sétif

1.3 The Climate

Setif Province is characterized by a semi-arid Mediterranean climate with continental influences, marked by distinct seasonal patterns of cold, rainy winters and hot, dry summers (A. Fellahi et al., 2021; Haddad et al., 2004; Menadi et al., 2022). The climate classification varies slightly across different areas of the region, with some zones described as semi-arid to cool in winter, particularly in elevated areas like the Tamentout forest where bioclimatic conditions support different vegetation patterns (Yaici et al., 2020).

Annual precipitation in Setif shows considerable variation depending on location and measurement period, ranging from 322mm in some studies to 453mm in others, with most sources indicating rainfall rarely exceeds 500mm annually (Belguidoum et al., 2020; Khallef et al., 2025; Koucim et al., 2021). Within the broader Soummam watershed context, annual rainfall varies dramatically from 400mm on the Setif upland to 1,000mm near the coastal areas, with this variation depending on geographical parameters such as altitude and distance from coastal zones (Aieb et al., 2020).

Temperature patterns in Setif exhibit significant seasonal variation, with average annual temperatures around 15-18°C (Belguidoum et al., 2020; Khallef et al., 2025). Winter temperatures can drop to extreme lows, with January being the coldest month averaging 5.03°C and minimum temperatures reaching 1°C in February (Khallef et al., 2025; Menadi et al., 2022).

Summer temperatures are notably high, with July being the hottest month averaging 26.07°C to maximum temperatures of 38.81°C (Khallef et al., 2025; Menadi et al., 2022).

The seasonal weather patterns are influenced by distinct atmospheric circulation systems, with most winter perturbations arriving from the northwest, while summer cloud masses typically move from southwest to northeast (Haddad et al., 2004). The region experiences a characteristic Mediterranean dry season lasting from July to October, with most precipitation occurring between October and April (Ceppi et al., 2025). Additionally, the climate is affected by the Sirocco, a dusty south wind blowing from the desert that can reach gale force, representing a prominent feature of the regional climate system (Ahmim & Labiod, 2020).

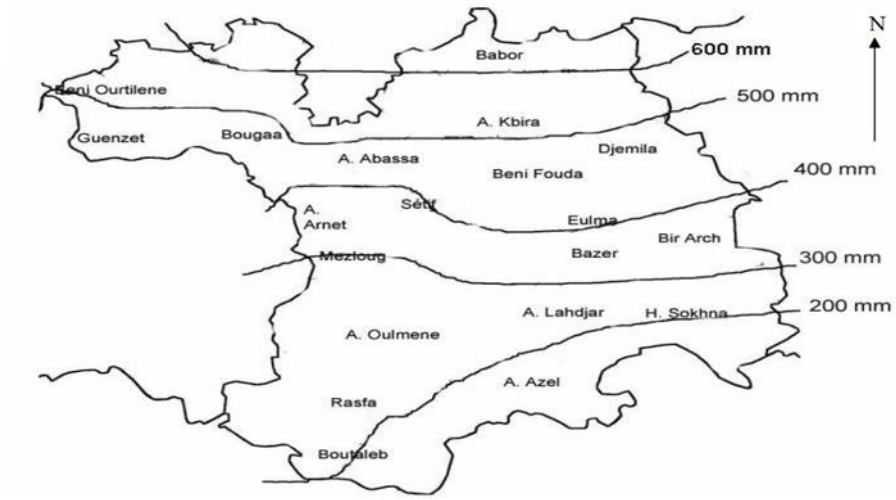

Figure 3. Distribution of precipitation levels in the Sétif region (DSA of Sétif)

1.4 The Soil

The soil characteristics of Setif Province are best documented in the forested regions, particularly in the Tamentout forest area which represents one of the most important forest ecosystems of the Tellian Atlas within the region. The forest soils in this area are classified as forest brown soils that exhibit several distinctive characteristics: they are notably stony, deep, and dry in nature (Yaici et al., 2020).

These soils are categorized as medium soils with favorable chemical and physical properties for supporting vegetation. They are particularly rich in humus content, which contributes to their fertility and water retention capacity (Yaici et al., 2020). The chemical composition is characterized by non-acidic fine elements, which creates suitable conditions for plant growth and root development.

A key feature of Setif's forest soils is their excellent aeration properties, maintained by the non-acidic fine elements that create a soil structure conducive to air circulation and root respiration (Yaici et al., 2020). This combination of deep profile, high humus content, and good aeration makes these soils well-suited for supporting the diverse forest ecosystems found throughout the mountainous regions of Setif Province. The stony nature of these soils reflects the underlying geological composition of the region, consistent with the alpine orogen structure that characterizes the broader Tellian Atlas mountain system where Setif is located.

1.5 Water Resources

Water resource management in Setif Province is addressed through the High Plains Setif Transfer Project, a major infrastructure initiative designed to overcome the natural water scarcity challenges facing the region (Jouve et al., 2022). This project reflects Algeria's broader water resource distribution patterns, where northern regions benefit from higher water availability due to topographical conditions and proximity to the Mediterranean Sea, while southern areas experience greater water stress (Jouve et al., 2022). The province's water challenges are closely linked to its semi-arid climate, with average annual precipitation of less than 400mm creating significant demand for water infrastructure to support agricultural activities (Bouchareb & Morad, 2023). To meet these needs, Setif has developed substantial water infrastructure including two large dam projects completed to transfer water from neighboring regions, supplemented by a series of wells designed to provide comprehensive water supply for various purposes, particularly for agricultural sector requirements (Bouchareb & Morad, 2023).

The water resource infrastructure directly supports the province's agricultural potential, serving 36,500 hectares of arable land distributed across two main sectors: more than 20,000 hectares in the eastern region (Elma sector) and 15,800 hectares in the western Setif Hills sector, with the latter developed in partnership with Bordj Bou Arreridj province (Bouchareb & Morad, 2023). This water management system is essential for maintaining agricultural productivity in a region where natural precipitation alone is insufficient to support intensive farming operations. The infrastructure includes an extensive network of dams, canals, and pumping stations designed to optimize the use of available water resources. It enables farmers to cultivate a wider range of crops and improve yields, even during dry seasons. Moreover, the coordinated management between sectors ensures equitable water distribution and minimizes losses due to evaporation or leakage.

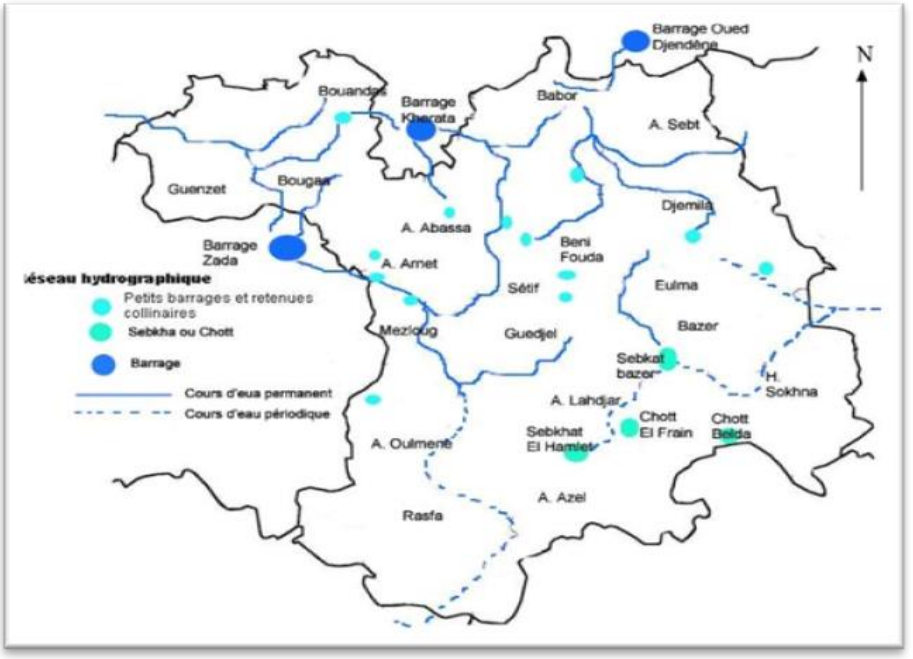

Figure 4. The hydrographic network of the wilaya of Sétif (Directorate of Agricultural Hydraulics, 2011).

2. DIAGNOSIS OF THE AGRICULTURAL SECTOR IN THE WILAYA OF SÉTIF

Table 1. Land Distribution in Sétif Province. (DSA Sétif, 2016)

SAU	Fallow land	Unproductive land	Passage and route	Forests	SAT
364 728,17	97 675,7	41 084,38	54 066,95	97 222	654 777,2
55,7026375	14,9173948	6,274558735	8,257304928	14,8481041	100

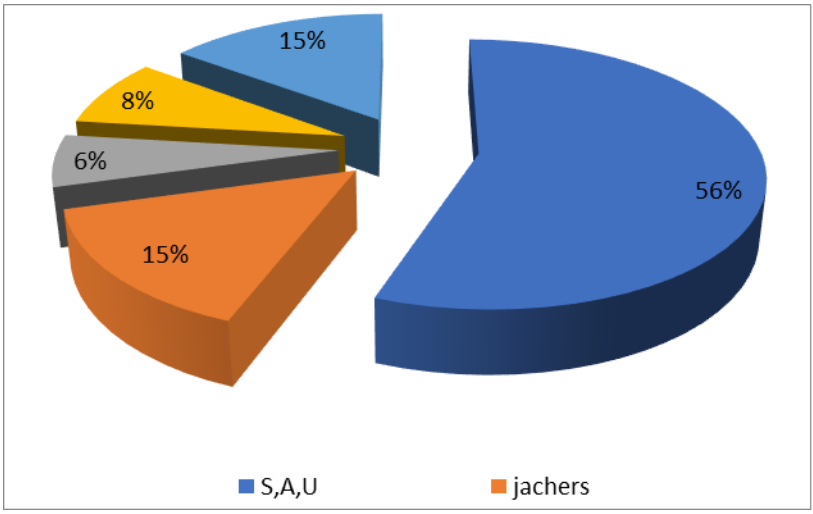

Figure 5. Distribution of total agricultural area (SAT) (DSA Sétif, 2016)

In the high plains region of Sétif (HPS), agriculture primarily revolves around cereal production and livestock farming, while also incorporating other agricultural speculations. The diversity of production systems is the result of the combination of physical, climatic, and structural factors of agricultural units, which lead to various forms of organisation and production logics (Benniou & Aubry, 2012).

In 2016, the total agricultural area was 654,777.2 hectares. The usable agricultural area (UAA) with 364,728.17 hectares represents 55.7% of the total area of the wilaya, Fallow land (or land at rest) covers 97,675.8 hectares, which is 14.95% of the total UAA, fruit farming 36,176.76 hectares, grazing land 54,067 hectares, and unproductive land 41,084.38 hectares ((Dsa, 2016) (Table 1).

2.1 Distribution of the SAU

This agriculture is mainly based on cereal cultivation, particularly located in the high plains, but there are also vegetable and forage crops. On the other hand, the olive tree and the fig tree constitute the wealth of the mountainous area. (Table 2)

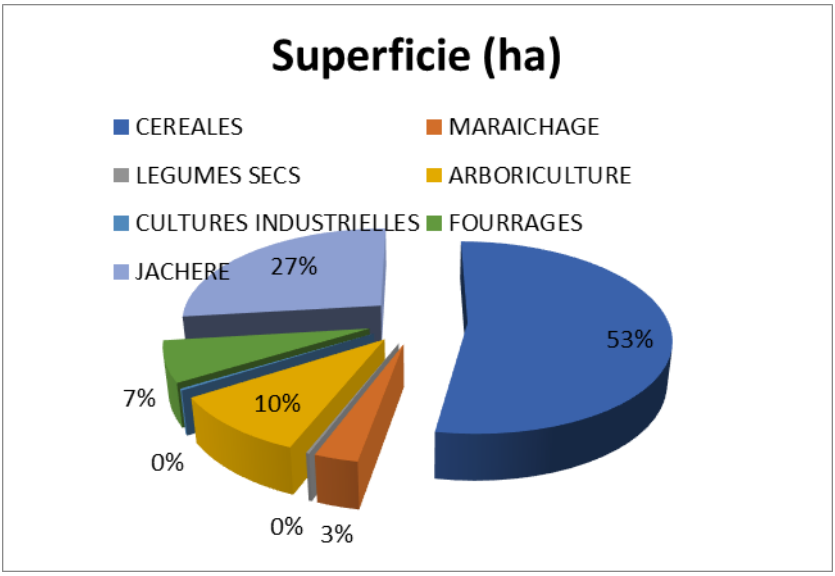

Figure 6. Distribution of the SAU (DSA Sétif, 2016)

Table 2. Distribution of SAU (DSA,20016)

Speculation	Area (Ha)	%
Cereals	191590	52,8122983
Market Gardening	10666,69	2,94030176
Pulses	814	0,224381287
Arboriculture	36176,76	9,9722211
Industrial Crops	1031,2	0,284253051
Fodder	24821	6,841975344
Fallland	97675,7	26,92456916
Total	362775,35	100

2.2 Agricultural Farms

Table 3. Number of farms in the region (DSA 2016)

	EAC	EAI	PRIVATE PILOT	FARMS	GCA CONCESSIONS	OTHER	Total
Number	519	947	40842	7	94	9	42418

The wilaya of Sétif has 42,418 agricultural holdings, more than 97% of which are of a private legal nature. This structure highlights the predominance of private initiative in the agricultural economy of the region. Public lands, however, continue to play a strategic role in supporting large-scale and organized agricultural projects. Together, these two ownership systems contribute to a diversified and resilient agricultural landscape across the province.They indeed occupy more than 65% of the UAA. The lands of the State's private domain (EAC+EAI) are no less important; they represent nearly 29% of the UAA (DSA Sétif, 2016).

2.3 Distribution of UAA By Type of Crop

The irrigated agricultural area is divided between vegetable crops (23%), fruit farming (22%), cereals (20%), and forage crops (33%).

Table 4. SAU irrigated by speculation (DSA Sétif, 2016)

Speculation	Area (Ha)	%
Market Gardening	10745,81	22,8838847
Arboriculture	10493,54	22,3466597
Cereals	9270	19,7410536
Fodder	15346	32,6802814
Industrial Crops	1101	2,34464941
Vineyards	1,63	0,00347119
Total	46957,98	100

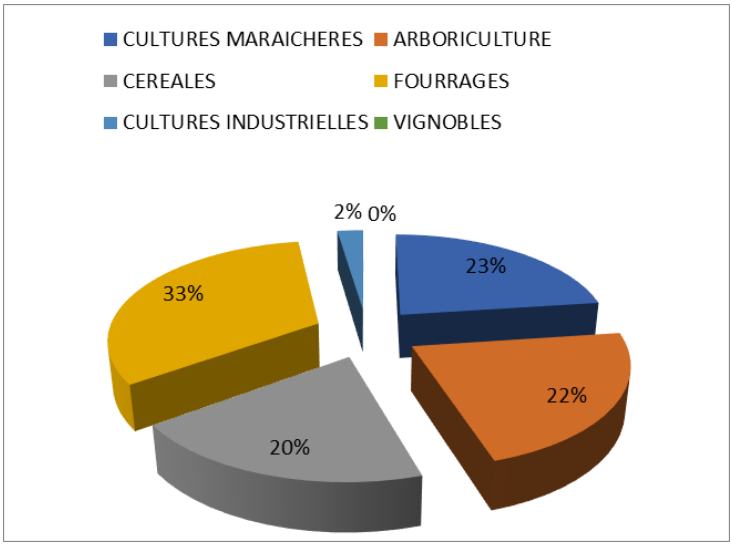

Figure 7. SAU irrigated by speculation (DSA Sétif, 2016)

Furthermore, the irrigation methods are as follows: The sprinkler irrigation method becomes dominant in the wilaya with 57% of the irrigated useful agricultural area. This method is particularly valued for its efficiency in water distribution and its adaptability to various types of terrain. Drip irrigation is also gaining importance, especially in areas where water resources are limited. In addition, traditional surface irrigation remains in use for certain crops that require higher water volumes.

Table 5. Distribution of irrigated UAA by irrigation method (DSA, 2016)

Irrigation Method	Sau (Ha)	%
Sprinkler	26843,8	57,1747083
Gravity	17599,25	37,4847073
Drip	2507,43	5,34058438
Total	46950,48	100

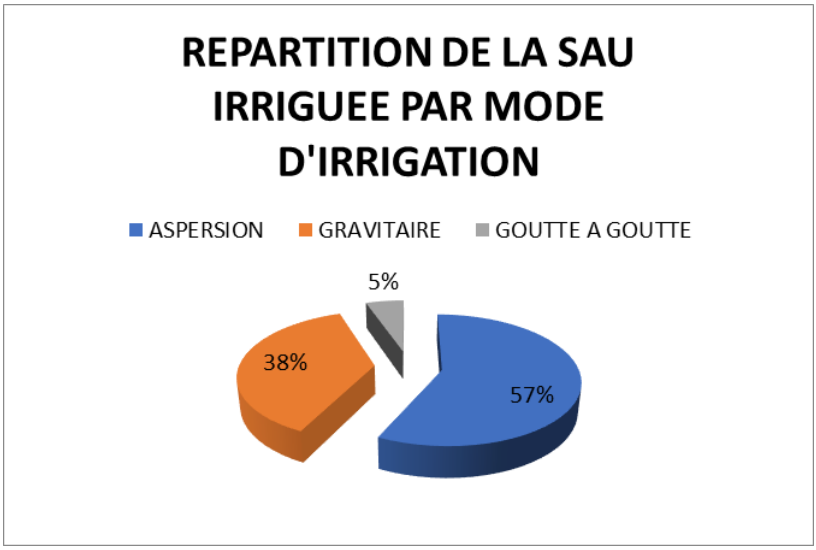

Figure 8. Irrigated SAU by irrigation method (DSA,2016)

2.4 Animal Production

Sheep farming occupies the first place with 513,461 heads, followed by cattle farming with an estimated population of 160,602 heads, including 77,446 dairy cows. While goat farming remains limited and is generally associated with sheep flocks. The numbers of small farms are 3,055,100 broilers, and 3,811,081 layers, 63,800 is the number of turkeys, Finally, for beekeeping, we record the presence of 76,542 hives (DSA, 2016). This diversity in livestock production reflects the adaptability of farmers to the region's environmental and economic conditions. It also demonstrates the importance of mixed farming systems in ensuring food security and income stability for rural households.

Table 6. Animal population of the Wilaya of Sétif (DSA, 2016)

Category	Effectif	%
Cattle	160602	2,08757597
Sheep	513461	6,67419363
Goats	76443	0,99363999
Broiler Poultry	3055100	39,7115437
Layer Poultry	3811081	49,5381198
Beekeeping	76542	0,99492684

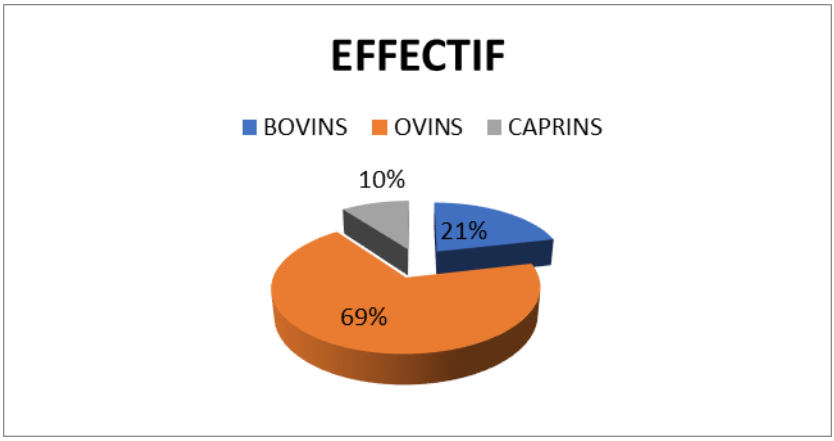

Figure 9. Cattle, sheep, and goat populations. 3rd quarter 2016 (DSA, 2016)

3. CEREALS IN THE WILAYA OF SÉTIF

The following table traces the evolution of cereal production in the wilaya of Sétif, based on the evolution of sown areas and rainfall. These two factors are closely linked, as fluctuations in annual precipitation directly influence the extent of cultivated land and overall yield levels. Understanding these variations is essential for assessing the region's agricultural performance and planning effective resource management strategies.

Table 7. Evolution of cereal production (DSA, 2016)

	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	MOY/10 ans
Cultivated area (ha)	173455	175135	174990	177000	184079	181023	183880	188390	189370	191450	181877,2
Harvested area (ha)	172048	130970	174922	176398	183865	180140	183677	147610	145254	191386	168627
Product (Qx)	2316135	1175600	2980000	2544674	3163006	2440439	3100000	1169500	995391	3195300	2308004,5
Yield (Qx/ha)	13	9	17	14	17	13	17	8	7	17	13,2
Rain (mm)	335	227	388	361	358	290	385	308	347	320	331,9

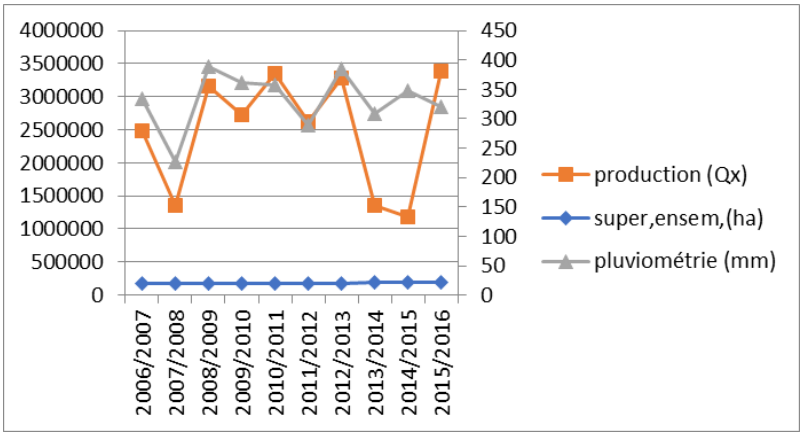

Figure 10. Evolution of cereal production based on sown areas and rainfall (DSA, 2016)

The annually sown areas revolve around an average of 181,877.2 ha, which is 53% of the UAA. The yields are very low (an average of 13 Qx/ha over 10 years) and we notice that production is irregular and evolves in correlation with rainfall around a decennial average of about 2308004 Qx.

Cereal cultivation is the main activity in the wilaya of Sétif. It covers an estimated area of more than 191,560 hectares, with durum wheat being the main cereal cultivated in the high plains of Sétif at 62%, barley at 24%, and soft wheat at 10%. The cultivation of cereals involves nearly 40,000 agricultural holdings (DSA, 2016).

Table 8. Distribution of areas according to vegetable production (DSA, 2016)

Speculation	Area (ha)	%
Durum Wheat	118825	62,0301733
Soft Wheat	18973	9,90446857
Barley	46327	24,1840677
Oats	7325	3,8238672
Triticale	110	0,05742326
Total	191560	100

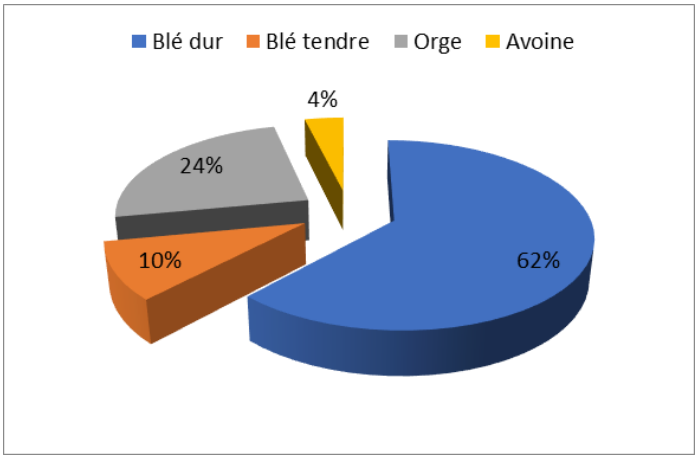

Figure 11. The distribution of areas according to vegetable production (DSA, 2016)

3.1 Localisation of Cereal Production Areas

The agricultural diversity in the Algerian cereal-growing area and the wilaya of Sétif has been understood through the dominant agricultural orientations (Abbas and Madani, 2001 Cited by Boulechfar, 2010), whose method is based on the use of SAU allocation statistics (10-year average and annual evolution). The orientations of production systems are related to the size of the UAA, water availability, and the climatic zone, which seem to be strongly structuring factors in the organisation and orientation of agricultural activities (Benniou et al, 2006). In the HPS, the strict cereal system with a predominance of durum wheat is more present in SAS (North), the association of wheat and barley in SAC (Centre), and the predominance of barley in the SAI climatic zone (South) (Boulechfar, 2010).

According to Boulechfar (2010), the distribution of areas in the study zone (figure) between 2004-2008 is as follows:

- **In the mountain zone (ZM):** Durum wheat dominates with 77.21% of the cereal area, followed by barley with 22.42%.
- **In the high plains zone (ZHP):** Approximately 70% of cereal areas are sown with durum wheat, followed by soft wheat with 16.21% and barley with 12.36% of the total cereal areas.
- **In the lowland zone (ZBP):** Durum wheat and barley share equally with 76.16% of the southern cereal areas, followed by soft wheat with it.

Oats are mainly present in the ZBP with 4.91% of the cereal areas in the south, and only occupy 3.3% of the total cereal areas.

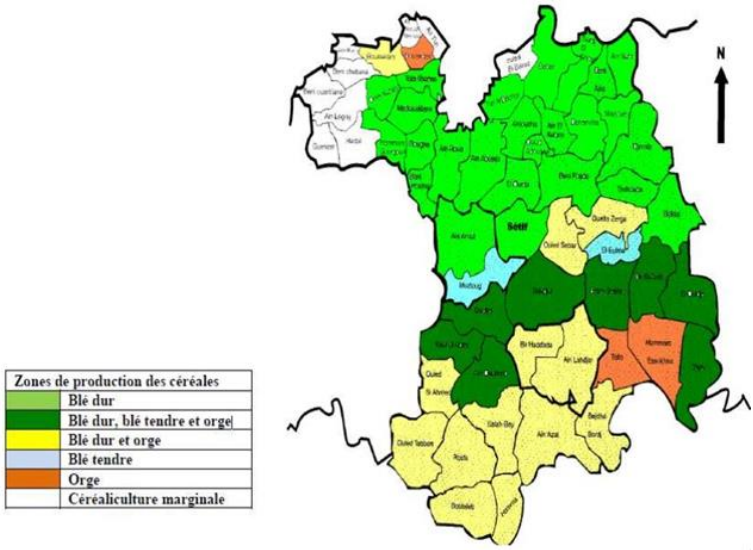

Figure 12. Distribution of cereal production areas according to dominant species (Source: agricultural statistics from the DSA of Sétif, 2016)

4. CEREAL CROPS AND PRODUCTION SYSTEMS

The agricultural landscape of Sétif is characterized by a mixed farming system that integrates cereal production with livestock operations, particularly sheep farming (Boudiar et al., 2025). A significant portion of farms derive the majority of their income from the cereal-livestock system, making this combination the economic backbone of regional agriculture (Abbas, 2012; Rouabhi et al., 2018).

Cereal crops dominate the agricultural territory, occupying the most important share of the Useful Agricultural Area (UAA) and constituting the dominant crop in nearly all municipalities of the wilaya (Abbas, 2012). The primary cereal crops cultivated in the region include durum wheat, barley, and soft wheat, which are generally rainfed with only 3% of cereal areas under irrigation (Meroni et al., 2021).

Farm operations tend to be small-scale, with cereals occupying an average of 110 hectares per farm, while forage crops occupy approximately 11 hectares (Rouabhi et al., 2018).The production system follows a Mediterranean agricultural calendar, with sowing occurring in autumn (October to November) depending on rainfall patterns, and harvests taking place from spring to early summer (May to July) (Meroni et al., 2021). All field operations are conducted under rainfed conditions without irrigation, making the system highly dependent on natural precipitation patterns (Boudiar et al., 2025). Cereal production yields are generally low, averaging 5-6 quintals per hectare in rainfed systems, with yields typically ranging between 0.5 to 2.5 tons per hectare and being highly influenced by climatic variability (Abbas, 2012; Meroni et al., 2021).

The cereal production also supports the livestock component of the mixed farming system, with cereal straw serving as one of the most commonly used feeds for dairy cows in the semi-arid region, alongside pasture, commercial concentrate, and wheat bran (Guedjal et al., 2023).

5. AGRONOMIC PRACTICES AND TECHNIQUES

Agricultural practices in the Sétif region are evolving from conventional to more sustainable approaches, with no-tillage systems gaining adoption among local farmers. Direct seeding of wheat reduces fuel consumption and machinery requirements while enabling soil rehabilitation and reducing environmental pollution (Fenni & Bounechada, 2011). Comparative studies of no-till versus conventional tillage systems demonstrate that no-till performs better economically, with a gross margin difference of $84/ha compared to conventional tilled wheat (Ariom et al., 2022; Rouabhi et al., 2019).

The efficiency gains from no-tillage are substantial, requiring only 241 minutes per hectare and 42 liters of fuel per hectare, compared to 624 minutes per hectare and 99 liters of fuel per hectare for conventional tillage systems (Ariom et al., 2022; Rouabhi et al., 2019). Research projects are actively assessing the effects of these different tillage approaches on soil chemical and biological quality in the region (Issaoun et al., 2024).

Fertilization practices in the region follow standardized protocols, with uniform application of mineral fertilizers including N-P_2O_5-K_2O at rates of 30-69-0 at seeding using DAP (di-ammonium phosphate), followed by 30-0-0 applications at tillering and heading stages using ammonium nitrate or other simple nitrogen fertilizers (Zaaboubi et al., 2020). In experimental settings, typical fertilization includes 100 kg/ha of triple super phosphate (46%) applied at sowing and 100 kg/ha of urea (35%) broadcasted at the tillering stage (Semcheddine & Hafsi, 2014).

Crop management follows uniform techniques with two-year rotations consisting of cereal crops followed by fallow periods (Zaaboubi et al., 2020). Seeding practices typically involve hand sowing at rates of 350 seeds/m^2 with row spacing of 0.18 meters (Semcheddine & Hafsi, 2014). Weed control is managed chemically using herbicides such as Granstar (tribenuron methyl) at application rates of 12 g/ha (Z. Fellahi et al., 2018).

6. RESEARCH AND EXPERIMENTAL STUDIES

The following experimental studies have been conducted on cereal cultivation in the Sétif region:

- **Long-term tillage system studies:** A five-year comparative study (2008-2013) at the ITGC experimental station examined the effects of direct seeding versus conventional seeding on arbuscular mycorrhizal symbiosis in durum wheat roots, conducted on clay-sandy-loamy soils with 2.6% organic matter content (Taibi et al., 2020).
- **Barley genotype evaluation trials:** Multi-environment trials assessed 26 barley genotypes in 2017 using randomized block designs with three replicates, evaluating performance under local semi-arid conditions (Bendada et al., 2020). Additional barley studies examined 17 genotypes across multiple locations (Algiers and Setif) over two crop seasons to assess genotype-by-environment interactions on grain yield (Hebbache et al., 2021). These experiments provided valuable insights into the adaptability and stability of different barley lines under varying environmental stresses. The findings help identify promising genotypes suitable for large-scale cultivation in semi-arid zones.

- **Durum wheat nitrogen response studies:** Three-year experiments (2015-2018) investigated four durum wheat genotypes (Bousselam, MBB, Megress, and GTAdur) under varying nitrogen rates from 0 to 120 kg N ha^{-1}, identifying modern genotypes with superior nitrogen use efficiency (Benchelali et al., 2022).
- **Bread wheat breeding line evaluation:** Field trials in 2020-2021 evaluated 34 bread wheat genotypes including 30 advanced breeding lines and four control varieties under rainfed conditions, using randomized complete block designs (Lamara et al., 2022).
- **Durum wheat selection programs:** Multi-year breeding studies (2012-2015) examined four parental varieties and their crosses through F5-F7 generations, identifying eight promising lines (L1, L8, L14, L28, L32, L35, L36, and L40) with consistently high production (Oulmi et al., 2023).
- **Alternative crop evaluation:** Three-season trials (2017-2020) at the University FERHAT Abbas campus evaluated Vicia narbonensis compared to Vicia sativa as potential alternatives to improve fallow periods in cereal-fallow rotations (Mahmah et al., 2023).
- **Disease monitoring studies:** Field surveys during 2021-2022 documented Fusarium Head Blight symptoms in wheat fields across the region, contributing to disease management research (Segmane et al., 2025).
- **Yield stability analysis:** Long-term yield data analysis (2014-2024) assessed growth trends and instability patterns for four cereal crops (durum wheat, bread wheat, barley, and oats) using five different analytical methods (Yacine et al., 2025).
- **Intercropping systems research:** Trials in 2018-2019 evaluated durum wheat-chickpea intercropping systems at two sites within the Sétif region, comparing sole crop versus intercrop performance (Kherif et al., 2021). The results indicated that intercropping can improve land use efficiency and overall system productivity compared to sole cropping. Additionally, intercropping contributed to better soil fertility management and reduced pest and disease incidence, enhancing the sustainability of the cropping system.

7. CHALLENGES AND PERFORMANCE

The semi-arid conditions of the Sétif region present specific challenges for cereal cultivation that directly impact crop performance and grain quality. The climatic conditions influence protein accumulation patterns in cereals, with the semi-arid environment of Sétif resulting in different protein compositions compared to more humid regions (Hacini et al., 2022). Under these semi-arid conditions, metabolic-type proteins become predominant, reflected in higher albumin and globulin fractions, along with significantly more alpha-beta and gamma gliadins compared to cereals grown in subhumid-semiarid environments (Hacini et al., 2022).

Despite these challenges, technological advances have improved the ability to monitor and predict cereal performance in the region. Remote sensing using MODIS-NDVI data has proven effective for forecasting cereal yields in the semi-arid conditions of Sétif, showing strong correlations between vegetation indices and grain yield from late February to mid-March, with R^2 values ranging from 0.55 to 0.82 for wheat and barley (Boulaaras & Bouregaa, 2024). These forecasting models demonstrate practical accuracy with root mean square errors ranging from 0.01 to 0.276 tons per hectare, and indicate that grain yield increases by approximately 0.659 to 0.746 tons per hectare for every 0.1 increase in NDVI value (Boulaaras & Bouregaa, 2024). This technology provides valuable yield predictions two to three months before harvest, offering farmers and agricultural planners important lead time for decision-making (Boulaaras & Bouregaa, 2024).

The Sétif region continues to play an important role in preserving and distributing traditional cereal varieties across Algeria's high plateau regions. Several traditional durum wheat varieties originated in the Sétif area, including Fouara and Tichedrett, both of which were first cultivated in the community of Sétif (Guetteche et al., 2022). The region has also contributed to the broader distribution of important varieties like Saïda183, which has become the most popular traditional variety grown across the Algerian High Plateau, with its cultivation expanding to main cereal-producing areas bordering the Tellian Atlas (Guetteche et al., 2022).

CONCLUSION

It is evident from this chapter that the state of Sétif is characterised by significant natural and agricultural resources that make it a prominent agricultural hub in Algeria, especially in grain production and livestock breeding. However, these potentials face several obstacles related to water scarcity, soil fragility, and irregular rainfall. Climate change is a compounding factor for these challenges. Therefore, the development of agriculture in Sétif requires adopting more effective strategies such as expanding modern irrigation systems, improving water management, diversifying crops, and introducing drought-resistant varieties. It is also necessary to enhance the integration between agriculture and livestock farming to optimise local resources and achieve better productivity. The rational and sustainable exploitation of these resources could enhance Setif's position as a leading region in agricultural production at both the national and regional levels.

REFERENCES

Abbas, K. (2012). Animal production systems in Algeria : Transformation and tendencies in the Sétif area.

Ahmim, M., & Labiod, A. (2020). New Data on the Current Distribution of Barbary Macaque Macaca sylvanus (Mammalia : Cercopithecidae) in Algeria.

Aieb, A., Lefsih, K., Scarpa, M., Bonaccorso, B., Cicero, N., Mimeche, O., & Madani, K. (2020). Statistical modeling of monthly rainfall variability in Soummam watershed of Algeria, between 1967 and 2018. Natural Resource Modeling.

Ariom, T. O., Dimon, E., Nambeye, E., Diouf, N. S., Adelusi, O. O., & Boudalia, S. (2022). Climate-Smart Agriculture in African Countries : A Review of Strategies and Impacts on Smallholder Farmers. Sustainability.

Bachir, H., Kezouh, S., Ait-oubelli, M., Semar, A., Smadhi, D., & Ouamer-ali, K. (2021). Improvement of Interpolation Using Information From Rainfall Stations and Comparison of Hydroclimate Changes (1913-1938)/(1986-2016). Al-Qadisiyah Journal For Agriculture Sciences.

Bank, W. (2022). World Development Indicators – Algeria. World Bank.

Belguidoum, A., Lograda, T., & Ramdani, M. (2020). Heavy metals accumulation in Hertia cheirifolia along the highway in Setif region, Algeria. Biodiversitas Journal of Biological Diversity.

Benchelali, S., Benkherbache, N., Mefti, M., Ronga, D., Louahdi, N., Russo, M., & Pecchioni, N. (2022). Nitrogen Use Efficiency in Durum Wheat (Triticum durum Desf.) Grown under Semiarid Conditions in Algeria. Agronomy.

Bendada, H., Guendouz, A., Benniou, R., & Louahdi, N. (2020). Indirect Selection of Tolerant Barley (Hordeum vulgare L.) Genotypes under Semi Arid Conditions Based on the Numerical Images Analysis Indices. Indian Journal of Agricultural Research.

Benniou, R., & Aubry, C. (2012). Farm diversity and crop growing practices in semi-arid regions : A case study of the Setif high plains in Algeria.

Bouchareb, N., & Morad, I. (2023). Contribution of the Algerian water management strategy to the agricultural sector of Setif province. Journal on Innovation and Sustainability.

Boudiar, R., Mekhlouf, A., Bekkar, Y., Yessaadi, M., Bachir, A., Karkour, L., Casas, A. M., & Igartua, E. (2025). Enhancing drought resilience in durum wheat : Effect of root architecture and genotypic performance in semi-arid rainfed regions. PeerJ.

Boulaaras, H., & Bouregaa, T. (2024). Cereal yield forecasting in semi-arid region of Algeria using MODIS-NDVI. Journal of Aridland Agriculture.

Ceppi, A., Achite, M., Toubal, A. K., & Caloiero, T. (2025). Mapping drought characteristics in northern Algerian Basins using the ERA5-Land dataset. Scientific Reports.

Dsa, S. (2016). Statistiques agricoles de la wilaya de Sétif. Direction des Services Agricoles.

FAO. (2021). Statistical Yearbook : World Food and Agriculture. Food and Agriculture Organization of the United Nations.

Fellahi, A., Djirar, N., Cherief, A., Boudrissa, A., & Eddaikra, N. (2021). Zoonotic cutaneous leishmaniasis and Leishmania infection among Meriones shawi population in Setif Province, Algeria.

Fellahi, Z., Hannachi, A., & Bouzerzour, H. (2018). Analysis of Direct and Indirect Selection and Indices in Bread Wheat (Triticum aestivum L.) Segregating Progeny.

Fenni, M., & Bounechada, M. (2011). Environmental and Agriculture Benefits of Direct Seeding of Wheat in Setif High Plains (North East of Algeria).

Ghorab, B., Madani, S., & Diafat, A. (2023). Nature, Architectural Composition, and Human Well-Being : A Case of a Contemporary Garden in Setif, Algeria. Green Building & Construction Economics.

Guedjal, F., Bir, A., & Mouffok, C. (2023). Feeding Practices of Dairy Owners in Semi-arid Region of Algeria. Asian Journal of Dairy and Food Research.

Guetteche, H., Jarrar, A., Khiyel, I., Djekkoun, N., Rouabah, L., Rouabah, A., Benbelkacem, A., & Nick, P. (2022). The popular Algerian barley

landraces Saïda and Tichedrett are autochthonous – evidence from RAPD, SSR and agrophenological markers. Plant genetic resources.

Hacini, N., Djelloul, R., Hadef, A., Samson, M., & Desclaux, D. (2022). Comparative Characterization of Grain Protein Content and Composition by Chromatography-Based Separation Methods (SE-HPLC and RP-HPLC) of Ten Wheat Varieties Grown in Different Agro-Ecological Zones of Algeria. Separations.

Haddad, B., Adane, A., Sauvageot, H., Sadouki, L., & Naili, R. (2004). Identification and filtering of rainfall and ground radar echoes using textural features.

Hebbache, H., Benkherbache, N., Mefti, M., Bendada, H., Achouche, A., & Kenzi, L. H. (2021). Genotype by environment interaction analysis of barley grain yield in the rain-fed regions of Algeria using AMMI model. Acta Fytotechnica et Zootechnica.

Issaoun, D., Metahri, M. S., Annabi, M., & Setbel, S. (2024). Impact Of Reduced Tillage On The Preservation of Soil Fertility And Macrofauna In Semi-Arid Conditions. Ekológia (Bratislava).

Jouve, V., Chaib, A. S.-, & Souchon, G. (2022). Two interconnected water transfers for irrigation and drinking water, a structuring project for the high plains of Setif. E3S Web of Conferences.

Khallef, B., Daoudi, B., & Kerkour, A. (2025). Spatial analysis of traffic accidents using geographic information systems : Case study of the wilaya of Sétif (Algeria). Geomatics, Landmanagement and Landscape.

Kherif, O., Seghouani, M., Zemmouri, B., Bouhenache, A., Keskes, M. I., Yacer-Nazih, R., Ouaret, W., & Latati, M. (2021). Understanding the Response of Wheat-Chickpea Intercropping to Nitrogen Fertilization Using Agro-Ecological Competitive Indices under Contrasting Pedoclimatic Conditions. Agronomy.

Koucim, M. A., Belguidoum, A., Lograda, T., & Ramdani, M. (2021). Heavy metals accumulation in Nerium oleander leaves across urban areas in Setif region, Algeria.

Lacheheb, D. E. Z., & Ballout, A. (2015). The Residential Subdivision under the Influence of the Unfinished Densification (Case Study for Subdivisions in Setif, Algeria).

Lamara, A., Fellahi, Z., Hannachi, A., & Benniou, R. (2022). Assessing the phenotypic variation, heritability and genetic advance in bread wheat (Triticum aestivum L.) candidate lines grown under rainfed semi-arid region of Algeria. Revista Facultad Nacional de Agronomía Medellín.

Mahmah, S., Mebarkia, A., & Rekik, F. (2023). A comparative study on narbon vetch and common vetch in the semi-arid region of Setif (Algeria). Journal of Agricultural Sciences Belgrade.

Menadi, S. E., Chisu, V., Santucciu, C., Domenico, M. D., Curini, V., & Masala, G. (2022). Serological, Molecular Prevalence and Genotyping of Coxiella burnetii in Dairy Cattle Herds in Northeastern Algeria. Veterinary Sciences.

Meroni, M., Waldner, F., Seguini, L., Kerdilés, H., & Rembold, F. (2021). Yield forecasting with machine learning and small data : What gains for grains?

Oulmi, A., Nadjim, S., Guendouz, A., Frih, B., Laadel, N., & Adjabi, A. (2023). Response of Durum wheat (Triticum turgidum L. var. Durum) to direct and indirect selection under semi-arid conditions in Algeria. Ciencia y Tecnología Agropecuaria.

Rouabhi, A., Laouar, A., Mekhlouf, A., & Dhehibi, B. (2018). What Are The Factors Affecting No-Till Adoption In The Farming System Of Sétif Province In Algeria? Turkish Journal of Agriculture - Food Science and Technology.

Rouabhi, A., Laouar, A., Mekhlouk, A., & Dhehibi, B. (2019). SOCIOECONOMIC ASSESSMENT OF NO-TILL IN WHEAT CROPPING SYSTEM: A CASE STUDY IN ALGERIA. New Medit.

Samir, D., & Khemissi, C. (2022). Application of geothermometric and hydrochemical methods to the investigation of thermal water of sources in the Northeastern of Algeria case of Setif city. Journal of Umm Al-Qura University for Applied Sciences.

Segmane, N. R., Mebarkia, A., Boutalbi, A., Laouar, A., ALANANBEH, K. M., Alamir, F., & Belalmi, M. (2025). Pathogenicity assessment of Fusarium clavum associated with wheat head blight in Algeria. Acta Agriculturae Slovenica.

Semcheddine, N., & Hafsi, M. (2014). Effect of Supplementary Irrigation on Agronomical and Physiological Traits in Durum Wheat (Triticum durum Desf.) Genotypes.

Taibi, H. H. Y., Smail-Saadoun, N., Labidi, S., Abdellaoui, K., Makhlouf, M., Laouar, A., Benouaret, C., Rezki-Sekhi, L., Boukais, A., & Sahraoui, A. L. (2020). The Influence of No-till Farming on Durum Wheat Mycorrhization in a Semi-Arid Region : A Long-Term Field Experiment.

Yacine, L., Toufik, M., & Mouna, K. (2025). Assessing the Dynamics of Major Cereals Productivity in Algeria : Case of Setif. Journal of Agronomy, Technology and Engineering Management.

Yaici, K., Dahamna, S., & Toumi, M. (2020). Contribution to the floristic and ethnobotanic study of the most utilized medicinal plants in the Sétifian Tell (south of the Tamentout forest) east Algeria. Mediterranean Botany.

Zaaboubi, S., Khiari, L., Abdesselam, S., Gallichand, J., Kebede, F., & Kerrache, G. (2020). Particle Size Imbalance Index from Compositional Analysis to Evaluate Cereal Sustainability for Arid Soils in Eastern Algeria.

CHAPTER 4
THE CONCEPT, PROCEDURE AND PRINCIPLES OF EXTENSION TEACHING

[1]Dr. Joy Chizaram Iro UKOHA

[1]Department of Agricultural Extension and Rural Development, Michael Okpara University of Agriculture, joyciroukoha@gmail.com, ORCID ID: 0000-0002-1132-8568

INTRODUCTION

Teaching is a process of arranging situations that stimulate and guide learning activities towards goal that specify desired changes in the behavior of people. It has been defined as the process of directing or guiding the activities of the learners so as to result in their learning (Onuekwusi, 2005). According to Ani (2008), teaching implies the transfer of knowledge from someone who knows to someone who does not know and is a normal mode educational curriculum that is central to organizational structures. Extension teaching is the process in which situations are so arranged as to stimulate and guide learning activities towards achieving some specified desired behavioral changes in individuals (Laogun, 2011). In other words, teaching means arranging situations in which the things to be learnt are brought to the attention of the learners, the interest developed, desire aroused, conviction/ created or achieved, action promoted and satisfaction ensured. Hence, teaching in some ways lead to learning.

Uwakah, (2005) opined that the purpose of teaching is not to merely inform people but to transform them and bring about desired changes in their behavior. Furthermore, teaching means 'guiding and learning process'. Teaching is not filling the basket; it is lightening a lamp. Effective teaching is the result of careful planning or design. This means careful planning of content or subject matter and careful selection of procedures, methods and instructional techniques, and good communication. Of course, the goal of teaching is learning.

Good extension teaching is the successful creation of opportunities or situations in which people gain abilities and stimulation necessary for successfully meeting their needs and interests in such a way as to attain continuous improvement and self-actualization. Teaching is closely associated with learning. According to Williams et al (1984) cited in Mundi and Awolumate (2019) learning is the process; teaching is closely associated with learning by which an individual through his own activity becomes changed in his behavior. It is essentially a response to a teaching situation where the learner is an active participant in his own education.

For Extension teachers to become proficient in the act of teaching according to Onuekwusi, (2005), they must:

- Be sincere in their desire to be good teachers
- Understand the desire, needs and interest of the learner
- Believe in educating people and not to use force
- Not underate those they want to teach
- Know the skills, methods and techniques of teaching
- Know the subject matter
- Know the appropriate materials, tools and aids to use

1. CRITERIA FOR EFFECTIVE EXTENSION TEACHING

There are some criteria that make for effective teaching which the extension agent must make provision for so as to help the farming groups or audience gain more understanding of the ideas, he is trying to teach them. These criteria as outlined by Mundi and Awolumate (2019); Mondal (2015) include:

Extension Teaching Requires Specific and Clearly Defined Teaching Objectives

Teaching must be clearly conceived and specifically defined. A teaching objective is simply the term used to describe the end product desired. All purposeful teaching should be seen as having specific objectives. What is going to be achieved at the end of the teaching must be clear and specified from the onset. In deciding on the objectives of teaching, one must consider the people to be taught, the behavioral changes to be developed in people, the content or subject matter to bring the desired change in behavior and the real-life situation in which the action is going to take place.

Extension Teaching Usually Requires That Several Methods Of Presentation Be Used For The Most Effectiveness

No one extension method will reach all the people nor will it influence all it does reach. Sometimes a combination of extension methods an enhance teaching and make it more effective.

In extension teaching, audio-visual materials play a crucial role in enhancing communication by providing visual representations of information, making concepts more concrete, capturing attention, and facilitating understanding for a wider audience, especially those with limited literacy, thereby increasing the effectiveness of the message delivery and knowledge transfer to farmers or beneficiaries.

Extension Teaching Requires That Learners Have Effective Learning Experiences

A learning experience is the mental or physical reaction one makes through seeing, learning or doing the things to be learnt through which he gains an understanding and meaning of the content (Mundi and Awolumate (2019). However, the meaning of what is taught should be understood and internalized by the learners. Mondal (2015) stressed that it usually requires a combination of teaching methods and aids relevant to a particular situation. The effective learning experience is one which results in a maximum number of desirable changes in the behavior of the learners.

Extension Teaching Should Provide A Suitable Learning Situation

A suitable learning situation consists of an extension teacher who joins the learning group to provide good stimulation and guidance of learning activity; the learners who are properly motivated and recognized the needs for learning; the subject matter whose content must be easy to understand; teaching materials or aids and good physical facilities that will enhance learning experience.

Extension Teaching Should Link Up New Materials with What is Already Known

The extension instructor has some responsibility for learning, understanding level of his learning and adequately preparing them for new understanding.

Extension Teaching Requires Effective Communication

All the elements of communication such as Source, Message, Channel and Receiver; that makes for effective teaching must be functional.

There should be content and method for effective teaching to take place

In terms of content, it borders on what to teach i.e the subject matter while method means how to teach, the delivery system. The content should be relevant to the audience, in other words their felt needs which the content must address. Extension teaching also requires that appropriate teaching methods and aids should be used with good combination to meet needs of the situation (Akubilo, 2015, Mondi, 2015).

Extension Teaching Must Be Looked Upon As An İntentional Process

It should be properly planned and designed on the basis of relevant data on the situation and available research findings. There is no scope for trial and error or haphazard thinking and action in extension teaching.

Extension Teaching Must Accomplish Certain Kinds Of Educational Changes İn Relation To The Subject Matter (Topic) To Be Learnt

Desirable changes in the knowledge, skill, attitude, understanding, goal, action and confidence of the people are to be achieved in relation to the topic being taught (Mondi, 2015). Changes in knowledge such as varieties of seeds to plant, amount of fertilizer to use, etc; changes in skills, ability such as mental skill e.g. working out solutions to problems.

Extension Teaching Requires Careful Evaluation of Results Which Should Guide Future Efforts

Extension teacher should constantly evaluate results in a precise and objective manner and base future effort on the findings. He should be able to assess whether the teaching been able to attain the objectives set forth.

In other words, if the desirable changes in the behavior of the people have taken place or not. This will indeed help him to take steps to remedy the deficiencies of lapses identified in the process.

2. STEPS IN EXTENSION TEACHING

The extension worker is a teacher, a facilitator or a motivator. Extension teaching is planned n deliberate act on the part of the extension worker. He is continually working to bring about desirable changes in human behavior. According to Uwakah (2005), the conscious efforts to organize teaching activities in a sequential, continuous and integrated manner, greatly increases the efficiency of learning. Effective teaching is the result of planning or design, in other words, careful planning of content or subject matter, careful selection of procedures, methods and instructional techniques, and finally good communication. The goal of teaching is learning. Therefore, the extension worker plans and arranges the learning situations and activities in such a way that the things to be learnt are:

- brought to the attention of the attention of the prospective learner
- his interest is developed gradually
- his desire is aroused
- he is convinced of the need to try or act
- his action is encouraged or promoted and
- overall satisfaction ensured

Hence, if he is to meet success in his efforts, he must understand and follow the scientific and logical steps in teaching in order to impart training to the clients. These steps include: Attention, interest, desire, Conviction, action and satisfaction (AIDCAS). If he wants to succeed in his efforts, he must understand and follow the scientific and logical steps in teaching. These steps are essential for effectively providing training to the clients. The steps include Attention, Interest, Desire, Conviction, Action, and Satisfaction (AIDCAS). By applying these steps systematically, he can ensure that the learning process becomes more engaging and productive. Each stage plays a crucial role in maintaining the learner's motivation and guiding them toward meaningful outcomes. Consistent application of the AIDCAS model can significantly enhance the effectiveness of the overall training process.

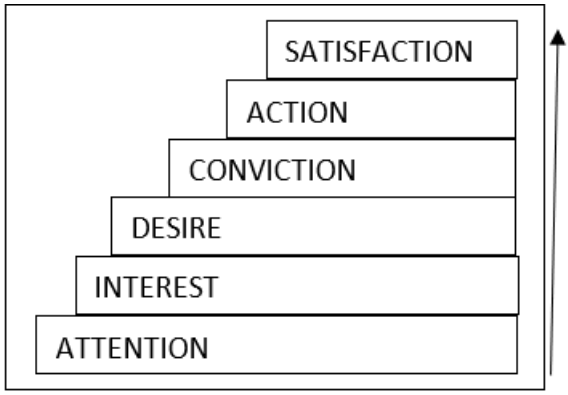

Figure 1. Steps in Extension teaching (Wilson and Gallup (1955) cited in Mondal, 2015)

2.1 Getting the Attention of the Learner

Attention is the first step in arousing the farmers' interest about a new idea or practice because most farmers are quite unaware of the great improvement in farming methods that have been developed by scientific research and how the employment of these methods can make farming so much more profitable. The first duty of an extension worker as a teacher is to direct the attention of the farmer to the newer methods of farming suggested by research source. Until the farmers' attention has been focused upon the new idea, technique, problem, demonstration results, message or change considered desirable, there is no recognition of a problem to solve or a want to be satisfied (Uwakah, 2005).

At this stage, mass media methods like radio announcements, television flashes/adverts, newspaper articles, posters, bulletins, exhibition, mobile phones etc and personal contact by the extension worker can be effectively used.

2.2 Stimulating the Learners' Interests

When the farmer's attention has been directed to the newer methods, the next step is to appeal to the interest by showing him how the new method may be of value to him, how it may save labour or increase his yield and profit (Mundi and Awo…).

This may be done by furnishing them with more information about the topic in a way they will be able to understand and use and how it and contribute to their welfare. It is necessary to present one idea at a time, relevant to their needs. Propaganda should not be used. Personal contact by the Extension worker, contact through local leaders, farm practitioners, radio, television etc are important at this stage (Mondal, 2015)

2.3 Arousing the Learner's Desire for Information

This means un-freezing the existing behavior and motivating the people for change. When the attention of the farmer has been directed to a new method and his interest aroused in a way or possibility that his new method may be of direct value in meeting his demand the farmers will want to get all possible information on how the new method may be used to his advantage (Laogun, 2011). At this stage, visit to demonstration farms, films, stories of other people who gained from adopting the new idea or solving the problem, personal contact, group discussions etc are all important.

2.4 Convincing the Learner That He Should Act

It is a stage of strong persuasion in order to convince the farmer about the practicability of the new idea or practice in their own situation and that it would be beneficial to him. The desire and conviction stages are most critical because at these stages of evaluation in the learning process, the farmer mentally tries to decide whether to try or not, what risks are involved and the possible gains. Therefore, when a farmer through the above steps has become convinced that the new method will lead to his profit and satisfaction, it becomes easier. Training and Field Day or farmers' day, slide show, personal contact by the Extension Agents is very effective at this stage.

2.5 Getting Action By the Learner

This is the stage of putting the idea or practice into operation. Teaching is without value unless converted into action. The extension teacher must do everything possible to make action easy.

According to Laogun (2011), if the improvement requires fertilization or an insecticide or new equipment, the extension worker must take the responsibility of arranging for its purchase by the farmer at a convenient source and at a fair price. The farmer by himself cannot do this and he will not act if there are obstacles in the way of action. Supervise, guide, direct and correct the farmer. Give all encouragement to ensure success. Demonstration, personal contact by the Extension Agent, supply of critical inputs and ensuring essential service are important at this stage.

2.6 Making Certain That the Learner Derives Satisfaction From His Action

Just like in any other business, a satisfied customer is the best advertisement (Uwakah, 2005). The end product extension effort is the satisfaction that comes to the farmer as a result of solving a problem or earning the new idea, meeting a need, or acquiring new skill/ change in behaviour. The extension worker has follow-up job. He must help the learner evaluate the progress made, measure an increase yield and strengthen the satisfaction obtained. A farmer that meets a want by the successful application of a new method becomes a local learner in influencing his neighbours to satisfy their wants by following the same practice and he finds prestige and satisfaction in teaching and helping them (Laogun 2011). Also, when a farmer has used a new method and realized profit and satisfaction from it, he gains confidence in his own ability to learn and is ready to try other new methods.

3. METHODS AND TECHNIQUES OF EXTENSION TEACHING

Teaching methods in extension may be defined as the way of organizing, using instructional techniques and devices to create situations in which communication can take place between the change agent and the learner (farmer). Stated in general terms, the purposed of using extension teaching methods are:

- Provide communication so that the learners 9farmers) may see, hear, and do the things to be learned

- Provide stimulation that caused the desired mental and/or physical reaction on the part of the learner, and
- Take the learner trough one or more steps of teaching/learning process, namely: attention, interest, desire, conviction and action.

4. CLASSIFICATION OF EXTENSION TEACHING METHODS

Methods used in extension according to Laogun (2011) may be classified into:

- Individual contact methods
- Group methods
- Mass methods.

Examples under them include:

- Individual Contacts: Farm and home Visit, Office calls, Telephone calls, Personal letters, Result demonstration
- Group Methods: General meetings, Group discussion, Exhibits, Conducted tours, Field days
- Mass Methods: Newspaper, Radio, Television, Publications (bulletins, pamphlets, leaflets, folders, posters, etc), and Method demonstration

4.1 Individual Methods

4.1.1 Farm and Home Visit

Farm and home visit constitutes the direct or face-to-face contact by an extension professional where information is exchanged or discussed with the farmer or the members of his family.

Advantages

- A farm visit gives the extension worker firsthand knowledge of farm and home conditions
- It builds confidence on the part of the farmers in the extension worker.
- It contributes to the selection of better local leaders and demonstration
- It develops good public relation

Disadvantages

- A farm visit requires a relatively large amount of agent's time
- The number of such contacts that can be made is definitely limited
- The time of visit is not always convenient for the farmer.
- There is danger that the extension worker may visit progressive farmer only and neglect those families where personal contact is most needed.

4.1.2 Office Calls

These are made by the farmer for the purpose of satisfying a felt need. They are an expression of interest by the farmer in a need which he hopes the extension worker can help him meet.

Advantages

- The caller is likely to be highly receptive to learning
- An office call is economical – user of agent's time
- An office call shows interest and confidence by the farmer in extension programme

Disadvantage

Office contacts are removed from the farm and may not reflect the real problem or accurately reveal pertinent conditions.

4.1.3 Personal Letters

Advantages

- It is useful in answering requests for specific information
- It is useful as a follow-up on farm visits and office calls

Disadvantages

- Famers with poor education background will find it difficult to use this method
- It is not a widely used correspondence

4.1.4 Telephone Calls

These are initiated by either the farmer or the extension worker. These calls are useful in giving specific information relating to treatment of identified diseases, control of insect pests or to answer questions on interesting broadcasts or requests for bulletins and leaflets.

Advantages

- It is the quickest means of getting the attention of extension worker/agency on times of emergencies
- It is relatively cheaper in terms of cost when compared to other methods

Disadvantages

- The spoken word is usually forgotten more easily than the written word
- It is difficult to sustain the farmers' attention and interest through this method.
- Many localities may not have telephone services and this therefore renders this method to be of limited use

4.1.5 Result Demonstration

This is intended for providing evidence on the advantages of suggested practices and to demonstrate their applicability to the local conditions. It is conducted by a farmer under the direct supervision of an extension professional. This assists the farmers to learn by what they see and do.

Advantages

- It is useful in starting new practices
- It gives the extension officer confidence in the practice he is recommending.
- It gives extension worker the opportunity to locate and encourage local leaders
- Individuals can use all their senses – see, hear, touch and carry out the demonstrated practice(s)

- It is an ideal way to present to the famers a comparison between traditional and new farming practices or between two new practices
- Since the famers' crops and livestock are involved, it can help to establish confidence in more scientific farming methods within wide range of farmers.

Disadvantages

- Result demonstration requires a large amount of extension worker's time
- The cost is high per practice
- Good demonstrators are hard to find
- Few people see the demonstration at most convincing stage.
- The teaching value is frequently destroyed by unfavorable weather

4.2 Group Methods

4.2.1 General Meetings

This includes all kinds of meetings held by the extension worker. The method of conducting the meetings may be by lectures, discussions, showing of slides and motion pictures or any combination of these. It is aimed at encouraging and stimulating the people to learn more about the problems that they face in the community through discussion.

Advantages

- Sharing of knowledge and experience with others leads to stimulating act.
- General meetings help in the development of local leaders
- It also enables a large number of people to acquire subject matter information.
- It saves extension worker's time.

Disadvantages

- A wide difference in education and interest of audience may create a difficult teaching situation
- The available meeting place may be inadequate

4.2.2 Exhibits/Group Discussion, Conducted Tours/Field Days

Exhibition is an organized display of information, actual samples, models, posters, photographs, and charts in a logical succession. This is sequentially organized for arousing the interest of the clientele on the subject matter. Tours on clientele are used to convince and provide them with an opportunity to see the results of new practices and products, skills and to provide an idea regarding the suitability and application of these things in their own environment.

Advantages

- Famers can become aware of new practices or techniques in a fairly informal atmosphere.
- Famers have the opportunity to discuss the merits of the farming practices with fellow farmers and experts
- Learning is self-initiated and a famers' day is ideal for inspiring people to acquire new knowledge and attitudes

Disadvantages

- At large field days, communication tends to be one-way, because there is often little chance for discussion between the famers and experts
- It is useful in creating awareness and knowledge of new practices but usually do not lead to the adoption of such skills.

4.2.3 Method Demonstration

Advantages

- It teaches needed skills to many people at one time
- Seeing, hearing, discussing and participating stimulate action
- It builds confidence in extension worker if demonstration is performed skillfully
- Local leaders easily learn simple demonstration and can repeat them with other groups

- It promotes personal acquaintance between the demonstrators and the farmers
- It influences changes in practice with many people at a single meeting

Disadvantages

- Requires a certain amount of showmanship not possessed by all extension workers
- With certain demonstrations, considerable equipment must be transported to the meeting places and this could be tasking and costly to do
- It is frequently difficult to ensure that all members of the group can see clearly

4.3 Mass Media Methods

This is an umbrella term for various means of communication both for the print and electronic media. The print media include: Newspapers, magazines, bulletins, pamphlets, leaflets, folders, posters, etc. while the electronic media include mainly radio and the television.

4.3.1 The Print Media

These are different types of mass media method for communicating information to a large number of literate people.

Newspapers Advantages

- Means of giving information to a large number of people and of reaching people who might otherwise be left out.
- They are in-expensive and useful in giving timely information to people.
- Farmers tend to place great reliance to what they read in newspapers demonstration
- It is handy for extension

Disadvantages

- Newspaper editing may mutilate or destroy the substance of a news story
- Some extension workers may lack writing ability and therefore cannot use the method effectively
- Newspaper stories are of no value where people are illiterates.
- It has limited circulation

Agric. Magazines Advantages

- Agric. Magazine combines printed colour words, pictures, and diagrams to convey accurate and clear information
- It can be looked at for as long as the viewer wishes and can be referred to again and again
- It is permanent reminder of extension messages
- It supplements other extension methods

Disadvantages

- It's only useful in areas where a reasonable proportion of the farmers 'population can read
- It is costly to produce frequently
- It is equally expensive for the farmers to get
- It has limited circulation

Publications (These include bulletins, pamphlets, leaflets, folders, posters, etc.) Advantages

- They can be read at leisure times and kept for future reference
- The information they contain is usually definite and readily understood.
- They are cheaper to produce and use than most other teaching materials.

Disadvantages

- They are not suitable for teaching people with limited education.
- Information prepared for general circulation may not be useful to all individuals or to all localities.

Radio

This is a mass media of communication and can get to a large number of people at any given time involving the least expense. Radio is used for communicating information on new methods and techniques, giving timely information on an issue.

Advantages

- It can reach people at relatively low cost
- Suited for timely presentation of programmes and is used to alert farmers at times of emergencies.
- It keeps people aware of recommended practices. A radio broadcast must be followed by other methods to bring people to adoption stage
- It can reach large number of people more quickly than any other method and it does not require reading ability on the part of the farmers to obtain necessary information.
- Apart from wider coverage, it is easy to operate and avail you the options to tune in or tune-out
- It is mobile (listening via car radios, mobile phones, television sets and computers) and can accompany many activities such as weeding, planting among others
- It can be interactive (ability for listeners to talk back via letter/telephone/e-mail/text)

Disadvantages

- Radio broadcasting time may not always be available to extension workers and that some farm homes may lack radio sets.
- Radio programmes are not designed to give much details about extension activities and events.
- It lacks credibility under the ownership control either government or private
- It has problems of language barriers

Television

Television combines both audio and visual impact and is very suitable for the dissemination of agricultural information. It is more useful in teaching to do a specific activity.

Advantages

- The main advantages include the fact that this method comes very close to face-to-face method of presentation and that it can reach many people at once.
- It is possible to give a clear view of key operations in low moving pictures through a television
- It combines both colour, vision with sound
- Television reports live extension event (field day show)
- Television is good for adult training
- It provides relevant information needs to the farmers

Disadvantages

- Due to high cost, many farm homes do not own television sets.
- The viewer may not be in a position to ask question to clarify the points made in a television presentation.
- Competition between educational programmes and entertainment often crowds out otherwise desired extension programmes.
- The potential of television for rural extension is low
- Television set is electricity powered.

The Advantages of Radio over Television in Communicating Extension Innovations to Rural Farmers

The advantages of radio over television in communicating extension innovations to rural farmers

- Radio can reach people at relatively low cost unlike the television that is costly

- It is suited for timely presentation of programmes and is used to alert farmers at times of emergencies while television cannot be used in times of emergency
- It keeps people aware of recommended practices because it can be listened to all the time unlike the television
- It can reach large number of people more quickly than the television and it does not require reading ability on the part of the farmers to obtain necessary information.
- Apart from wider coverage, it is easy to operate and avail one the options to tune in or tune-out unlike the television
- It is mobile (listening via car radios, mobile phones, television sets and computers) and can accompany many activities such as weeding, planting among others
- It is not power-dependent but can be powered by battery in the rural areas of which television cannot do

5. PROCEDURE FOR EFFECTIVE TEACHING IN EXTENSION WORK

For effective teaching in extension work, the following procedures should be taken into consideration.

- There is need for visibility for all. Arrangement of exhibits and other materials such as chairs should not obstruct participants' view. Participants should see clearly what is being taught (Yahaya, 2003) cited in Mundi and Awolumate (2019).
- Speaker should speak clearly. Adults comprehend spoken word better than written words at every speed of presentation.
- Speaker should be seen by all participants. Talk with and to the people or even at the people
- Always start with the present interests, needs or problems of the farmers /group.
- Presentation should be step by step in logical in sequence. Present one idea or one theme at a time. Be it in written or spoken words, one sentence or one idea is ideal.

- Employ or use every possible practical device to show relationship of ideas and materials.
- Repeat frequently, ideas being presented
- Make physical surroundings comfortable and attractive, that is, a conducive environment
- Summarize your presentation. A good summary of the content, giving what was attempted, what was accomplished, what is yet to be done is always essential.
- Always endeavour to have farmers leave in a spirit of accomplishment and desire for more.

CONCLUSION

Extension has the following principles that guide teaching:

- **Principles of linking teaching with life**: Link teaching with used life situation, this will help to drive the teaching home. The learner will begin to see himself in the real situation of things or events and thereby enhance learning
- **Principle of interest:** Interest should be developed in teaching because without interest, specific objectives will not be achieved. When a programme is based on the needs/problems of the people, it readily motivates the people and ensures that learning becomes a satisfying experience (Kromah, 2016).
- **Principle of definite aim or purpose:** Teaching should be purposive and definite. This is easier when teaching is carefully planned to reflect the objectives and bring about the desired change.
- **Principle of selection:** Teacher or extension worker should be able to select appropriate teaching methods that will make teaching lively and learning, more interesting/easy to understand.
- **Principle of communication:** Extension teacher should be able to communicate his teaching methods to the learners to ensure greater understanding and satisfaction (Yusof et. al., 2023)
- **Principle of teaching steps by steps:** That is, doing one thing at a time.

We must show step by step what is involved in the new technique being recommended, that is, "How to do and What to do" Uwakah (2005) emphasized that care should be taken to ensure that the farmer observes fully all the practices a partial demonstration is the best way to teach in all extension teaching situations.

- **Principle of practice. In teaching, practice is emphasized**: There is what is called teaching practice. Practice makes perfection or leads to perfection. The farmer must be given a chance to try the new behavior himself so as to gain the necessary skills and confidence, make mistakes and be corrected politely and finally master the whole idea (Uwakah, 2005).
- **Principle of Reward:** The need for reward/incentives in all learning situations is very important. The reward/reinforcement here can either be material or psychological. Material reward can be gifts, certificates, badges, visits to the head office, free transportation and invitation to party. Psychological rewards which should be utilized more often include praise, congratulatory messages, publication of names in the extension bulletin, promotion to local leader etc
- **Principle of Follow-Up:** There is need for regular check on farmers' progress in order to maintain satisfaction as well as ensure continued adoption which is the final measure of sues in all extension activities. Reference materials and books can also be distributed to the farmers during follow-up; this will help furnish them with information when necessary.

REFERENCES

Ani, A. O. (2007). Agricultural Extension A pathway way for sustainable Agricultural Development progromme. Apani Publications, Kaduna. Pp 97 - 99

Akubuilo, C. J. C. (2008). Modern Approaches to Agricultural Extension New Generation Boos, Enugu. Pp 19

Kromah, A. T. (2016). Basic Extension Principles. University of Illinois Urbana-Champaign. https://meas.illlinoistps

Laogu, E. A. (2011). Extension Teaching/Learning Process and Methods. In: S. F. Adedoyin (ed). Agricultural Extension in Nigeria. Publication of Agricultural Extension Society of Nigeria. Pp 202 -203

Mondal, S. (2015). Agricultural Extension. Kalyari Publishers, New Delhi. Pp 12 - 19

Mundi, N. E. and Awolumate, S. (2019). Course Guide for Extension Teaching, Learning Process and Methods. School of Science and Technology, National Open University of Nigeria.

Onuekwusi, G. C. (2005). Audio-Visual Use in Extension in Nwachukwu and Onuekwusi (eds) Agricultural Extension and Rural Sociology in Nigeria. Snap Press Limited, Enugu. Pp 71 – 90

Uwakah, C. T. (2005). Extension Teaching Methods in Nwachukwu and Onuekwusi (eds) Agricultural Extension and Rural Sociology in Nigeria. Snap Press Limited, Enugu. Pp 31 – 39

Williams, S. K. T, J. M. Fenley and C. E. Williams (1984). A manual for Agricultural Extension Workers in Nigeria, Ibadan, Les Syraden Press. Pp.54.

Yahaya, M. K (2003). Development Communication. Lesson from Change and Social Engineering Projects. Pp 197 – 198.

Yosof, A., Arshad, M. M. & Hamzar, S. R. (2023). Extension Education Principles through Postgraduate Programme: A Conceptual Review. International Journal of Academic Research in business & Social Sciences, 13(14), 166 - 176

ISBN: 978-625-92866-0-0