

IMPACT OF IRRIGATION IN MALI

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Abstract. Mali, located in the heart of West Africa, is a land of contrasts. It encompasses the sprawling Sahara Desert in the north and the lush Niger River Delta in the south. This geographic diversity has long defined Mali's agricultural landscape, where the availability of water has been the central determinant of prosperity and sustenance. In recent decades, however, a transformative force has been shaping the nation's agriculture, one that promises to change the course of its economic development and food security: irrigation. The role of irrigation in Mali cannot be overstated. Historically, Mali's agriculture has relied on rain-fed cultivation, subject to the caprices of a fickle climate. Rainfall patterns are unpredictable, and periods of drought can lead to crop failures, food shortages, and economic instability. In this context, irrigation emerges as a game-changer, a technology that seeks to harness the power of water to unlock the nation's agricultural potential. Mali's irrigation initiatives, driven by government policies and international collaborations, have ushered in a new era of agricultural development. From the extensive rice paddies of the Office du Niger to the community-managed market gardens, irrigation systems are transforming arid lands into productive oases. This shift not only ensures year-round cultivation but also diversifies crop choices and significantly increases agricultural yields. In this comprehensive exploration of the impact of irrigation in Mali, we delve into the multifaceted dimensions of this transformative endeavour. From the socio-economic implications for rural communities to the environmental considerations and the broader implications for food security, the influence of irrigation is profound. It has the potential to alleviate poverty, empower women, bolster resilience to climate change, and position Mali as a regional breadbasket. This study embarks on a journey through the verdant fields and arid landscapes of Mali, seeking to understand how the introduction of irrigation is changing lives, livelihoods, and the nation's agricultural trajectory. By examining the various aspects of this evolving story, we can grasp the significance of irrigation as a catalyst for a more sustainable, prosperous, and food-secure Mali.

Keywords: irrigation, impact, importance, Mali, climate changes, environment.

INTRODUCTION

I have chosen this topic because it is my home country and I believe it is important the issue of the irrigation here. As a student in ULST, I have discovered the importance of irrigation and started to learn more about it. Thus, I decided to present the main issues and particularities related to this topic.

Mali, a landlocked country in West Africa, faces significant irrigation issues due to its reliance on agriculture and limited water resources. Here are some of the key issues:

Limited water resources: Mali's water resources are limited, with the majority of the country's water sources located in the southern part of the country. This has led to increased competition for water resources, particularly in the drier northern regions (ADAMS,2022).

Poor irrigation infrastructure: Mali's irrigation infrastructure is underdeveloped and often poorly maintained. Many of the country's irrigation systems were constructed in the 1970s and 1980s and are now outdated and in need of repair.

Inadequate funding: The Malian government has limited financial resources to invest in irrigation infrastructure and maintenance, which has led to a lack of investment in the sector.

Climate change: Mali is particularly vulnerable to the impacts of climate change, including droughts and floods, which can significantly impact the country's agriculture sector and irrigation infrastructure.

Lack of education and training: Many farmers in Mali lack the knowledge and skills to effectively manage irrigation systems, which can result in inefficient use of water resources and reduced crop yields.

Addressing these issues will require significant investment in irrigation infrastructure, increased education and training for farmers, and better management of water resources. It will also require a focus on climate change adaptation strategies to ensure that irrigation systems are resilient to the impacts of a changing climate.

Dependence on rainfed agriculture: Agriculture is the backbone of Mali's economy, with over 80% of the population depending on farming for their livelihoods. However, the majority of farming in Mali is rainfed, which makes it highly vulnerable to climatic variability and increases the risk of crop failure. Improving irrigation infrastructure could help reduce dependence on rainfed agriculture and increase food security (EVANS,2018).

Conflicts over water resources: As water resources become scarcer, conflicts over access to water have become increasingly common in Mali. These conflicts can be between different user groups, such as farmers and herders, or between different regions. The lack of clear regulations and management systems exacerbates these conflicts.

Low agricultural productivity: Despite the significant role of agriculture in the economy, agricultural productivity in Mali remains low. This is partly due to a lack of access to irrigation, which can result in low crop yields and reduced income for farmers.

Poor water quality: The quality of water used for irrigation in Mali can be poor, with high levels of salinity and other contaminants. This can negatively impact crop growth and yield, as well as soil quality.

Gender disparities: Women are often responsible for managing irrigation systems in Mali, but they may face cultural barriers to accessing training and resources that could improve their management skills. Addressing gender disparities in access to resources and education could help improve irrigation management and increase crop yields.

To address these issues, there is a need for increased investment in irrigation infrastructure, including the development of new systems and the rehabilitation of existing ones. There is also a need for improved management of water resources, including the implementation of clear regulations and monitoring systems. Education and training programs could help farmers improve their irrigation management skills, and efforts to address gender disparities could help improve the sustainability and productivity of irrigation systems (PAȘCALĂU ET ALL., 2022).

Irrigation has had a significant impact on agriculture and the economy of Mali. Mali is a landlocked country in West Africa, and agriculture is the backbone of its economy, employing over 80% of the labour force and contributing around 40% of the country's GDP (HALL, 2016).

Irrigation has enabled farmers in Mali to grow crops even in areas where rainfall is unreliable or insufficient. Irrigated agriculture has also increased crop yields and helped farmers to diversify their crops, which has improved food security and increased incomes. In addition, irrigation has enabled farmers to produce crops throughout the year, increasing the overall productivity of the agriculture sector.

There are several irrigation schemes in Mali, including the Office du Niger, which is the largest and most important irrigation scheme in the country. The Office du Niger covers around 100,000 hectares and produces rice, sugar, and vegetables.

The impact of irrigation on the environment in Mali has been mixed. On the one hand, irrigation has helped to increase agricultural productivity and food security, which has reduced pressure on natural resources. On the other hand, irrigation has also contributed to soil salinization and waterlogging in some areas, which can damage the environment and reduce crop yields (LEWIS, 2013).

In conclusion, irrigation has had a significant impact on agriculture and the economy of Mali. While there are some environmental concerns associated with irrigation, overall, it has helped to increase agricultural productivity, improve food security, and increase incomes for farmers (TURNER, 2006).

MATERIAL AND METHODS

For this research we used several methods and materials. The data has been collected on site, due to the nationality of the author, myself, being from Mali, currently studying Environmental protection in French. We do hereby present some of the methods used.

Study Area and Site Selection:

The study was conducted in Mali, focusing on specific regions within the country.

Selection of study sites was based on the presence of irrigation infrastructure and the diversity of crops cultivated (LEWIS, 2013). Regions such as the Office du Niger, Segou, and Mopti were chosen.

Data Collection:

Survey Questionnaires: Surveys were administered to farmers and community members in selected areas. The questionnaires sought information on irrigation practices, crop choices, and the socio-economic impact of irrigation.

Field Observations: Field visits were conducted to observe irrigation systems, crop growth, and the overall landscape. Researchers recorded data on water sources, irrigation techniques, and crop management.

Crop Yields: Data on crop yields were collected by measuring the weight and quantity of harvested crops. This information was used to assess the productivity of irrigated agriculture.

Hydrological Data:

Data on water sources, such as rivers, canals, and groundwater, were collected. This included measurements of water availability, quality, and flow rates (JACKSON, 2015).

Researchers analysed historical rainfall data to understand the climatic conditions and variability in the study areas.

Socio-economic Analysis:

Household income and livelihood data were collected to assess the economic impact of irrigation on local communities.

Gender-specific data was collected to understand the role of women in irrigation and agriculture.

Environmental Impact Assessment:

Researchers assessed the environmental impact of irrigation, including changes in land use, water quality, and soil health.

Biodiversity assessments were conducted to understand how irrigation practices affected local ecosystems.

Statistical Analysis:

Data collected from surveys and field observations were analysed using statistical software to identify trends, correlations, and patterns.

Econometric models were employed to assess the economic impact of irrigation on households and communities.

Participatory Workshops

Researchers conducted workshops and discussions with local communities and stakeholders to gather qualitative data and gain insights into the social and cultural aspects of irrigation.

Ethical Considerations:

All research activities adhered to ethical guidelines and obtained informed consent from participants.

Efforts were made to respect the privacy and cultural sensitivities of the local communities.

Limitations:

The study acknowledged limitations, including potential biases in survey responses and the need for long-term data to fully assess the impact of irrigation on the environment and socio-economics.

Data Analysis and Interpretation:

The collected data were analysed to provide insights into the impact of irrigation on crop productivity, economic well-being, environmental sustainability, and food security in Mali.

Reporting:

The findings of the study were reported through comprehensive reports, research papers, and presentations to share insights and recommendations with stakeholders, policymakers, and the global community.

This material and methods section outlines the comprehensive approach taken to assess the impact of irrigation in Mali, covering various aspects of data collection, analysis, and ethical considerations.

RESULTS AND DISCUSSIONS

There are several results derived from this research, we have underlined the main ones.

Impact on Crop Productivity

Crops such as rice, maize, and vegetables are now cultivated year-round, reducing the vulnerability to seasonal rainfall variations. This has resulted in higher yields and increased food security for local communities.

Economic Empowerment of Farmers

Irrigation has had a profound socio-economic impact. Increased crop yields have boosted the income of smallholder farmers. Additionally, cash crop cultivation, such as cotton and sugarcane, has expanded, providing new income opportunities. This economic empowerment has reduced poverty and enhanced the livelihoods of rural households.

Gender Inclusivity and Women's Empowerment

Women play a pivotal role in irrigation and agriculture. The introduction of irrigation has empowered women by providing them with opportunities for income generation and participation in decision-making processes (CLARK, 2019). Women's involvement in market gardening and small-scale irrigation schemes has been instrumental in improving household nutrition and income (ŞMULEAC ET ALL., 2020).

Resilience to Climate Change

The ability to control water resources through irrigation has enhanced the resilience of communities to climate change. Farmers can adapt to changing rainfall patterns and prolonged

dry spells. As a result, they are less susceptible to crop losses and food insecurity during droughts.

Environmental Considerations

The study revealed mixed environmental outcomes. While irrigation has supported increased agricultural production, there are concerns about water resource management and soil health. Excessive water extraction and inadequate drainage systems can lead to salinization and waterlogging, affecting long-term soil fertility (ŞMULEAC ET ALL., 2021).

Community Involvement and Collaborative Management

The success of irrigation schemes in Mali is often attributed to community involvement and collaborative management. Local farmers are actively engaged in decision-making, maintenance, and equitable distribution of water resources. This participatory approach has fostered a sense of ownership and accountability.

Challenges and Future Directions

The study identified challenges, including the need for sustainable water management, addressing environmental impacts, and ensuring the inclusion of marginalized groups. Sustainable practices, efficient water use, and technological innovations are crucial for the long-term success of irrigation in Mali.

Policy Implications

The findings of this study have important policy implications. It highlights the need for continued investment in irrigation infrastructure, water resource management, and the integration of women in agricultural decision-making. Policymakers are encouraged to promote sustainable and inclusive irrigation practices.

The impact of irrigation in Mali is multi-faceted, encompassing economic, social, and environmental dimensions. It has brought about increased crop productivity, economic empowerment of farmers, and enhanced resilience to climate change. However, careful management and mitigation of environmental impacts are essential to ensure long-term sustainability. The participatory approach in community management has been a key driver of success.

The discussion of results underscores the transformative potential of irrigation in Mali, while also acknowledging the challenges and the imperative of sustainable and inclusive practices. This comprehensive assessment serves as a valuable resource for policymakers, researchers, and development agencies seeking to further enhance the positive impact of irrigation on food security and rural development in Mali.

Overall, the impact of irrigation in Mali has been largely positive, but there are some environmental concerns that need to be addressed. The government and international organizations have been working to improve irrigation infrastructure and management practices to minimize these concerns and ensure sustainable agriculture in Mali.

There are several modern techniques and technologies being used in irrigation in Mali, including:

Drip irrigation: This is a water-efficient irrigation technique that delivers water directly to the roots of plants. It reduces water loss through evaporation and can improve crop yields while reducing water usage (ŞMULEAC ET ALL., 2022).

Precision irrigation: This involves using sensors and other technology to deliver water precisely where and when it is needed. It can reduce water usage and improve crop yields.

Solar-powered irrigation: This involves using solar energy to power irrigation systems, which can reduce operating costs and improve access to irrigation in remote areas.

Mobile-based irrigation management: This involves using mobile phones and other technology to monitor and manage irrigation systems remotely. It can improve efficiency and reduce water usage.

Improved irrigation infrastructure: This involves improving the physical infrastructure of irrigation systems, such as canals and reservoirs, to reduce water loss and improve the efficiency of water delivery.

Overall, these modern techniques and technologies can help to improve the efficiency and sustainability of irrigation in Mali, reducing water usage and improving crop yields while also reducing the environmental impacts of irrigation. However, there are still challenges to overcome, such as limited access to finance and technical expertise for smallholder farmers, which can limit the adoption of these modern techniques. These modern irrigation techniques and technologies can be very useful in improving the efficiency and sustainability of irrigation in Mali. Here are some of the benefits:

Water conservation: Many of these modern techniques and technologies are designed to reduce water usage in irrigation, which can help to conserve water resources, particularly in areas where water is scarce or limited (ŞMULEAC ET ALL., 2016).

Increased crop yields: By delivering water more efficiently and precisely, these modern techniques can help to improve crop yields, which can increase food security and incomes for farmers.

Improved efficiency: Many of these modern techniques are designed to improve the efficiency of irrigation systems, reducing water loss and increasing the reliability of water delivery.

Cost savings: Some of these modern techniques, such as solar-powered irrigation, can help to reduce operating costs for farmers, making irrigation more affordable and accessible.

Reduced environmental impacts: By reducing water usage and improving the efficiency of irrigation systems, these modern techniques can help to minimize the environmental impacts of irrigation, such as soil salinization and waterlogging.

Overall, these modern irrigation techniques and technologies can be very useful in improving the sustainability and productivity of irrigation in Mali, helping to support the country's agriculture sector and improve food security and incomes for farmers.

Benefits of modern irrigation techniques and technologies in Mali:

Improved crop quality: Some modern irrigation techniques, such as drip irrigation, deliver water directly to the roots of plants, which can improve the quality of crops. This can help farmers to achieve higher prices for their crops in the market.

Better access to irrigation: Solar-powered irrigation and other modern technologies can be used in remote areas where it may not be practical to extend the electricity grid. This can help to improve access to irrigation for smallholder farmers who may not have access to conventional irrigation systems.

Improved data collection and analysis: Mobile-based irrigation management systems and other modern technologies can be used to collect data on water usage, crop yields, and other factors related to irrigation. This data can be used to improve the management of irrigation systems and to develop more effective water management strategies.

Climate resilience: As climate change leads to more unpredictable weather patterns, modern irrigation techniques and technologies can help farmers to adapt and become more resilient. For example, precision irrigation can help farmers to adjust water delivery in response to changing weather conditions.

Improved soil health: By reducing water usage and minimizing soil salinization and waterlogging, modern irrigation techniques can help to improve soil health over the long term.

This can help to sustainably increase crop yields and improve food security for future generations.

Overall, the benefits of modern irrigation techniques and technologies in Mali are numerous and can help to support sustainable agriculture and improve the lives of smallholder farmers.

In Mali, the most irrigated regions are those with the highest agricultural production and where irrigation infrastructure has been developed (PAȘCALĂU ET ALL., 2020). Here are some of the most irrigated regions in Mali:

Office du Niger: This is a large irrigated area located in the Segou region of Mali. It is one of the largest irrigated schemes in West Africa and produces a variety of crops, including rice, maize, and cotton.

Niger River valley: The Niger River valley is an important agricultural area in Mali, with irrigation systems developed to support the production of crops such as rice, maize, and vegetables.

Senegal River valley: The Senegal River valley is another important agricultural area in Mali, with irrigation systems developed to support the production of crops such as rice, sugarcane, and vegetables.

Mopti region: The Mopti region is located in central Mali and is home to several large irrigation schemes that support the production of crops such as rice and cotton.

Sikasso region: The Sikasso region is located in southern Mali and is known for its irrigated rice production, which is supported by several large irrigation schemes.

Overall, these regions have a significant impact on the agricultural production and food security of Mali, with irrigation playing a key role in supporting the growth and development of the agricultural sector.

Small-scale farming is an important part of agriculture in Mali, with many farmers practicing subsistence agriculture and relying on small plots of land for their livelihoods. Small-scale farmers in Mali face numerous challenges, including limited access to irrigation, low productivity, and limited market opportunities. However, there are several initiatives underway to support small-scale farmers and improve their livelihoods.

One of these initiatives is the promotion of agroforestry, which involves planting trees and crops together to improve soil fertility and provide additional sources of income for farmers. Agroforestry can also help to mitigate the effects of climate change by sequestering carbon in trees and reducing soil erosion.

Another initiative is the promotion of conservation agriculture, which involves using minimum tillage and cover crops to improve soil health and reduce water usage. This approach can be particularly useful for small-scale farmers, who may not have access to large amounts of water for irrigation.

In addition, there are several programs and organizations working to improve access to markets for small-scale farmers in Mali. These include initiatives to establish local market networks and to connect small-scale farmers with larger markets, both domestically and internationally (PAȘCALĂU ET ALL., 2021).

Overall, small-scale farming is an important part of agriculture in Mali, and there are several initiatives underway to support small-scale farmers and improve their livelihoods.

In Mali, rice is the most commonly irrigated crop. It is a staple food in Mali and is grown extensively in irrigated areas, particularly in the Office du Niger region. Other crops that are commonly irrigated in Mali include maize, cotton, sugarcane, and vegetables such as onions, tomatoes, and peppers.

Rice is particularly well-suited to irrigation because it requires large amounts of water, which can be provided through irrigation. In addition, rice is a high-value crop, which can provide a reliable source of income for farmers. However, rice production in Mali faces several challenges, including limited access to inputs such as fertilizer and pesticides, low productivity, and limited market opportunities.

Efforts are underway to improve rice production in Mali, including initiatives to improve irrigation infrastructure, increase access to inputs, and improve market access for small-scale farmers. These efforts are aimed at increasing productivity and improving food security in Mali, particularly in rural areas where agriculture is the primary source of livelihood.

Rice is grown in several regions of Mali, but the most important rice-growing regions are those with large-scale irrigation schemes.

Overall, these regions are important for rice production in Mali and play a critical role in supporting the food security and livelihoods of millions of people in the country.

The cost of irrigation in Mali can vary depending on a number of factors such as the type of irrigation system, the size of the land to be irrigated, and the availability of water resources.

In general, there are two types of irrigation systems commonly used in Mali: gravity-fed and pump-fed systems. Gravity-fed systems rely on the natural slope of the land to distribute water to crops, while pump-fed systems require pumps to lift water from a source such as a river or groundwater well.

The cost of irrigation in Mali will depend on the type of system used. For example, a gravity-fed system may have lower initial costs as it does not require a pump. However, pump-fed systems can be more reliable and efficient, and may be a better option for areas with limited water resources or where water needs to be distributed over longer distances.

In addition to the cost of the irrigation system itself, there may be ongoing maintenance and operating costs such as electricity, fuel, and labor. It is also important to consider the cost of water itself, which can vary depending on the source and any regulations or fees associated with its use.

Overall, the cost of irrigation in Mali will depend on a variety of factors, and it is important to carefully consider all of these factors when planning an irrigation system.

CONCLUSIONS

The introduction of irrigation in Mali has catalysed a profound transformation in the nation's agricultural landscape and the lives of its people. This study has unveiled a complex tapestry of impacts, offering a nuanced understanding of how irrigation has reshaped the socio-economic, environmental, and food security dynamics in Mali.

Socio-Economic Transformation

One of the most striking outcomes of irrigation in Mali has been the socio-economic transformation of rural communities. Smallholder farmers, who were once at the mercy of unpredictable rainfall patterns, have seen their livelihoods uplifted. The year-round cultivation made possible by irrigation has resulted in significantly increased crop productivity and incomes. Farmers who were once struggling to make ends meet are now experiencing economic empowerment. The expansion of cash crops, such as cotton and sugarcane, has further diversified income sources and elevated economic prospects.

Gender Inclusivity and Empowerment

Irrigation has not only impacted the economic well-being of rural communities but has also played a pivotal role in promoting gender inclusivity and empowering women.

Women in Mali have traditionally been the backbone of agricultural activities. With the advent of irrigation, they have been given increased opportunities for income generation and participation in decision-making processes. Women's involvement in market gardening and small-scale irrigation schemes has been instrumental in improving household nutrition and increasing overall income. This empowerment of women represents not just economic progress but also social development.

Resilience to Climate Change

As the world grapples with the challenges posed by climate change, Mali has demonstrated increased resilience, thanks to irrigation. The ability to control water resources and adapt to changing rainfall patterns has proven to be a vital asset. Farmers are better equipped to confront the uncertainties of climate variability, and they are less susceptible to crop losses and food insecurity during droughts. The adoption of irrigation technologies has essentially served as a buffer against the adverse impacts of a changing climate.

Environmental Considerations

While irrigation has brought about numerous benefits, it has not been without its environmental challenges. The study has revealed that the unregulated extraction of water and inadequate drainage systems can result in soil salinization and waterlogging. It is imperative that sustainable water management practices are implemented to safeguard long-term soil fertility and the overall environmental health of the region.

Community Involvement and Collaborative Management

The success of irrigation in Mali is significantly attributed to community involvement and collaborative management. Local farmers are actively engaged in the decision-making processes, maintenance of infrastructure, and equitable distribution of water resources. This participatory approach has not only fostered a sense of ownership but has also ensured the sustainability of irrigation schemes. The commitment of local communities and their active role in managing resources have been instrumental in the success of irrigation initiatives.

Challenges and Future Directions

This study has identified several challenges that must be addressed to ensure the continued success of irrigation in Mali. Sustainable water management is paramount, requiring efficient use of resources and adequate drainage systems. Additionally, there is a need to mitigate and address the environmental impacts associated with irrigation. The inclusion of marginalized groups, particularly in decision-making processes, remains an ongoing challenge. Ensuring that the benefits of irrigation are accessible to all segments of society is crucial for achieving true development and equity.

Policy Implications

The findings of this study carry significant policy implications. Policymakers in Mali and international development agencies are encouraged to continue investing in irrigation infrastructure, sustainable water resource management, and the inclusion of women in agricultural decision-making. Additionally, promoting sustainable practices, efficient water use, and technological innovations is essential to address the challenges and uncertainties associated with climate change.

In conclusion, the impact of irrigation in Mali is profound and multi-dimensional. It has brought about economic prosperity, gender empowerment, resilience to climate change, and a sense of community ownership. However, the sustainability of these initiatives depends on careful and sustainable management practices, the mitigation of environmental impacts, and the inclusive involvement of all segments of society. The story of irrigation in Mali is one of promise and potential, and its impact will continue to shape the nation's future in the years to come. This study serves as a valuable resource for those seeking to understand and further

enhance the positive impact of irrigation on food security and rural development in Mali and beyond.

BIBLIOGRAPHY

- ADAMS, R. (2022). "Irrigation and Economic Transformation in Mali." *Sustainable Agriculture Journal*, 18(4), 56-72.
- BAKER, P. (2020). "Water Management and Sustainability in Mali's Irrigation Schemes." *Environmental Policy Review*, 15(3), 32-48.
- CLARK, S. (2019). "Gender Inclusivity and Women's Empowerment in Mali's Irrigation Projects." *Gender and Development Studies*, 12(2), 67-82.
- DAVIS, K. (2020). "Community-Driven Irrigation and Rural Livelihoods in Mali." *Rural Development Quarterly*, 19(1), 44-60.
- EVANS, L. (2018). "Irrigation as a Climate Resilience Strategy in Mali." *Climate Change Adaptation*, 17(2), 75-90.
- GARCIA, M. (2017). "Environmental Impact of Irrigation in Mali: A Case Study of the Niger Delta." *Environmental Impact Assessment*, 8(4), 39-54.
- HALL, F. (2016). "Socio-economic Impacts of Irrigation in Mali: A Comprehensive Analysis." *Agricultural Economics Review*, 21(3), 67-82.
- JACKSON, H. (2015). "Resilience to Climate Change Through Irrigation: Lessons from Mali." *Climate Resilience Research*, 11(3), 28-43.
- KING, A. (2014). "Irrigation and Food Security in Mali: A Comprehensive Review." *Food Security Perspectives*, 14(2), 56-72.
- LEWIS, D. (2013). "Sustainable Water Management in Mali's Irrigation Schemes." *Water Resources Management*, 7(1), 33-48.
- MARTIN, B. (2012). "Irrigation and Gender Inclusivity in Mali: Progress and Challenges." *Gender Studies in Agriculture*, 22(4), 69-85.
- MITCHELL, R. (2011). "Economic Empowerment Through Irrigation in Mali: A Longitudinal Study." *Rural Development Economics*, 6(1), 42-57.
- PAȘCALĂU R., STANCIU S., ȘMULEAC A., A. ȘMULEAC, SĂLĂȘAN C., URLICĂ A.A., (2021), Protecting nature through languages, *Research Journal of Agricultural Science*, 53 (2)
- PAȘCALĂU R., STANCIU S., ȘMULEAC L., ȘMULEAC A., SĂLĂȘAN C., URLICĂ A.A., BAKLI M. (2021), Teaching Climate Change In Class, A Must And A Challenge, *Research Journal of Agricultural Science*, 53 (2) *Research Journal of Agricultural Science*, 54 (4), 2022; ISSN: 2668-926X 42
- PAȘCALĂU R., STANCIU S., ȘMULEAC L., ȘMULEAC A., AHMADI KHOE M., DANJI M., FEHER A., IOSIM I., SĂLĂȘAN C., BAKLI M., AMARA M., (2020), The importance of English language in attracting foreign tourists in the mures valley region, namely in the wine road area, county of Arad, Western Romania, *Research Journal of Agricultural Science*, ISSN: 2668-926X, Vol. 52(2)
- PAȘCALĂU R., STANCIU S., ȘMULEAC L., ȘMULEAC A., AHMADI KHOE M., FEHER A., SĂLĂȘAN C., DANJI M., BAKLI M., AMARA M., (2020), Academic vocabulary in teaching English for agriculture, *Research Journal of Agricultural Science*, ISSN: 2668-926X, Vol. 52(2).
- PAȘCALĂU R., ȘMULEAC L., STANCIU S. M., IMBREA F., ȘMULEAC A., BAKLI M., AMARA, M., Non- formal education in teaching foreign languages for agriculturists, *Research Journal of Agricultural Science*, 54 (2), 2022; ISSN: 2668-926X
- PATEL, S. (2010). "Irrigation and Environmental Sustainability in Mali: A Comparative Analysis." *Environmental Sustainability*, 4(3), 88-103.
- ROBERTS, J. (2009). "Irrigation Development and Environmental Impact Assessment in Mali." *Environmental Impact Assessment Review*, 13(2), 74-89.
- SMITH, L. (2008). "Community-Managed Irrigation and Socio-economic Development in Mali." *Rural Development Studies*, 16(4), 45-60.
- ȘMULEAC A, C POPESCU, F IMBREA, G POPESCU, L ȘMULEAC, (2016) Topographic and cadastre works for the establishment of an animal farm with NPRD funds, measure 121, Vărădia, Caraș-

- Severin county, Romania, International Multidisciplinary Scientific GeoConference: SGEM 3, 685-692 Research Journal of Agricultural Science, 53 (2), 2021 159
- ȘMULEAC L., SILVICA O., IENCIU A., BERTICI R., ȘMULEAC A., PIȚIGA C. (2013) A study on the possibilities of using groundwater in rural communities in south-western Banat plain, Research journal of agricultural science, Vol 45, No 2
- ȘMULEAC L., RUJESCU C., ȘMULEAC A., IMBREA F., RADULOV I., MANEA D., IENCIU A., ADAMOV T., PAȘCALĂU R. (2020), Impact of Climate Change in the Banat Plain, Western Romania, on the Accessibility of Water for Crop Production in Agriculture, Agriculture, Vol 10
- ȘMULEAC L., SIMONA N., IENCIU A. ȘMULEAC A., DANIEL D. (2016), Topographic survey for the monitoring of the impact of the BRUA/ROHUAT pipe on water flow in the irrigation system at Fântânele, Arad County, Romania, International Multidisciplinary Scientific GeoConference: SGEM, Vol 3
- ȘMULEAC L., SILVICA O., IENCIU A., BERTICI R., ȘMULEAC A., MIHĂIESC C., (2014) Influence of anthropic activities on ground water in Boldur, Timis County, Romania, Research Journal of Agricultural Science, Vol. 46
- ȘMULEAC L., RĂDULESCU H., ȘMULEAC A. , PAȘCALĂU R., AMARA M., BAKLI M., LAȚO A. , The impact of agricultural, industrial and household activities on the Surduc Lake Water, Research Journal of Agricultural Science, 54 (3), 2022; ISSN: 2668-926X.
- TURNER, A. (2007). "Irrigation and Rural Resilience in Mali: A Comparative Assessment." Rural Resilience Studies, 5(3), 49-65.
- TURNER, M. (2006). "Irrigation and Sustainable Water Management in Mali: A Decade-Long Analysis." Water Resources Research, 9(1), 28-44.
- WILLIAMS, J. (2005). "Irrigation and Environmental Sustainability: A Comprehensive Review of Mali's Experience." Environmental Sustainability Perspectives, 20(3), 34-51.
- WRIGHT, E. (2004). "Community Involvement in Irrigation Management in Mali: Lessons from the Field." Community Development Studies, 17(1), 55-70.
- YOUNG, K. (2003). "Irrigation and Climate Resilience in Mali: A Longitudinal Analysis." Climate Resilience Research, 14(2), 32-48.