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Legal framework of agrivoltaics

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Analyzing Policy Framework of Agrovoltaics across the Water Energy and Food (WEF) Nexus in The Gambia

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Abstract. The projected increase in demand for food, water, and energy owing to systemic shocks has heightened the need for innovative solutions and integrated resource governance. The Agrovoltaics for Mali and Gambia (APV MaGa) Project, focuses on sustainable electricity production through agrovoltaics' triple land-use system and are leveraged with digital technologies. The project attempts to address The Gambia's high food importation gap, growing dependency on fossil fuels for electricity generation, and high electricity tariffs. However, the nascence of agrovoltaics presents a new energy dimension that calls for increased coordination of sectoral policy and management, a domain of WEF nexus governance detached mainly from governance practice. Thus, a policy and institutional foresight of the potential implications of agrovoltaics' integration is warranted, since Gambia's decision-making for land, water, energy, and agriculture remains mainly sectoral. A qualitative research design was adopted, using a sample of twenty-eight key informative interviews, policy document analysis, and grey literature. Research findings show that the existing policy frameworks such as 'Feed-in tariffs for excess RE, renewable energy fund, and capital subsidies can practically accommodate the frame of the agrovoltaics. However, clarification is required on the siting aspect of solar panels within the compartmentalized land policy structures. Institutionally, the Ministry of Energy's nexus platform allows for technical coordination of agrovoltaics projects. However weak institutional harmonization, technical/financial incapacities, and overriding national interests due to sectoral bias present challenges. Therefore, harmonization of sectoral divergent policy provisions, interests, and prioritization of sustainability concerns will foster the pertinent integration of agrovoltaics for fast expansion.

Keywords: Agrovoltaic, Digital Technology, Policy Framework, Rural Development, Smart Agriculture, Water-Energy-Food Nexus, West Africa

1. Introduction

Water, energy, and food constitute the primary resources for human well-being and sustainable development, yet global projections show a forecasted increase of demand by 55%, 60%, and 70% respectively by 2050 [7; 5;13]. In response, a drive for the optimization of the agriculture sector has seen the advancement of innovative technological frames such as precision agriculture and renewable energy-oriented technologies by FAO and the World Bank [15;16].

The APV concept is a form of renewable energy-related technology that is a mixed hybrid system that deploys photovoltaic panels over a unit area of land while minimizing land demand. In particular, agrovoltaics seek to address trade-offs between water, energy, and food, with substantial benefits in all three key sectors (8;15). However, the nexus thinking inherent in the Water, food, and energy concept (WEF) which is reflected in agrovoltaics is shaped largely by Western knowledge which limits practical application, especially in the Global South regions' institutional and policy processes on a grand scale or concrete local contexts (6; 12;27]**.** For example, the Agrovoltaics for Gambia (APV MaGa) project focuses on sustainable electricity production through agrovoltaics leveraged with digital technologies, presenting a great opportunity to address the Gambia's 50% food importation gap, high fossil fuel dependency for electricity generation and high electricity tariffs.

Although solar PV is not new to the African experience, agrovoltaics' technology is nascent and presents a new energy governance dimension that demands an often-detached domain of Water, Energy and Food (WEF) nexus governance. An assessment of agrovoltaics revealed that beyond technical and economic benefits, significant barriers such as social conflicts and the absence of relevant regulations and standards plague the adoption of agrovoltaics [41]. Therefore, the adoption/implementation of agrovoltaics especially in developing countries for the agriculture sector should not only consider technical feasibility, but also prioritize the complexity of politics and competing interests across multi-level governance systems in the agriculture sector [14].

The Gambia plans to expand irrigation and has promised to increase the amount of total renewable energy provided to the grid from the current 1% share to 10% as a signatory to the ECOWAS (GNAIP, 2015). However, it is estimated that 98% of its power is currently derived from fossil fuels, and its electricity tariff, which is 14.27 (GMD/kWh) and twice as high as that of Senegal, Burkina Faso, Cote d'Ivoire, and Ghana in West Africa, makes an energy transition necessary (GNAIP, 2015; Renewable Policy, 2013). In order to maximize the potential advantages of digital technology, the APV MaGa Project, supported by the Bundesministeriums fur Bildung und Forschung (BMBF), in collaboration with numerous international and local organizations, presents a key WEF nexus innovation. The agrovoltaics are intended to be put at a specific height above the ground with the purpose of generating power, collecting rainwater, and growing crops. With the objective to demonstrate the technical and socioeconomic viability of the technology in the context of West Africa, the project will investigate and demonstrate the potential of APVs for The Gambia.

Thus, if coherent strategies are to be promoted for APV technology integration and rapid expansion, it is necessary for the Agrovoltaic project in The Gambia to have a thorough awareness of the regulatory and institutional interlinkages. However, in The Gambia, governance practice poses a challenge because land-use regulations are compartmentalized and decisions regarding land, water, energy, and agriculture are still made at the sectoral level [11]. Further, the legacy framework for policy creation assumes linearity and a mechanistic cause and effect, ignoring the dynamic nature of systemic shocks like climate change and technological breakthroughs across resource systems.

Thus, this paper seeks to examine the implications of the policy frameworks for agrovoltaics across the water, energy, and agriculture sectors. While we do not attempt an exhaustive review of the WEF nexus, rather, an anticipatory policy dimension is presented using the case of The Gambia to help highlight lessons and flag policy concerns that improve agrovoltaics and various renewable-energy technology integration and expansion.

1.1 Conceptual framework

Technology alone is insufficient to ensure success, rather the enabling environment plays a significant role in determining the implementation and success/failure of agrovoltaics. The conceptual framework adopted for the paper focuses on the adequacy of the policy and institutional frameworks for integrating the agrovoltaics technology. From this perspective, the enabling environment (inputs depicted as **A**) dictates the inter-sectoral coordination amongst water, food, and energy sectors for agrovoltaics implementation (interaction depicted as **B**) and determines the potential success in ensuring enhanced resource efficiency and improving livelihoods (outputs labeled **C**), as illustrated in Fig 3.

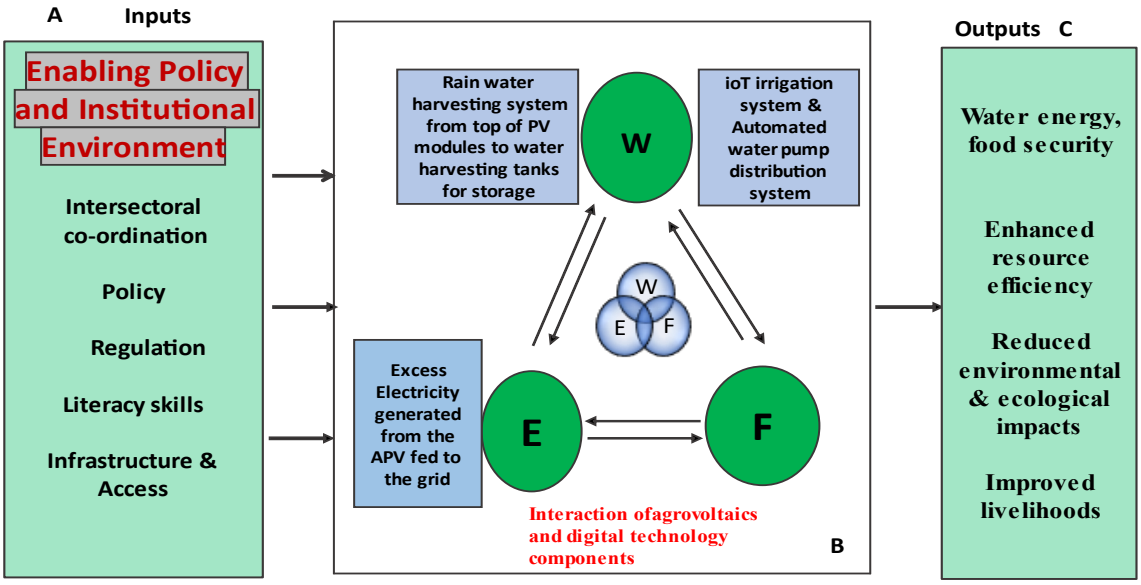

Figure 1. Conceptual Framework showing the influence of the institutional and policy enabling environment on the WEF interaction of agrovoltaics in an ideal scenario (Adapted and modified from [32].

1.2 Methodology

This study was exploratory and adopted a qualitative research design that combines policy mapping analysis with twenty-six key-informant interviews and desk-based reviews. The researcher's internship with Gambia's National Research Institute allowed access to published documents and unpublished briefs to understand the nuances of the institutional framework framing the agriculture sector. The mapping policy analysis was adapted and modified to evaluate solar off-grid pumps in India. The policy analysis entailed reviewing the water, energy, and agriculture sectors and the related national policies, plans, and frameworks. The crux of the mapping analysis was to evaluate water, energy, and agriculture policy provisions in consideration of the components of the APV project. Interviews ensured the inclusion of the voice of local and national-level policy-makers for policy-relevant recommendations that are politically acceptable and feasible to improve policies. The interviewees included actors from government agencies such as the National Agriculture Research Institute (NARI), National Water and Electricity Company (NAWEC), Public Utilities Regulatory Authority (PURA), Energy Ministry, Fisheries and Water Resources Ministry, and Agriculture Ministry representatives.

2. Results and Discussion

2.1 Existing Supportive Policy Provisions for Agrovoltaics

The National Development Plan (2018-2021) seeks to increase the share of renewable energy from 2 to 40% by 2030 and the energy policy provisions for renewable energy projects. The existing supportive policy provisions for the practical adoption of agrivoltaics include significant incentives ranging from financial capital subsidies to a renewable energy fund to support renewable energy projects. These provisions in detail include;

- Feed-in tariffs entail the selling of excess energy generated with a favorable feed-in tariff measure to support selling excess electricity to the grid. Furthermore, Gambia as a pilot country chosen under the ECOWAS regional group, as a pilot for the validation of a set of tools to assess tariffs for grid-connected and off-grid renewable energy systems in West Africa (technical training & assistance), is in a better position to carry out feed-in tariffs calculations.

- There is a renewable energy fund and an import duty exemption of 18% VAT for 22 renewable energy technologies &equipment and priority dispatch of renewable energy plants.

- In addition, the proceeds from the sale of carbon emission credits are exempt from tax and import duty (National Energy Policy 2015-2020).

- The agricultural and energy policies state the siting of solar projects in low-quality areas for example abandoned mines/old transportation/transmission zones only and transmission areas to minimize land impacts

- The policy provisions recognize solar PV for residential, water and sanitation, and commercial use for irrigation to be overseen by the institution PURA (Public Utilities Regulation Authority) which oversees the regulation of water, electricity, and sewerage.

- Institutionally the Gambia National Platform for Energy nexus under the Ministry of Petroleum and Energy aims to ensure a central base for dialogue on energy coordination and meeting renewable electricity targets by 2025, as highlighted in the National Development Plan and the ECOWAS 2030 target. This Energy Nexus Platform is a facilitator and technical coordination platform for Agrovoltaic

2.2 Concerns/Gaps in the Policy Provisions for Agrovoltaics

- Absence of spatial planning law for a certain area to be used equally for agriculture and APV. The triple land-use system proposed by agrovoltaics is currently not defined in the law and the agricultural policy states that solar projects minimize land sharing with agricultural activities.
- Need for policy, mindset, and cultural reform on the social acceptance of the APV feature for rainwater harvesting component. The National Agriculture Policy (2017) states that “rainwater harnessing for agricultural use is one of the priority areas for investment in the GNAIP referred to as ‘water for productive use. However, the policy document does not implicitly recognize solar PV and agrovoltaics in particular a potential rainwater harvest source, although they favorably advocate for solar energy systems. On the other hand, the water policy recognizes rainwater harvesting from water tanks and ponds, not necessarily solar PVs. Thus, all three policies do not recognize solar PV as a rainwater harvester or dual land-use option under agriculture. In practice, the interviewee highlighted that robust rainwater harvesting in agriculture is still minimal. Instead, it is still voluntary, with agricultural extension officers not prioritizing it due to the

overall bias of a higher water per capita in the country despite water accessibility challenges in the drier regions of the Central River Region, namely the districts of Niania, and Upper Salaoum.

- Designation and siting criteria for solar projects (APVs) under land administration for agriculture is a challenge since the policy provisions under the agriculture ministry recognize siting of solar projects in low-quality areas for example abandoned mines/old transportation/transmission zones only (National Energy Policy - The Gambia 2015-2020). Therefore, there is an absence of a comprehensive legal framework for building or certification scheme clearance for dual-system of APVs.
- Absence of a comprehensive legal framework for building or certification scheme clearance for dual-system of APVs.

2.3 State of Policy Provisions for WEF Nexus Implementation

The study findings showed that the WEF nexus thinking is acknowledged at the highest policy level for national agenda programs reflected in National Development Plans. The Vision 2020 document highlights integrating the ministries and sectors to achieve food security and economic development. However, individual sector policies such as the water policy and energy policy limit integration from a practical perspective due to challenges.

2.3 Concerns/Gaps in the Policy Provisions for WEF Nexus

- Absence of harmonized sectoral divergent interests, incentives, and sustainability consideration. There is a weak establishment of how land administration and water regulation in the agriculture sector. For example, the sectorally administered agriculture and energy incentives have implications for the water and agriculture sector, yet are often not factored in or overlooked due to overriding national interests' agenda. For example, projects tend to be rolled out by non-governmental organizations collaborating with a distinct vertical (ministry) or a horizontal structure (departmental institution) resulting in increasing duplication of sectoral- efforts.
- Competing and conflicting interests frame the sectoral Policies and established Institutional WEF Governance Structure. The solar equipment tax importation exemption has led to increased solar-powered boreholes by individual farmers, raising water over-abstraction concerns. The agriculture sector also has direct input subsidies such as fertilizers; for example, the agricultural subsidy for fertilizer in 2021 increased to D524 million compared to D201 million in 2020 (Touray, 2021). Although this is very supportive of the agriculture sector's set targets, it raises concerns over water quality since enforcement and regulation for abstraction are minimal.
- The Gambia government established an integrated way of thinking framing the Public Utilities and Regulations Authority (PURA) which oversees water, energy, and waste regulation. However, from a practical perspective, there is a lack of integration and cross-sectoral coordination for the polycentric nature of governance systems and limited Intersectoral coordination in projects on cross-cutting issues such as water and sanitation, land rehabilitation, green and blue infrastructure initiatives, and nutrition projects.
- The multiplicity of illegal shallow wells and groundwater users demands a large workforce that the utilities are financially incapacitated to manage and police water abstraction. The unavailability of trained water experts and renewable energy experts (who, in any case, are diffusion media) results in a lack of diffusion channels that facilitate policy interpretation, translation, and subsequent implementation. Furthermore, reduced funding from sectoral budgetary allocations and donor funding for projects aimed at the agriculture, energy, and water sector in the water sector has hampered efforts for intersectoral- collaborations, synergies, and weakened communications.
- Climate extremity for the food-deficit country poses abrupt changes across the integrated resource systems namely water, energy, and agriculture sectors. Furthermore, climate change may increase the severity of conflicts between different water uses as

growing seasonal and localized water scarcity is occurring with an increasing frequency.

Conclusion

The paper shows how the inclusion of the voice of actors can enhance understanding of the local context and highlight gaps inherent in the enabling environment of the WEF nexus in the frame of an Agrovoltaics project. Research findings show that the existing frameworks for the energy and agriculture sectors, such as the 'Feed-in tariff exists for excess RE, Renewable energy fund and capital subsidy can practically accommodate the frame of the agrovoltaics. However, a need for future clarification on the siting aspect of solar panels in the land administration aspects and structures is lacking. results suggest coupling the sectors under the Energy nexus is driven by national interests for irrigation, agriculture, and electricity. The Ministry of Energy's energy nexus platform was established in 2021 and allows for technical coordination of nexus projects such as the agrovoltaics project, however weak institutional harmonization and compartmentalized land-use policies create barriers for sectoral projects. Sectoral bias and overriding national interests have led to poor recognition of the implications of agriculture and energy incentives on other sectors such as the water sector. Findings revealed that capacity, and technical capabilities for design and installation, poor groundwater regulation, and ecological protection need consideration.

Recommendations

Robust cross-sectoral WEF nexus sharing agreements and soft approaches to improve intersectoral coordination. There is a need to revise and clarify the designation and siting criteria for solar projects land administration for agriculture beyond commercial irrigation use options in the Gambia and consider the potential for aquavoltaics. The Gambia's energy nexus platform needs more harmonization of sectoral divergent interests (incentives) and the extent of sustainability issue considerations. Furthermore, the energy nexus platform should head the discourse on a comprehensive legal framework for the planning and intersectoral laws associated with APV. There is a need to leverage the Africa Continental Free Trade Area (AfCFTA)'s operational instruments such as (an online negotiating forum) to drive discourse on APV integration. Improved communication networks such as digital social media platforms on agrivoltaics and incentives offered by the government can drive social awareness and improve citizenry participation in water resource stewardship since technology alone is not enough. Future studies should integrate quantitative methods such as modeling of the WEF nexus to quantify the impacts and trade-offs as supplementary data to stakeholder perspectives used in this study.

Data availability statement

The data used to support the results of the article/contribution has been attached as interview questions and an appendix has been attached. The data is based on ethical and third-party restrictions as data used for Master' thesis research work in collaboration with project partners of the APV MAGA project.

Author contributions

The authors acknowledge the original contribution to investigation, methodology, conceptualization, and, writing according to the credit guidelines.

Competing interests

"The authors declare no competing interests."

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References

1. Adaptation Fund Board, Proposal for The Gambia (2020) Project and Programme Review Committee Twenty-sixth Meeting Bonn, Germany (virtual), 13-14 October 2020 https://www.adaptation-fund.org/wp-content/uploads/2020/10/AFB.PPRC_.26.b.7-Proposal-for-The-Gambia.pdf
2. Adeh, E. H., Good, S. P., Calaf, M., & Higgins, C. W. “Solar PV power potential is greatest over croplands”. Scientific reports, (2019), 9(1), pp 1-6.
3. Agostini, A., Colauzzi, M., & Amaducci, S. “Innovative Agrivoltaic systems to produce sustainable energy: An economic and environmental assessment”, Applied Energy, (2021), 281, 116102.
4. Albrecht, T. R., Crootof, A., & Scott, C. A, “The Water-Energy-Food Nexus: A systematic review of methods for nexus assessment”. Environmental Research Letters, (2018). 13(4), 043002.
5. Alcon F, Tapsuwan S, Brouwer R, Yunes M, Mounzer O, de-Miguel M D “Modelling farmer choices for water security measures in the Litani river basin in Lebanon”. Sci. Total Environ. (2019). 647: 37-46. https://doi.org/10.1016/j.ins.2014.10.013
6. Al-Saidi, M., & Elagib, N. A. Towards understanding the integrative approach of the water, energy, and food nexus. Science of the Total Environment, (2017). 574, 1131-1139.
7. Avellán, T., Ardakanian, R., Perret, S. R., Ragab, R., Vlotman, W., Zainal, H., ... & Gany, H. A. “Considering resources beyond water: irrigation and drainage management in the context of the water–energy–food nexus. Irrigation and Drainage”, (2018). 67(1), 12-21.
8. Barron-Gafford, G. A., Pavao-Zuckerman, M. A., Minor, R. L., Sutter, L. F., Barnett-Moreno, I., Blackett, D. T., ... & Macknick, J. E. Agrivoltaics provide mutual benefits across the food–energy–water nexus in drylands. Nature Sustainability, 2(9), (2019). 848-855.
9. Beaton, C., Jain, P., Govindan, M., Garg, V., Murali, R., Roy, D., ... & Pallaske, G. “Mapping Policy for Solar Irrigation Across the Water-Energy-Food (WEF) Nexus in India”. (2019). Winnipeg, Manitoba, Canada: International Institute for Sustainable Development.
10. Bellfield, H., Sabogal, D., Goodman, L., & Leggett, M. (2015). Case study report: Community-based monitoring systems for REDD+ in Guyana. Forests, 6(1), 133-156.
11. Bensouda A. “Issues and Options for Improved Land Sector Governance in Gambia Results of the Application of the Land Governance Assessment Framework, Synthesis”(2013). Report, https://thedocs.worldbank.org/en/doc/a91b90185037e5f11e9f99a989ac11dd-0050062013/related/Gambia-Summary.pdf
12. Bizikova, L., Roy, D., Swanson, D., Venema, H. D., & McCandless, M. “The water-energy-food security nexus: Towards a practical planning and decision-support framework for landscape investment and risk management”. (2013). Manitoba: The International Institute for Sustainable Development
13. Bousselot, J., Slabe, T., Klett, J., Koski, R. "Photovoltaic array influences the growth of green roof plants." (2017). Journal of Living Architecture, 4(3): 9-18.
14. Daniell, K. A., Coombes, P. J., & White, I. Politics of innovation in multi-level water governance systems. Journal of Hydrology, (2014). 519, 2415-2435.
15. Dayioglu and Turker, U, Digital Transformation for Sustainable Future-Agriculture 4.0: A review. (2021), Journal of Agricultural Sciences, 27(4), 373-399.
16. De Laurentiis, V., Hunt, D. V., & Rogers, C. D. Overcoming food security challenges within an energy/water/food nexus (EWFN) approach. (2016). Sustainability, 8(1), 95.
17. Dinesh, H., & Pearce, J. M. The potential of agrivoltaic systems. Renewable and Sustainable Energy Reviews, (2016), 54, 299-308.
18. Dupraz, C., Marrou, H., Talbot, G., Dufour, L., Nogier, A., & Ferard, Y. “Combining solar photovoltaic panels and food crops for optimizing land use: Towards new agrivoltaic schemes”, (2011). Renewable energy, 36 (10), 2725-2732.

19. Endo, A., Tsurita, I., Burnett, K., & Orencio, P. M. A review of the current state of research on the water, energy, and food nexus. (2017), Journal of Hydrology: Regional Studies, 11, 20-30.
20. FAO, AQUASTAT, (2016), Database. Retrieved on July 29, 2021 from http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en
21. Gallagher, L., Dalton, J., Brethaut, C., Allan, T., Bellfield, H., Crilly, D., Cross, K., Gyawali, D., Klein, D., Laine, S., The critical role of risk in setting directions for water, Food and energy policy and research. Current Opinion Environ. Sustain. 2016, 23 (23), 12e16.
22. Giupponi, C., & Gain, A. K. (2017). Integrated spatial assessment of the water, energy, and food dimensions of the sustainable development goals. Regional Environmental Change, 17(7), 1881-1893.
23. IFAD (2020); Gambia; The National Agricultural Land and Water Management Development Project Report, 5635-GM, accessed at www. Ifad.org?en? web? operations?-?project?1100001643.
24. Kamilaris, A., Kartakoullis, A., & Prenafeta-Boldú, F. X. A review on the practice of big data analysis in agriculture. *Computers and Electronics in Agriculture*, (2017). *143*, 23-37.
25. Krually, M. (2020) Gambia: Energy-Shift, A Sure Panacea for Sustainable Electricity Supply in the Gambia. All Africa accessed at https://allafrica.com/stories/202004300331.htmlOECD (Organisation for Economic Co-operation and Development) (2012) OECD environmental outlook to 2050: the consequences of inaction. OECD, Paris
26. Macnaghten, P., Owen, R., Stilgoe, J., Wynne, B., Azevedo, A., de Campos, A., ... & Velho, L. (2014). Responsible innovation across borders: tensions, paradoxes, and possibilities. Journal of Responsible Innovation, 1(2), 191-199.
27. Naidoo, D., Nhamo, L., Mpandeli, S., Sobratee, N., Senzanje, A., Liphadzi, S., ... & Mabhaudhi, T. (2021). Operationalising the water-energy-food nexus through the theory of change. *Renewable and sustainable energy reviews*, *149*, 111416.
28. Nhamo, L., Ndlela, B., Nhemachena, C., Mabhaudhi, T., Mpandeli, S., & Matchaya, G. (2018). The water-energy-food nexus: Climate risks and opportunities in southern Africa. Water, 10(5), 567.
29. Panel, M. M. Byte by byte: Policy innovation for transforming Africa's food system with digital technologies. (2019). Malabo Montpellier Panel.
30. Pahl-Wostl, C."Governance of the water-energy-food security nexus: A multi-level coordination challenge." *Environmental Science & Policy*, (2019). *92*, 356-367.
31. Jammeh, M., Mam-Yassin, C., AComprehensive Food Security and Vulnerability Analysis (CFSVA: Gambia, World Food Programme,(2016). United Nations accessed at https://documents.wfp.org/stellent/groups/public/documents/ena/wfp290335.pdf
32. Rasul, G., & Sharma, B. (2016). The nexus approach to water–energy–food security: an option for adaptation to climate change. *Climate Policy*, *16*(6), 682-702.
33. Schroeder, K., Lampietti, J., & Elabed, G. "What's Cooking: Digital Transformation of the Agrifood System". (2021). World Bank Publications.
34. Touray.AF Kebba(2021) Gambia: Government To Spend D524 million on Fertilizer Subsidy, FORAYAA newspaper, Serrekunda accessed August 2021 at www.allafrica.com
35. UNDP (2020). Human Development Report. Country Notes – The Gambia.
36. Available at: http://hdr.undp.org/sites/all/themes/hdr_theme/country-notes/GMB.pdf.
37. UNECA (2012) Developing The Gambian Information Economy and Society and Accelerating the Process of Transforming The Gambia into the Silicon Valley of Africa THE GAMBIAN ICT4D-2012 PLAN accessed at https://www.ellipsis.co.za/wp-content/uploads/2016/07/Gambia.pdf
38. UN Environment. 2018. In the Gambia, building resilience to a changing climate. Available at https:// www.unenvironment.org/news-and-stories/story/gambia-building-resilience-changing-climate

39. UNEP, “Roadmaps for water management in West Africa, Case studies from The Gambia, Guinea Bissau and Sierra Leone Development and implementation of IWRM Plans”, (2020) accessed September 2021 at https://www.unepdhi.org/wp content/uploads/sites/2/2020/08/UNEP_DHI_casebook_print_nomarks.pdf
40. WWAP (World Water Assessment Programme) (2009) The United Nations world water development report 3: water in a changing world. UNESCO/Earthscan, Paris
41. WWAP (World Water Assessment Programme) (2012) The United Nations world water development report 4: managing water under uncertainty and risk. UNESCO, Paris
42. World Bank (2020a). Systematic Country Diagnostics for the Republic of The Gambia. Washington, DC. Available at: http://documents1.worldbank.org/curated/en/782131589568063735/pdf/The-Gambia-Systematic-Country-Diagnostic.pdf.
43. World Bank (2020b). Africa Pulse: Charting the Road to Recovery. Available at: https://www.worldbank.org/en/publication/africa-pulse.
44. World Bank (2020c). Doing Business 2020: Comparing Business Regulation in 190 Economies – Economy Profile of the Gambia, The (English). World Bank, Washington, DC
45. Yu, Y., & Ko, Y. (2021). A review of the attributes of successful agrovoltaic projects.

Appendix

Interview Questions

1) Forms of policy provisions for Agrivoltaic system components across the water, energy, and agriculture sectors and the inter-sectoral coordination issues faced.

    - Are there any existing laws and policy provisions for solar PV use in the water sector? if yes name them.
    - Are there any existing laws and policy provisions for solar PV use in the agriculture sector? f yes names them.
    - Are there any existing law and policy provisions for solar PV use in the energy sector? if yes name them?
    - Name a few examples of solar PV projects, involving more than one ministry /sector that were introduced in The Gambia?
    - What guidelines or laws were used to ensure smooth co-ordination of the project amongst the different sectoral/ ministries administration structures?
    - What are some of the challenges faced in ensuring inter-sectoral coordination for the projects and how were they addressed?
    - Are there any existing law and policy provisions for integrating solar PV use for electricity generation and crop production on the same plot of land in The Gambia?
    - What would be the potential practical challenges faced in establishing such an integrated land-use solar PV system such as the agrovoltaics in The Gambia?
    - What is the practical advice/recommendations you would suggest to guide the integration of agrovoltaics for agriculture and electricity production in The Gambia?
    - What policy recommendations would you suggest to improve the adoption of agrovoltaics’ triple-land-use system on a plot of land within the agriculture sector?