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# A literature review of climate-smart landscapes as a tool in soil-water management in Sub-Saharan Africa

**Benson Turyasingura [1, 3, 4, *], Wycliffe Tumwesigye [2, 3, 4], Atuhaire Abraham [1], Jennifer Turyatemba Tumushabe [1], Rogers Akatwijuka [1]**

[1] Faculty of Agriculture and Environmental Sciences, Kabale University, P.O. Box 317, Plot 346, Block 3 Kikungiri, Kabale, Uganda
[2] Department of Agriculture, Agribusiness and Environmental Sciences, Bishop Stuart University, Uganda
[3] College of Agriculture and Environmental Science, Haramaya University, Haramaya P.O. Box 161, Ethiopia
[4] African Center of Excellence for Climate Smart Agriculture and Biodiversity Conservation (Climate SABC), Haramaya University, Ethiopia P.O. Box 138, Dire Dawa, Ethiopia
*Corresponding authors email: bturyasingura@kab.ac.ug
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**Abstract:** Worldwide, information is needed about the social landscape management as there is no known studies that have documented how climate-smart landscape approaches improve soil and water status. In Sub-Saharan Africa, effective social landscape governance necessitates a certain amount of social capital, including trust and agreed-upon standards. Climate-smart landscapes are key to successful soil and water management but little effort have been made to critically improve effective soil and water resources. The study was guided by the specific objectives, which include examining equitable climate-smart landscapes and finding out the major challenges facing the implementation of climate-smart landscapes. Using "landscape governance" AND "climate smart landscape," 31 papers (31) were obtained from the Web of Science (WOS) and twenty-nine (27) from the Scopus databases using search engines from (1992-2022). On equitable climate-smart landscapes, it was found that multi-stakeholder participation in landscape management is an iterative and changing process that can assist in addressing and resolving disputes as well as facilitating fair negotiation procedures for underrepresented and minority groups. Proper planning and the implementation of a comprehensive planning framework that links various planning activities and decision-making processes are required for landscape approaches to be successful. The major challenges included policies and institutions, financial difficulties in the conservation of natural resources, and socio-economic issues. The novelty from this study is to inform policy makers on climate-smart landscape approaches to ease soil and water management.

**Keywords:** Land leveling design, Profile method, Plane shape, Linear programming

## 1. Introduction

In Sub-Saharan Africa (SSA), the responsibilities of soil and water management would also need to be coherent and complementary [1], and governance arrangements would need to prevent one actor from gaining greater power than others [2]. Additionally, governance plans must to incorporate not only the landscape's own stakeholders but also larger-scale entities [3]. For instance, REDD+ schemes and other national programs may incorporate landscape activities [4].

According to Tscharntke et al. [5], landscape governance is intrinsically complicated contend that the circumstances necessary for it to be successful have been becoming better. The ownership of land and natural resources by the state has been giving way to the distribution of power among the private sector [6], local governments, and civil society in many countries [7].

Effective landscape governance, according to Ros-Tonen et al. [8], necessitates a certain amount of social capital, including trust, agreed standards to ease soil and water management [9]. They also stress the role of linking governments in establishing connections between various actors and facilitating successful landscape governance [8]. Such organizations can serve as knowledge brokers as well as be important facilitators of multi-stakeholder negotiations, group learning, and conflict resolution [10]. This study reviewed landscape governance as a key to successful climate smart landscape management. The study assessed the role of landscape governance in climate smart landscaping and the major challenges for scaling out CSA in many agroecological zones in SSA.

The literature cites on the potentials of artificial landscape governance like trust, and agreed standards to ease soil and water management. However, it does not stipulate the conditions that may limit the realization of such benefits and how local communities can embrace them to ease soil water management.

The literature cites the potentials of CSA, for example, the improved potato varieties being tolerant to pests and diseases and prolonged dry spells. Nonetheless, it does not stipulate the conditions that may limit the realization of such benefits. It also points out the benefits of various CSA practices in addition to the above. However, it does not highlight the biophysical, environmental, and farmer related factors like knowledge about the technology that may jeopardize their potential, other than their practice.

The review aimed at landscape governance as a key to successful climate smart landscape for soil and water management. The study assessed the climate-smart landscape approaches for soil and water management, equitable climate-smart landscapes, and the major challenges facing the implementation of climate smart landscapes in SSA respectively.

The examination of social landscape governance as a factor in effective soil and water management in a climate-smart landscape may yield information that influences the understanding and openness of all stakeholders to climate-smart landscape approaches. The population that depends on these water resources as well as the environment may be protected through improved farming practices in the various agroecological zones around the world if the role of landscape governance in a climate-smart landscape is understood. The creation of policies to safeguard the water from further deterioration in quality and quantity may be aided by these improvements to soil and water [11]. Climate-smart landscapes operate under the tenets of integrated landscape governance, even though explicitly incorporating adaptation and mitigation into their management objectives may improve suitable planning and plan implementation.

The novelty of this study is to inform policymakers on climate-smart landscape approaches to ease soil and water management. Besides, much information is needed about social landscape management, as no known studies have documented how climate-smart landscape approaches improve soil and water status in SSA. The study adds novelties about landscape ecology using climate-smart approaches, which have not yet been used in any published literature for this region. International agencies must finance climate-smart landscape approaches while also implementing proper policy to improve proper landscape management.

## 2. Conceptual Framework

According to the definition of a social landscape, it is "a place, as seen by people, whose character is the product of humankind's action and interaction with the physical environment at its core" [12], a space marked off by a participant with a particular set of goals [13]. It serves as a stage for interactions between things, including people, in which their connections are governed by physical, biological, and social norms [14]. This is as a result of many years of human settlement activity but little information has been made to conserve landscape areas.

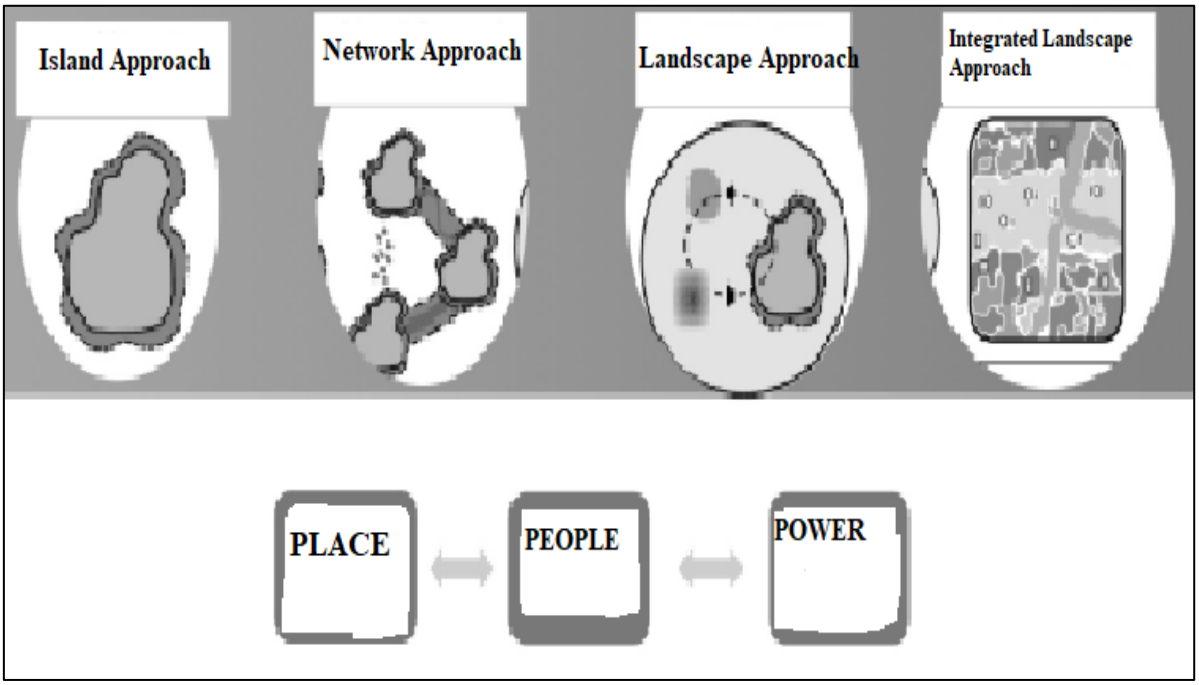


**Figure 1.** Social Landscape Approaches [17].

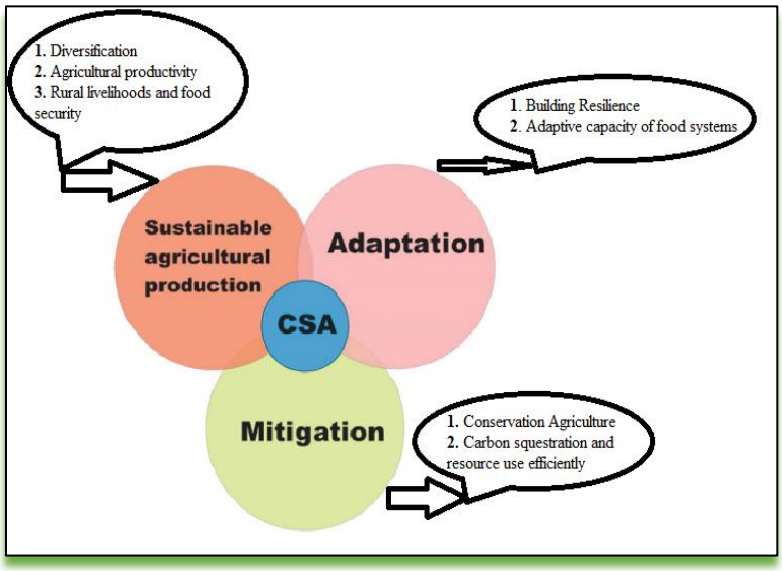


**Figure 2.** CSA goals [20].

Social Landscape governance (SLG), which "comprises the complex mechanisms, processes, and institutions through which citizens and groups articulate their interests, mediate their differences, and exercise their legal rights and obligations [15]," is "The exercise of political, economic, and managerial expert" to achieve social or political system's "affairs at all levels." The goal of the place-based, multi-stakeholder. SLG process is to maintain, improve [16], or restore the functions of the landscape as well as the goods and services that these functions deliver [17].

CSA is defined as agricultural activity that effectively and sustainably raises output and income, mitigates or eliminates greenhouse gas emissions, and advances the achievement of national food security and development goals [19-20]. In general, this idea aims to combine environmental stability and food production without compromising either of them. Hence, the goal of CSA is shown in the (Figure 2) above.

According to Onyeneke et al. [21], “there is a direct and perhaps fatal connection between agriculture and climate change [22]”. On the one hand, changes in the agricultural system and land use, such as deforestation, account for nearly 30% of all global GHG emissions [23], while “the effects of climate change are causing land degradation, low agricultural productivity, and food insecurity on the other.” Because smallholder farmers are more susceptible to the effects of climate change, they need more robust production systems. Natural resource management is also necessary for an agricultural system to be more productive and robust [24]. As a result, the benefits of mitigation have been observed to greatly increase with the changeover of this system [25].

According to Teklewold et al. [26], climate smart agriculture aims to boost agricultural productivity in a way that is both environmentally and socially responsible, to increase farmers' adaptability to climate change, and to lessen the impact of agriculture on global warming by lowering greenhouse gas emissions and increasing carbon sequestration on farmland. It aids smallholder farmers in bolstering their standard of living in the face of climate change while also minimizing its effects [25]. Hence, according to FAO, [28, p. 557], climate-smart agriculture is a triple win. This is because it sustainably increases productivity [29-30], increases resilience and adaptation [31], reduces greenhouse gases [32], and enhances achievement of the national food security and development goals [20].

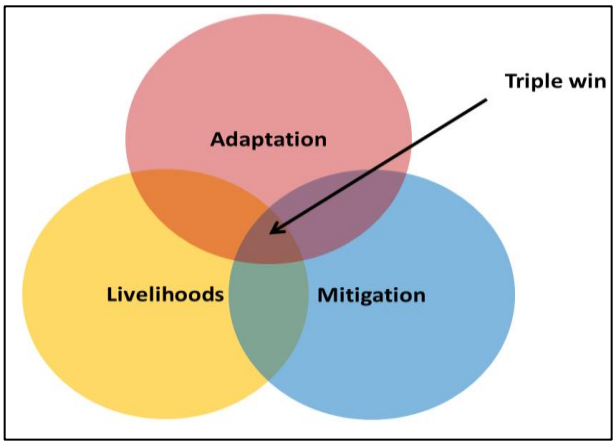


**Figure 3.** CSA as a triple win, FAO [28, p. 557]

## 3. Materials and Methods

In line with the study conducted by Turyasingura et al [11], 56 papers were selected for this study from a total search of 345. In addition, 31 papers from WOS and 27 publications from Scopus were found relevant for this study and were selected and discussed (*see* Figure 4). Thus, the review focused the climate-smart landscape approaches for soil and water management, equitable climate-smart landscapes, and the major challenges

facing the implementation of climate smart landscapes (1992-2022). Different searching platforms were used in this study to reduce bias on the information given. Thirty-one papers (31) were obtained from the Web of Science (WOS), and twenty-nine (27) from the Scopus databases using "Landscape governance" AND "Climate smart landscape." Hence, fifty-six papers were got from searching engines.

The flow chart provides a detailed description of selected literature review (*see* Figure 4). The total number of articles reviewed was three hundred forty-five. Twenty-seven papers were obtained from the Scopus database, thirty-one papers from the Web of Science, and around 17 papers were excluded from this study because they were outside of the search topic and specific objectives.

livestock owners [36]. Forging cooperation and information sharing across various stakeholders requires assessing their collaborative capacity and facilitating participative decision-making processes. Multi-stakeholder planning and management needs financial support to raise agricultural output and incomes and provide environmental advantages [37].

The conventional "silo" strategy needs to be replaced with a supporting and integrated policy environment within national policy [38], legislative [39], and institutional contexts [40]. Joint planning and coordinated interactions across ministries are necessary for implementing landscape approaches, and they can be encouraged through platforms for cross-sector dialogue.

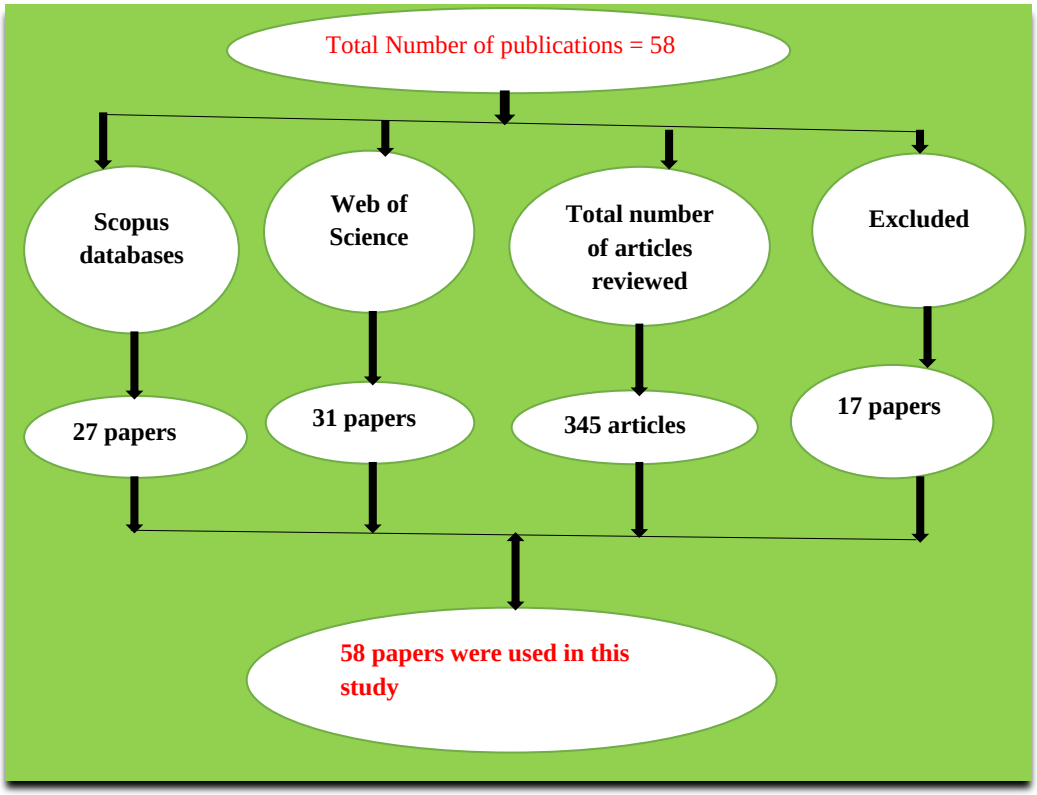


**Figure 4.** Flowchart for the selection of literature [11]

## 4. Empirical Literature

### 4.1. Climate Smart Landscape Approaches

According to Scherr et al. [27] enhancing ownership and achieving strong pledges for the implementation of climate-smart agriculture, [34] depend on ensuring the assignation of all participants in the policymaking development. Members involved in land scape governance in the bargaining process must have changing levels of authority, including resident officials [35], community leaders, landlords, land users, tenant farmers, institutions of the central government, and

According to Sara J Scherr [20], improving the capacities for climate-smart landscape planning and putting climate-smart practices into practice calls for land-use planning expertise, as well as the ability to raise funds [41], encourage innovation [42], and enhance production cycle management [43] This capacity building is necessary to strengthen planning and negotiation, expand rural enterprises, reinforce financial rewards, and increase productivity and marketability [44].

Implementing a comprehensive planning framework that links various planning activities and decision-making processes is required for landscape approaches to be successful. It is more likely that planned activities won't be implemented successfully or sustainably if planning is exclusively done at the national or regional level without sufficient input from local stakeholders [44]. Contrarily, plans made at the landscape or community level without the backing of enabling laws or governmental authorities may also face difficulties because of a number of issues, including tenure instability, subpar infrastructure, and insufficient institutions and markets.

Communities should be able to manage and take advantage of the variety of resources in the environment, such as, for example, forested and farmed mountains, fertile valleys, and watercourses. Policies should be devised to assist planning procedures at local levels. Rural-urban relations must be considered in local planning processes [36].

The implementation of landscape techniques for climate-smart agriculture frequently encounters a major obstacle in the form of institutional capacities. The strengthening of institutions and political support for the scheduling and enactment of climate-smart landscapes over landscape methods, according to Scherr, Shames, and Friedman [45], requires a comprehensive comparative examination of various institutional models to guide program design. They call for adaptable governance structures and may also call for local flexibility in defining rights to and duties for land, forests, and water.

### 4.2. Equitable Climate-Smart Landscapes

Frequently, diverse entry points, priorities, and visions of landscape planning and goals exist among stakeholders (e.g., land-use systems, risk aversion, increased productivity) [45]. Considering the interests of all parties involved is essential to setting up a successful negotiation process. In order to do this, management strategies that address resource management, dispute resolution, and minimizing trade-offs had to be developed.

Through multi-stakeholder participation, landscape management is an iterative and changing process that can assist in addressing and resolving disputes as well as facilitating fair negotiation procedures for underrepresented and minority groups [46]. It can assist in negotiating agreements that include all parties. The process must be as transparent, straightforward, realistic, logical, and feasible as is possible given the resources at hand in order to be easily understood and permit stakeholder participation in all phases. In order for all parties involved to fulfill their obligations, the procedure should also provide accountability and transparency.

Water management and the wise use of water resources are crucial components of landscape design strategies for putting into place climate-smart agriculture systems that can also aid in conflict avoidance. Ecosystem management can be crucial in this situation. With the use of trees, various agricultural land management strategies, and water storage, communities can be shielded from floods and other severe weather occurrences. Effective water management is necessary for both developing resilient production systems and reducing the risks brought about by the impacts of climate change on hydrological regimes, as well as the frequency and severity of droughts and flooding.

Effective water resource management calls for procedures that protect ecological functions [47]. These procedures must be supported by widespread agreements on the modalities of usage among water and land users, as well as other interested parties [48]. The best way to implement these agreements will be through participatory governance procedures supported by integrated land-use and resource planning.

River basins are an example of a large hydrological unit that requires nested planning that involves many stakeholders at different scales [49]. The comprehensive management plan for local landscapes, which may be a micro-catchment or community territory [50], is linked to a multi-sector and multi-stakeholder plan for the river basin as part of this strategy [51]. Therefore, an example of a water management intervention designed to produce climate-smart agriculture that has evolved over time to include social landscape governance at the watershed level [52].

### 4.3. Challenges facing Climate-Smart Landscapes

The scaling out of climate smart landscapes face the challenge of poor policies and institutions in adaptation and mitigation objectives [53], and headed by various ministries with involvement from various constituencies [54]. Policies favoring traditional farming methods predominate over those favoring climate-smart farming methods [55]. While integrating variation and justification goals needs long-term development, policy forecasting is short-term in nature [56].

There is also the challenge of financial difficulties like the funds for adaptation and mitigation are usually scarce and uncoordinated because they come from various sources [53]. Activities for mitigation and adaptation are in competition for funding. Agricultural producers, especially smallholder producers, have trouble accessing financing and technical expertise, making it difficult for them to change their methods and diversify their agricultural landscapes [24].

Farmers' ability to effectively implement various agricultural methods and land-use decisions is impacted

by poverty [53], cultural obstacles, a lack of educational opportunities [57], a lack of institutional capacity, and insecure land tenure. National regulations and farm subsidies do not incentivize farmers to use landscape strategies [42], and conduct climate-smart agriculture [58].

## 5. Conclusion and Recommendations

### 5.1. Conclusion

This research has produced significant findings on resource governance that address a wide range of issues at the core of solutions-oriented rural development, including strategies for increased social inclusion and justice, poverty reduction, improved security of land and resource rights, and integrated landscape planning and management as part of climate smart agriculture and these maintain soil and water resources. The creation of the Global Landscapes Forum (GLF) has given civil society, governments, and researchers a crucial forum to collaborate in order to improve the interaction between science and policy, improve the caliber of research, and advance the implementation of landscape governance. However, there is still much to be done, and landscape governance research will continue to be important in rural people's search for governance mechanisms that can improve human well-being for all as a cornerstone to sustainable soil and water management in a climate wise landscape.

### 5.2. Recommendations

From this study, building capability is required to support the development of solutions that take the terrain into consideration. Examples include design principles for green infrastructure that are subject to discussion and change by the social-ecological network in the region where the people are active. Frameworks and practical techniques for assessing landscape services that pinpoint social and business value are also required.

## References


[1] B. Arts, (2003) Non-state actors in global governance: three faces of power, Preprints aus der Max-Planck-Projektgruppe Recht der Gemeinschaftsgüter.

[2] U. Schneckener (2009) Spoilers or Governance Actors? Engaging Armed Non-State Groups in Areas of Limited Statehood. SFB-Governance Working Paper Series, Berlin.

[3] P. Gonçalves, K. Vierikko, B. Elands, D. Haase, A. C. Luz, M. Santos-Reis, Biocultural diversity in an urban context: An indicator-based decision support tool to guide the planning and management of green infrastructure, Environmental and Sustainability Indicators, 11(2021) 100131. https://doi.org/10.1016/j.indic.2021.100131

[4] T.A. Gardner, N.D. Burgess, N. Aguilar-Amuchastegui, J. Barlow, E. Berenguer, T. Clements, F. Danielsen, J. Ferreira, W. Foden, V. Kapos, S.M. Khan, A framework for integrating biodiversity concerns into national REDD+ programmes, Biological Conservation, 154(2012) 61-71. https://doi.org/10.1016/j.biocon.2011.11.018

[5] T. Tscharntke, A.M. Klein, A. Kruess, I. Steffan-Dewenter, C. Thies, Landscape perspectives on agricultural intensification and biodiversity – ecosystem service management. Ecology Letters, 8(2005) 857-874. https://doi.org/10.1111/j.1461-0248.2005.00782.x

[6] M. Lockwood, J. Davidson, A. Curtis, E. Stratford, R. Griffith, Governance principles for natural resource management, Society & Natural Resources, 23(10) (2010) 986-1001. https://doi.org/10.1080/08941920802178214

[7] A. Shah, T. Thompson, (2004) Implementing decentralized local governance: a treacherous road with potholes, detours, and road closures, World Bank Publications. https://doi.org/10.1596/1813-9450-3353

[8] J. Reed, J.R. Borah, C. Chervier, J. Langston, M. Moeliono, A. O'Connor, E.L. Yuliani, T. Sunderland, (2020) A methods toolbox for integrated landscape approaches, Operationalizing integrated landscape approaches in the tropics, p89.

[9] M.A.F. Ros-Tonen, M. Derkyi, T.F.G. Insaidoo, From co-management to landscape governance: Whither Ghana's modified taungya system?, Forests, 5(12) (2014) 2996-3021. https://doi.org/10.3390/f5122996

[10] A. Widayati, B. Louman, E. Mulyoutami, E. Purwanto, K. Kusters, and R. Zagt, Communities' Adaptation and Vulnerability to Climate Change: Implications for Achieving a Climate-Smart Landscape, Land, 10(8) (2021) 816. https://doi.org/10.3390/land10080816

[11] B. Turyasingura, P. Chavula, H. Hirwa, F. S. Mohammed, N. Ayiga, E. Bojago, and H. Ngabirano, (2022) A systematic review of climate change and water resources in Sub-Saharan Africa, 16 November 2022, PREPRINT (Version 1) available at Research Square https://doi.org/10.21203/rs.3.rs-2281917/v1

[12] A. Niţă, A. Buttler, L. Rozylowicz, and I. Pătru-Stupariu, Perception and use of landscape concepts in the procedure of Environmental Impact Assessment: Case study-Switzerland and

Romania, Land use policy, 44(2015) 145-152. https://doi.org/10.1016/j.landusepol.2014.12.006

[13] E. Conrad, M. Christie, I. Fazey, Understanding public perceptions of landscape: A case study from Gozo, Malta. Applied geography, 31(1), (2011) 159-170. https://doi.org/10.1016/j.apgeog.2010.03.009

[14] J. Kooiman, (2003) Societal Governance. In: Katenhusen, I., Lamping, W. (eds) Demokratien in Europa. VS Verlag für Sozialwissenschaften, Wiesbaden. https://doi.org/10.1007/978-3-663-09584-2_11

[15] S. Aminuzzaman, (2016) Political economy of local governance: A study of the grassroots level local government in Bangladesh.

[16] C. Gonçalves P. Pinho, In search of coastal landscape governance: a review of its conceptualisation, operationalisation and research needs, Sustainability science, 17(5) (2022) 1-19. https://doi.org/10.1007/s11625-022-01147-6

[17] J. Marquardt, C. Fast, J. Grimm, Non-and sub-state climate action after Paris: From a facilitative regime to a contested governance landscape, WIREs Climate Change, 13(5) (2022) 791. https://doi.org/10.1002/wcc.791

[18] C.B. Field, V.R. Barros, (Eds.) (2014) Climate change 2014–Impacts, adaptation and vulnerability: Regional aspects, Cambridge University Press. https://doi.org/10.1017/CBO9781107415379

[19] P. Officer, (2016) Food and agriculture organization of the United Nations. FAO, Italy.

[20] V. Venkatramanan, S. Shah, (2019) Climate Smart Agriculture Technologies for Environmental Management: The Intersection of Sustainability, Resilience, Wellbeing and Development. In: Shah, S., Venkatramanan, V., Prasad, R. (eds) Sustainable Green Technologies for Environmental Management, Springer, Singapore. https://doi.org/10.1007/978-981-13-2772-8_2

[21] R.U. Onyeneke, C.O. Igberi, C.O. Uwadoka, J.O. Aligbe, Status of climate-smart agriculture in southeast Nigeria, GeoJournal, 83(2) (2018) 333-346. https://doi.org/10.1007/s10708-017-9773-z

[22] V. Venkatramanan, S. Shah, R. Prasad, (2020) Global climate change: resilient and smart agriculture, Springer Singapore. https://doi.org/10.1007/978-981-32-9856-9

[23] A.-F. Alidu, N. Man, N.N. Ramli, N.B.M. Haris, A. Alhassan, Smallholder farmers access to climate information and climate smart adaptation practices in the northern region of Ghana, Heliyon, 8(5) (2022) 09513. https://doi.org/10.1016/j.heliyon.2022.e09513

[24] B. Turyasingura, M. Mwanjalolo, and N. Ayiga, Diversity at Landscape Level to Increase Resilience. A Review, East African Journal of Environment and Natural Resources, 5(1) (2022) 174-181. https://doi.org/10.37284/eajenr.5.1.723

[25] C.M. Mwungu, C. Mwongera, K.M. Shikuku, M. Acosta, P. Läderach, (2018) Determinants of Adoption of Climate-Smart Agriculture Technologies at Farm Plot Level: An Assessment from Southern Tanzania. In: Leal Filho, W. (eds) Handbook of Climate Change Resilience, Springer, Cham. https://doi.org/10.1007/978-3-319-71025-9_78-1

[26] H. Teklewold, A. Mekonnen, and G. Kohlin, Climate change adaptation: a study of multiple climate-smart practices in the Nile Basin of Ethiopia, Climate and Development, 11(2) (2019) 180-192. https://doi.org/10.1080/17565529.2018.1442801

[27] S.J. Scherr, S. Shames, R. Friedman, Defining integrated landscape management for policy makers, EcoAgriculture policy Focus, 10 (2013) 1-6.

[28] L. Palombi, R. Sessa, (2013) Climate-smart agriculture: sourcebook, Food and Agriculture Organization of the United Nations (FAO).

[29] L. Karlsson, L.O. Naess, A. Nightingale, J. Thompson, 'Triple wins' or 'triple faults'? Analysing the equity implications of policy discourses on climate-smart agriculture (CSA), Journal of Peasant Studies,45(1) (2018) 150-174. https://doi.org/10.1080/03066150.2017.1351433

[30] K. Descheemaeker, P. Reidsma, and K. E. Giller, (2020) Climate-smart crop production: understanding complexity for achieving triple-wins, Climate Change and Agriculture, 275-318. https://doi.org/10.19103/AS.2020.0064.14

[31] H. Shilomboleni, (2022) Political economy challenges for climate smart agriculture in Africa, in Social Innovation and Sustainability Transition, Springer. 261-272. https://doi.org/10.1007/978-3-031-18560-1_18

[32] M. Gardezi, S. Michael, R. Stock, S. Vij, A. Ogunyiola, and A. Ishtiaque, Prioritizing climate-smart agriculture: An organizational and temporal review, WIREs Climate Change, 13(2) (2022) 755. https://doi.org/10.1002/wcc.755

[33] S.J. Scherr, S. Shames, R. Friedman, From climate-smart agriculture to climate-smart landscapes, Agriculture & Food Security, 1(1) (2012) 1-15. https://doi.org/10.1186/2048-7010-1-12

[34] J. Reed, M.A.F. Ros-Tonen, T.C.H. Sunderland, (2020) Operationalizing integrated landscape approaches in the tropics, Center for International Forestry Research. https://doi.org/10.1016/j.landusepol.2020.104822

[35] Y.B. Malla, Changing policies and the persistence of patron-client relations in Nepal: Stakeholders' responses to changes in forest policies, Environmental History, 6(2) (2001) 287-307. https://doi.org/10.2307/3985088

[36] P.F. Kelly, The politics of urbanrural relations: land use conversion in the Philippines, Environment and Urbanization, 10(1) (1998) 35-54. https://doi.org/10.1177/095624789801000116

[37] E.C. O'Donnell, J.E. Lamond, C.R. Thorne, Learning and Action Alliance framework to facilitate stakeholder collaboration and social learning in urban flood risk management, Environmental Science & Policy, 80 (2018) 1-8. https://doi.org/10.1016/j.envsci.2017.10.013

[38] A. Bohman, E. Glaas, M. Karlson, Integrating sustainable stormwater management in urban planning: Ways forward towards institutional change and collaborative action, Water, 12(1) (2020) 203. https://doi.org/10.3390/w12010203

[39] J. Corfee-Morlot, L. Kamal-Chaoui, M. G. Donovan, I. Cochran, A. Robert, P-J. Teasdale, (2009) Cities, climate change and multilevel governance.

[40] D. Armitage, R. DeLoë, R. Plummer, Environmental governance and its implications for conservation practice, Conservation Letters, 5(4) (2012) 245-255. https://doi.org/10.1111/j.1755-263X.2012.00238.x

[41] L. Heeb, E. Jenner, M.J.W. Cock, Climate-smart pest management: building resilience of farms and landscapes to changing pest threats, Journal of Pest Science, 92(3) (2019) 951-969. https://doi.org/10.1007/s10340-019-01083-y

[42] A. Chandra, P. Dargusch, K.E. McNamara, A.M. Caspe, D. Dalabajan, A study of climate-smart farming practices and climate-resiliency field schools in Mindanao, the Philippines, World Development, 98 (2017) 214-230. https://doi.org/10.1016/j.worlddev.2017.04.028

[43] M. Akhtar-Schuster, R.J. Thomas, L.C. Stringer, P. Chasek, M. Seely, Improving the enabling environment to combat land degradation: Institutional, financial, legal and science-policy challenges and solutions, Land Degradation & Development, 22(2) (2011) 299-312. https://doi.org/10.1002/ldr.1058

[44] N. Clay, K.S. Zimmerer, Who is resilient in Africa's green revolution? Sustainable intensification and climate smart agriculture in Rwanda, Land use policy, 97 (2020) 104558. https://doi.org/10.1016/j.landusepol.2020.104558

[45] J. Sayer, T. Sunderland, J. Ghazoul, J.L. Pfund, D. Sheil, E. Meijaard, M. Venter, A.K. Boedhihartono, M. Day, C. Garcia, C. Van Oosten, (2013) Ten principles for a landscape approach to reconciling agriculture, conservation, and other competing land uses, Proceedings of the national academy of sciences, 110(21), 8349-8356. https://doi.org/10.1073/pnas.1210595110

[46] P.A. Kwaku Kyem, 'Of intractable conflicts and participatory GIS applications: The search for consensus amidst competing claims and institutional demands' Annals of the Association of American Geographers, 94(1) (2004) 37-57. https://doi.org/10.1111/j.1467-8306.2004.09401003.x

[47] S.I. Simonovic, Decision support systems for sustainable management of water resources: 1. General principles, Water International, 21(4) (1996) 223-232. https://doi.org/10.1080/02508069608686519

[48] S. Pollard, D. Du Toit, Integrated water resource management in complex systems: How the catchment management strategies seek to achieve sustainability and equity in water resources in South Africa, Water SA, 34(6) (2008) 671-679. https://doi.org/10.4314/wsa.v34i6.183668

[49] A. Cohen, S. Davidson, (2011) The watershed approach: Challenges, antecedents, and the transition from technical tool to governance unit, Water Alternatives, 4(1) 1.

[50] H. Hirwa, Q. Zhang, F. Li, Y. Qiao, S. Measho, F. Muhirwa, N. Xu, C. Tian, H. Cheng, G. Chen, H. Ngwijabagabo, Water accounting and productivity analysis to improve water savings of Nile River Basin, East Africa: from accountability to sustainability, Agronomy, 12(4) (2022) 818. https://doi.org/10.3390/agronomy12040818

[51] Y.-P. Fang, R. Zhu, C.-J. Zhang, G. Rasul, N. Neupane, Cascading adaptation of rural livelihood to changing environment: Conceptual framework and experiment from the Koshi River basin, Advances in Climate Change Research, 11(2) (2020) 141-157. https://doi.org/10.1016/j.accre.2020.05.005

[52] B. Turyasingura, N. Ayiga, Review on the Impacts of Climate Change on the Plant Water Interactions, Journal of Resources Development and Management, 87 (2022) 1-11. https://doi.org/10.7176/JRDM/87-01

[53] C.A. Harvey, M. Chacon, C.I. Donatti, E. Garen, L. Hannah, A. Andrade, L. Bede, D. Brown, A. Calle,

J. Chara, C. Clement. Climate-smart landscapes: opportunities and challenges for integrating adaptation and mitigation in tropical agriculture. Conservation Letters, 7(2) (2014) 77-90. https://doi.org/10.1111/conl.12066

[54] J. Casado-Asensio, R. Steurer, Integrated strategies on sustainable development, climate change mitigation and adaptation in Western Europe: communication rather than coordination, J. Public Policy, 34(3) (2014) 437-473. https://doi.org/10.1017/S0143814X13000287

[55] H.S. Jat, V. Kumar, S.K. Kakraliya, A.M. Abdallah, A. Datta, M. Choudhary, M.K. Gathala, A.J. McDonald, M.L. Jat, P.C. Sharma, Climate-smart agriculture practices influence weed density and diversity in cereal-based agri-food systems of western Indo-Gangetic plains, Scientific Reports, 11(1), (2021) 15901. https://doi.org/10.1038/s41598-021-95445-1

[56] T. Benson, N. Ayiga, Classifying the Involvement of Men and Women in Climate Smart Agricultural Practices in Kayonza Sub-county, Kanungu District, Uganda, International Journal of Energy and Environmental Science, 7(1) (2022) 7-12. https://doi.org/10.11648/j.ijees.20220701.12

[57] S. Cao, C. Xu, L. Chen, X. Wang, Attitudes of farmers in China's northern Shaanxi Province towards the land-use changes required under the Grain for Green Project, and implications for the project's success, Land use policy, 26(4) (2009) 1182-1194. https://doi.org/10.1016/j.landusepol.2009.02.006

[58] B. Turyasingura, P. Chavula, Climate-Smart Agricultural Extension Service Innovation Approaches in Uganda: Review Paper, International Journal of Food Science and Agriculture, 6(1), 35-43. https://doi.org/10.26855/ijfsa.2022.03.006

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