Socio-Ecological Systems (SES) for improved soil carbon management

Introduction

We can adopt many methods to offset greenhouse gas emissions and reduce the risk of further global warming. One of those methods is soil carbon sequestration. This is considered to be a "potentially effective and enduring climate change mitigation strategy" (Yang et al., 2019).

Further, through increased adoption of practices to improve soil carbon management, there are further benefits of improved protection of biodiversity and enhance food security, which also assists in achieving the United Nations (UN) Sustainable Development Goals (SDGs) 2, 13 and 15 (Hamidov et al., 2018).

Factors concerning the adoption of these practices have recognised poor communication regarding the co-benefits associated with appropriate soil carbon management, carbon pricing policies and general uncertainty of carbon farming practices (Rochecouste et al., 2017)

Whilst not underestimating the already large volume of work devoted to empirical research regarding soil carbon research, insufficient has been attributed to the integration of social and ecological variables that could influence it in the form of a social-ecological system (SES) (Hossain et al., 2017; Willcock et al., 2016).

With this as a concern, where the social input of individuals and communities are considered as influencing variables in the development of an SES, the study is required to how a framework could be designed to answer the questions:

1. What are the current trends in soil carbon management research?
2. What are the research gaps and opportunities for further improvement in soil carbon management research?
3. To what extent has the concept of SES been used in reviewed studies?
4. What are the implications for soil carbon management using a conceptual SES framework? (Amin et al., 2019)

Methodology

A search for relevant literature was conducted by Amin et al. (2019) in two stages; Australia and the rest of the world. Using data management software, word searches were also conducted focusing on the extent to which SES frameworks had been used in soil carbon management. Using this software, reviews of the literature allowed for both qualitative and quantitative analysis. The articles so analysed were categorised as ecological, social, or social-ecological.

This allowed for a more thorough examination of the relationship between the two source classifications of "SES components" and "soil carbon management co-benefits"

Results

After 2011, research articles into soil carbon management increased probably as a result of the incorporation of the Carbon Farming Initiative (CFI). Then this declined from 2015 when the CFI was absorbed into the Emissions Reduction Fund; this could reflect changes due to research funding availability.

Present trends in soil carbon management appear to be either focused on land use studies or soil management studies in agriculture; management practices were less influential on soil carbon stock compared to environmental variables (Rabbi et al., 2015; Chappell and Baldock, 2016).

Research on agricultural land use revealed that farmers had strong preferences for certain types of practice and brought into focus the need for consideration of carbon farming co-benefits to ensure greater farmer adoption (Evans, 2018).

The research by Amin et al. (2019) indicates that the bulk of prior research on soil carbon management concentrated on the ecological component of soil carbon change (such as soil texture and water availability), with only a small fraction of the literature devoted to social variables such as farmer's attitudes, farm characteristics.

This leads to a tilted perspective on the co-benefits of soil carbon management, better possibly understood by scientists but with less understanding, hence motivation, by the community of farmers expected to provide more optimal end results.

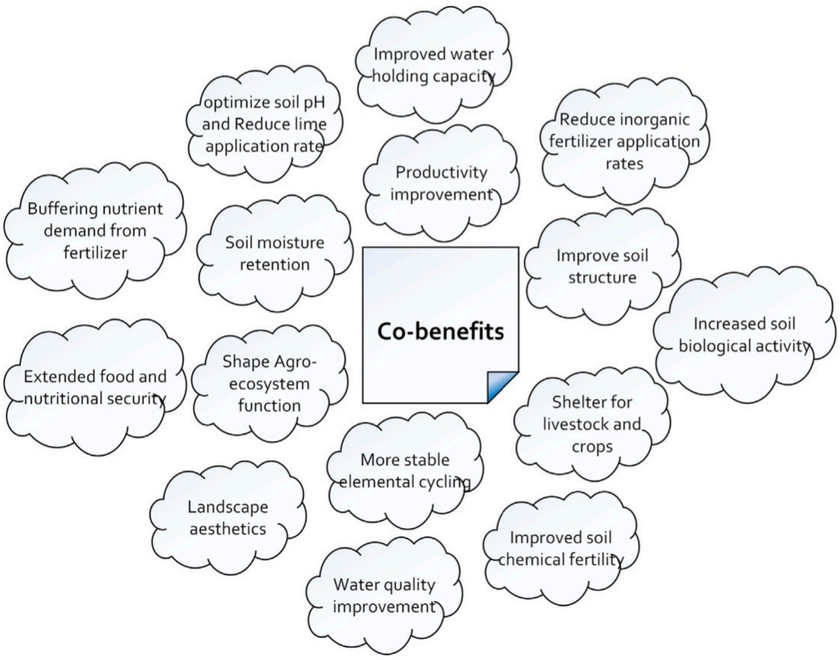

Fig. 3. Identified Co-benefits of the soil carbon management in Australia from Stage 1 of the systematic review (n = 97).

The figure is taken from Amin et al., 2019, "A systematic review of soil carbon management in Australia and the need for a social-ecological systems framework", Science of the Total Environment, vol. 719, p. 135182.

Knowledge gaps in soil carbon management indicate limited insight into economic benefits and poor understanding of costs by farmers concerning carbon storage ((Rochecouste et al., 2015, Longmire et al., 2015).

This situation exists because "The funding initiatives for soil carbon storage in Australian agriculture have not considered variation in individual's attitudes to climate change or other demographic characteristics" (Grundy et al., 2016; Evans, 2018)

Opportunities for soil carbon management research

As stated by Amin et al., 2019:

> The narrative around carbon sequestration is that farmers are motivated by production benefits and that taking action on soil carbon can improve system profitability. Consequently, the crucial gap in soil carbon management research is identifying social and ecological variables and their interactions.

With this in consideration, more studies should be undergone to improve better understanding by non-scientists (in this case, possibly farmers) who can see the practical benefits of soil carbon sequestration and be more motivated to contribute to its increased success.

This then offers potential for further reach on how a conceptual SES framework could be designed to actively better understanding and improve the culture of the agricultural community in gaining greater acceptance of soil carbon sequestration processes and their co-benefits and development of appropriate policies for incentivising progress.

SES components and variables

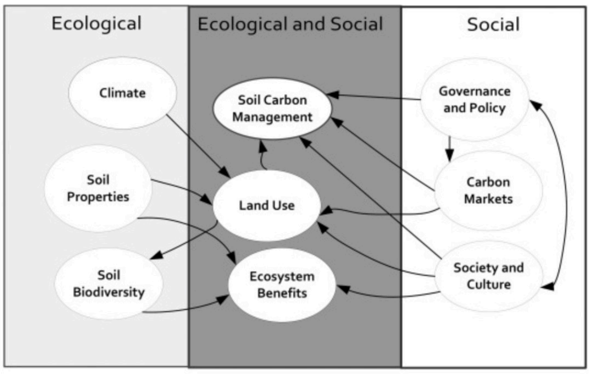

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Fig. 5. Social-ecological System key components (Ecological, Social, Ecological and Social), with corresponding key variables (e.g. Climate, Land Use and Society and Culture) and proposed interaction of key variables for soil carbon management in Australian agriculture (n = 97). Direction of arrows indicates a potential interaction between key variables and could be a positive or negative relationship.

The figure is taken from Amin et al., 2019, "A systematic review of soil carbon management in Australia and the need for a social-ecological systems framework", Science of the Total Environment, vol. 719, p. 135182

An appropriate system should have social, ecological and social and ecological components. This framework should indicate the interactions between key variables and these components and create policies that clarify the benefits of involvement to all parties, as can be seen portrayed in the above figure.

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Conclusion

Future research is required to ensure a better understanding of soil carbon management by including the social components that should be integrated into an appropriate SES. These social components include the attitudes of the agricultural community toward climate change, involving farmers to assist in soil carbon management research and assisting with the adaptation to new technologies and possible changes to agricultural practice and methodologies.

The inclusion of all stakeholders is imperative to provide unity in the direction of future improvement.

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