RESEARCH ARTICLE

Integrating climate mitigation and environmental peacebuilding objectives through sustainable land use systems: Theory of change and indicators

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Abstract

Land is an essential natural resource for climate mitigation and peace. It is commonly connected with sources of GHG emissions and with drivers of (violent) conflict. Therefore, climate mitigation and peacebuilding strategies are co-designing sustainable land-use systems (SLUS) with affected communities to integrate land-based climate mitigation and peacebuilding objectives. SLUS is practiced within agricultural production systems that meet sustainability principles (environmental, social, and economic). Nevertheless, there needs to be more program evaluation frameworks, especially measurable indicators, that integrate these two objectives (achieving peace and climate mitigation). This study aims to develop a methodology and criteria to evaluate the precise mechanisms of SLUS influencing greenhouse gas (GHG) emissions and drivers of conflict. A mix-method approach was used in two case study regions, Cesar and Caquetá, Colombia, where SLUS strategies where implemented. First, we conducted three workshops, two in-person and one virtual (n = 103). Secondly, we held semi-structured interviews (n = 115) to make an analysis of the conflict. Our research focused on the drivers of land-based emissions and conflict drivers targeted by the SLUS implementation. Lastly, through a household survey (n = 929), we illustrated the impacts of SLUS in peacebuilding at the farm level. Results show that SLUS, such as cocoa agroforestry, can contribute to climate change mitigation and deliver co-benefits in four core factors: (i) socio-economic inclusion by creating jobs and diversifying livelihoods, (ii) dialogue and conflict transformation by allowing negotiations around the participatory design of farms, including conservation agreements, (iii) natural resource governance, and (iv) cooperation by creating knowledge exchange and a community of practice.

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1. Introduction

Land plays a critical role in GHG emissions in the tropics. Article 5 of the Paris agreement stresses the importance to mitigate climate change through land use activities. Drivers of conflict [1] and post-war contexts [2] are also influenced by land use activities. After a peace agreement, the most readily available assets to kick-start post-conflict stabilization and recovery are often natural resources such as land [3]. Therefore, many peacebuilding strategies are targeting the land-use sector and delivering Sustainable Land-Use Systems (SLUS) as a means to provide livelihoods to affected communities [4,5]. SLUS embody various agricultural practices, technologies, and resource management strategies tailored to specific farm and landscape contexts. These systems promote the production food in a sustainable manner. They can store carbon and mitigate risks from natural hazards; offer cultural values; support critical ecological functions such as nutrient and water cycling, filtering, and buffering; and are central to farmers' economic vitality and survival [6]. Therefore, several efforts to reduce GHG emissions in the tropics target the land-use sector and aim at delivering SLUS as a means to provide alternative livelihoods [7].

The international community and the global governance systems represented by different United Nations agencies have put forward different strategies to separately mitigate the effects of climate change Sustainable Development Goals (SDG13) and build peace and stability in fragile countries (SDG 16) [8,9]. However, climate change and conflict are deeply interconnected in their causes and solutions [10]. For instance, actions to build peace can create the enabling environment for cooperation around climate mitigation and adaptation [7,11]. Meanwhile, climate change adverse effects and climate adaptation and mitigation strategies could be indirect drivers of conflict by increasing food insecurity or restricting land uses, which may also have a multiplier effect augmenting the likelihood of social unrest and violence, especially in agricultural-dependent communities and fragile contexts [12–15].

Efforts to reduce land-based emissions include safeguards oriented to prevent unexpected social, environmental, and development outcomes. Global initiatives have been developed with the aspiration of achieving land-based emissions reductions (Paris Agreement of 2015) and restoring landscapes (Bonn Challenge of 2011). These initiatives include financial mechanisms to reduce land-based emissions, such as Reducing Emissions from Deforestation and forest Degradation (REDD+), fostering conservation, sustainable management of forests, and enhancement of forest carbon stocks in tropical countries.

However, as countries with the potential for reducing land-based emissions are emerging from or experiencing conflict, such initiatives need to coordinate peacebuilding and mitigation strategies to be successful. An example of theses overlapping challenges is Colombia that have suffered from prolonged conflict and is increasingly becoming a source of land-based GHG emissions [16]. The Colombian government is aware of potential synergies between policies for peacebuilding and policies for climate change mitigation in the land sector [17]. Particularly, because agricultural (including illicit crop cultivation) and cattle ranching activities practiced in conflict-affected areas are important drivers of GHG emissions associated with deforestation and landscape degradation [18]. Although other land-use changes can be a source of GHG emissions, deforestation (i.e. changes from native forests to other land uses) is the single most important source of GHG in Colombia, with 19.2% of total emissions in 2018. The impact of other land-use changes represented less than 1% in the same period [19]. To achieve the reduction of GHG emissions however, will require understanding existing barriers typically present in conflict and post-conflict areas, and peacebuilding measures, such as those related to weak state presence, land-use competitions between legal and non-legal activities and limited access to markets [20,21].

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An approach that integrates climate and peace objectives are SLUS. They constitute an entry point to integrate efforts to reduce land-based emissions with those for achieving peace-building objectives in areas affected by land-related conflicts, which are the most common type of conflicts in tropical regions [7]. For instance, SLUS can incorporate REDD+ social and environmental safeguards, such as acknowledging the priorities and ownership of local communities, national and local policies for climate mitigation, and a conflict-sensitive approach that enables co-design with local communities [22]. It goes in line with the promotion of natural resource management. Natural resource management refers to managing natural resources such as land, water, soil, plants, and animals [23]. Authors claim that the goal of natural resource management should not be to handle or control only ecosystems but rather, to enhance humans' interactions with the surrounding environment in a sustainable manner [24,25].

Despite the linkages between land use, carbon emissions and peace there is a lack of program evaluation frameworks that integrate these sectors [26,27]. Attempts have been made within the field of environmental peacebuilding, which integrates similar objectives in the fields of environment, conflict and peace. It is defined as *the multiple approaches and pathways by which the management of environmental issues is integrated in and can support conflict prevention, mitigation, resolution and recovery* [15]. This field has expanded in the literature, and current debates recognize that monitoring and evaluation (M&E) in environmental peace-building is a topic that will help understand when interventions achieve their climate and peace objectives, when they do not, and why. For example, attribution in environmental peace-building has been a challenge in matching interventions with outcomes. Some authors emphasize the importance of understanding land-related tensions before external actors implement any effort to improve land sustainability and access to avoid unintended consequences [2]. Other authors argue that potential impacts on peacebuilding should also be assessed in the frame of climate mitigation initiatives as co-benefits beyond merely preventing environmental and social risks [4,28–30]. Therefore, the added value of having programming and evaluation frameworks that integrate climate mitigation and adaptation goals and peacebuilding is that such frameworks can take into account not only the unintended consequences of climate mitigation projects, but they will proactively and consciously take into account peacebuilding activities [4]. Furthermore, how a specific intervention contributes to one another, enhancing their impacts. In the same line, climate change consequences and peacebuilding interventions interact with a broad range of socio-economic, gender and political factors, which integrated environmental peacebuilding interventions can address [31]. Finally, developing more sophisticated, consistent and widespread M&E tools in environmental peacebuilding will provide accountability and learning for beneficiaries, implementers and funders [15].

The underlying dynamics of SLUS and how they can contribute to mitigation and peace-building are not well understood. The document aims to develop indicators to monitor whether environmental peacebuilding has been successful. Our main research question is: How is the implementation of SLUS contributing to climate change mitigation and peace-building in Caquetá and Cesar, Colombia?"

The subsequent section presents the methodological design. Consequently, the results section consists of both a context and a conflict analysis conducted with SLUS members and stakeholders to determine existing drivers of conflict that can be affected by the interventions. Further, mechanisms for understanding SLUS's contributions to peacebuilding are presented. Thereafter, we present a set of indicators for measuring the contributions of SLUS to climate mitigation and peacebuilding. The following section discusses the results in light of the existing literature on environmental peacebuilding. The final section concludes and recommends possible uses of the research.

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2. Materials and methods

2.1. Case study description

This study demonstrates the clear overlapping challenges of climate and conflict risks in Colombia [16]. Colombia was selected because of its high deforestation rates and its emergence from a long history of conflict. The Colombian armed conflict has lasted for over 60 years, having, as a consequence, over 9 million victims [32]. Colombia has the highest rate of internally displaced people in the continent and massive damages to its natural environment including unsustainable resource use and exploitation, illicit crops, soil erosion, deforestation, destruction and contamination of water sources. These factors also impact other activities perpetuating a vicious loop such as forced displacement, land appropriation and indiscriminate logging [33,34]. In 2016, the Colombian Government (GoC) and the Revolutionary Armed Forces of Colombia (FARC) signed a peace agreement, including essential goals relating to sustainable rural development of conflict-affected areas. Additionally, the GoC has expressed its commitment to the Paris agreement, the Aichi Targets and the 20x20 land restoration initiative. Achieving these national priorities implies developing sustainable land-use systems as integral to moving beyond the conflict that has plagued the country for the past 50 years [35]. However, during the post-peace agreement period (2017–2018), the area of forest disturbance increased by 50% (about 238 000 ha) across the Andes-Amazon Transition Belt in comparison with the four-year peace negotiation stage (2013–2016). Using remote sensing data sets, researchers have identified and mapped forest disturbance. Among the reasons are the withdrawal of FARC's informal governance structures of control over forested areas, and the consequent entrance of actors such as drug cartels, large landowners and dissidents who cleared forests with expectations of favorable land tenure policies. It increased large-scale cattle ranching, coca cultivation dispersal, and speculative illegal land markets. Many lands are overutilized, indicating worsening soil degradation [18,36–38]. Since then, according to the Institute of Hydrology, Meteorology and Environmental Studies (Instituto de Hidrología, Meteorología y Estudios Ambientales—IDEAM), deforestation rates have stabilized, dipping to 197,159 hectares cleared in 2018, and under 158,894 hectares lost the following year[39]. Furthermore, the violence against environmental and social leaders have been staggering. According to the international NGO Global Witness, 2021 marks the second year in a row Colombia registered the most killings nationwide (65 only during 2020), despite government promises to increase security in rural areas and offer activists protection [40].

The areas chosen for this study are the departments of Cesar and Caquetá. We selected these regions because they present geographical overlaps between priority areas for forest conservation, climate change mitigation and peacebuilding. Caquetá shows high deforestation rates and political violence due to the prolonged presence of the FARC guerrilla as one of the foremost perpetrators leaving a high volume of victims of violence. Cesar presents high rates of soil degradation and violence from paramilitary groups and the presence of rebel groups, with high numbers of victims of violence as well. Farmers in these two regions of the country have a strong sense of identity. They have been significantly affected by the armed conflict through illegal drug trafficking and natural resource exploitation [41]. Both regions are rich biodiversity hotspots with a high sensibility to climate change and a low resilience capacity to cope with risk, especially with regards to the management of land and water [42,43]. Furthermore, these regions have a strong presence from armed groups; therefore, many citizens have been displaced, and earned their livelihoods by cultivating illegal crops or working in the informal mining sectors. As a result, this rapidly changed the social dynamics creating social unrest, an impoverished economic situation, environmental degradation, deforestation, and loss of biodiversity. Over the years, the widened disparities and inequalities have put a heavy strain

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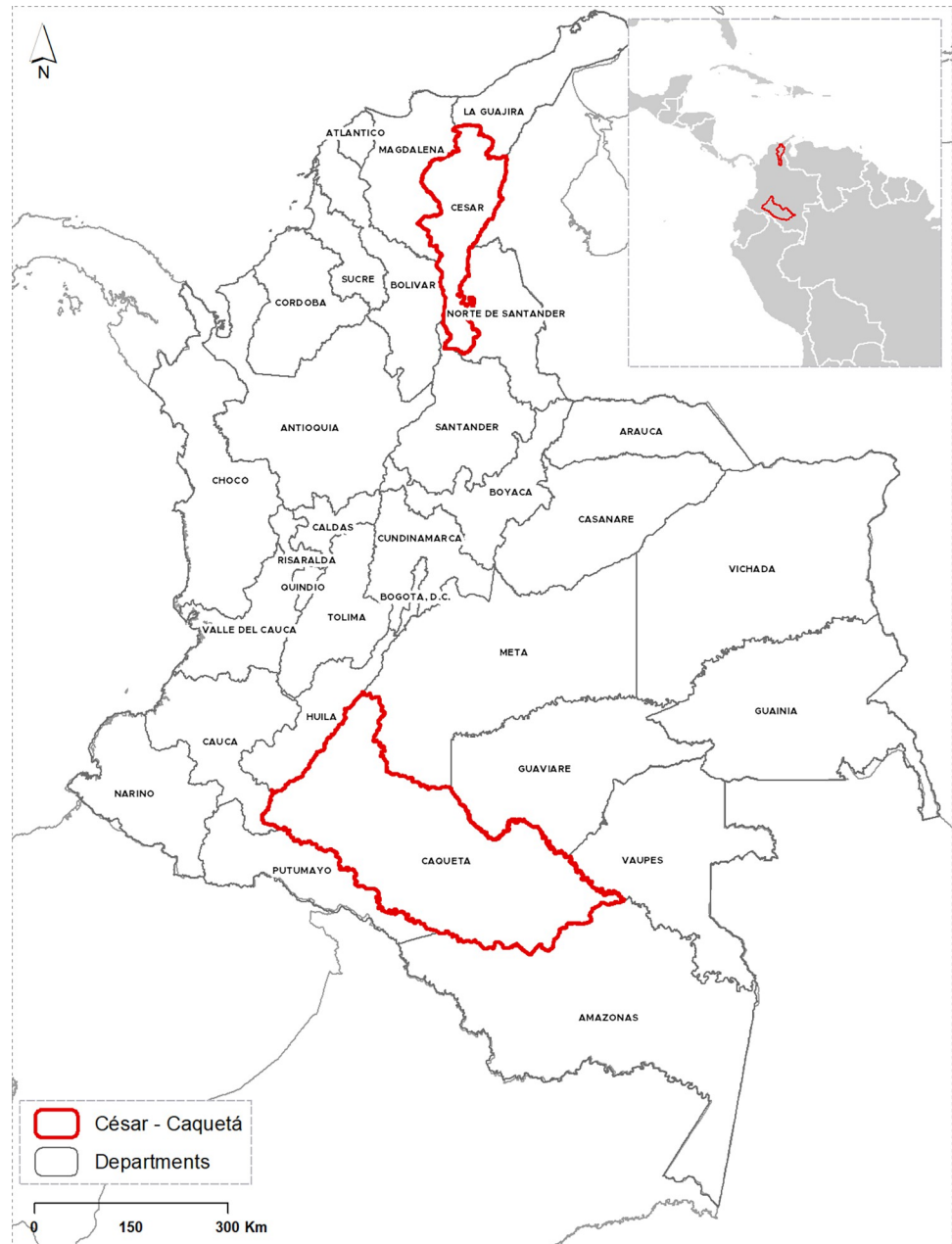
Fig 1. Geographical location of Caquetá and Cesar in Colombia. Base layer source: Sistemas de Información Geográfico para el Ordenamiento Territorial—IGAC. https://sigot.igac.gov.co. Global Administrative Data v3. https://gadm.org. Red regions represent the departments of interest, Caquetá and Cesar.

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on individuals, families, communities and institutions [44,45]. Both regions are highly dependent on agricultural activities for their economic development, thus sustainable land uses are essential to cope with environmental and social vulnerabilities [21] (Fig 1).

2.1.1. Caquetá. Caquetá is located in the south of Colombia along three climatic regions: Piedemonte Amazónico, Central Amazonía and Southwest Amazonia, spanning over two significant ecosystems, the Andes and the Amazon, which provides extraordinary biodiversity with the territory [43,46]. Caquetá represents an ideal case study for integrating climate

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mitigation and peacebuilding because it represents climate and conflict vulnerability intersections [4]. On the one hand, the armed conflict has affected its civil population, around 122,000 people are registered in the region as victims of forced displacement [47]. The FARC controlled de facto many of the social, economic and political aspects of vulnerable rural regions, including income and land use [48]. After the peace agreement, strategic areas were liberated from guerrilla control and different actors began entering the region to invest in mining and agribusiness [49]. Furthermore, FARC dissidents and other criminal gangs are now present in Caquetá, aiming to control coca, gold and timber production [50].

From another perspective, Caquetá is a unique biodiversity hotspot corridor with vast flora and fauna native to the region [48]. Four national parks are located in Caquetá, safeguarding about 25,000 square kilometres of rich biodiversity and abundant sources of water feeding the Amazon basin, including large parts of the iconic Serranía de Chiribiquete [51]. However, Caquetá's population growth was historically fueled by dispossessed farmers escaping from the bi-partisan political violence (liberal vs conservatives) of the 1950s and the armed conflict between the FARC rebels and the government in the 1970s [52]. Many were even motivated by governmental policies that promised to give titles to people who moved with plans to 'clean land' in the Amazonian wild forest. They could then establish farms (fincas), hoping to gain officially recognized title to the land [53]. Moreover, Caquetá concentrates around 47% of forest loss in the Colombian Amazon, where agriculture and cattle ranching increased by almost 40% from 1999 to 2017 [54]. The establishment and eradication of illicit crops, deforestation for building infrastructure for the oil industry, extractive mining, and cattle ranching are among the drivers of deforestation causes in Caquetá [55]. Nevertheless, cattle ranching is an important source of income for the department's rural populations [21].

2.1.2. Cesar. Cesar is located in the northeast of Colombia, has an area of 22,000 km^2 divided into five ecoregions; the Serranía del Perijá mountain range, the Cesar River valley, the Sierra Nevada de Santa Marta mountain range, the Magdalena river valley and the Cienaga de Zapatosa marshes complex [42]. Along with its multitude of rivers and fertile soils, the mountain systems from the Serranía del Perijá and the Sierra Nevada de Santa Marta make the land suitable for a great variety of agricultural activities. Among these are extensive cattle ranching, palm oil plantations, and the production of maize, coffee, and rice [56]. In the 2010s coal mining had a boom and became the main economic activity in Cesar [57]. According to the Colombian Geographic Institute (Instituto Geográfico Agustín Codazzi IGAC), over 63% of the soil is inadequate to use. As a consequence, 81% of the soil present some degree of erosion [58]. The armed conflict has heavily impacted Cesar. Due to its natural resource richness, many armed groups have directed their activities in this territory. The National Liberation Army (Ejército de Liberación Nacional—ELN Spanish) and the FARC have attacked mining infrastructure; far-right paramilitary and drug trafficking groups concentrated their territorial control between 1996 and 2006, affecting the land distribution and displacing vulnerable rural populations [59]. In Cesar, the influx of the armed conflict, specifically paramilitary violence, is considered "pro-business" [60]. Meaning that land accumulation, monopolies, and unsustainable land uses such as massive coal mining and large cultivations were supported by paramilitary forces [61]. For example, the mining company Drummond has been officially acused by the national prosecutor office to have financially supported the leaders of the United Self-Defense Forces of Colombia (*Autodefensas Unidas de Colombia*, or AUC, in Spanish), who were located in the coal mining areas in the north of the department of Cesar [62]. Furthermore, agricultural practices and unsustainable land uses have been associated with episodes of violence. For example, according to research conducted by the governmental institution national center for historical memory, between 1971 and 2018, 112 members of different trade union organizations in the palm oil industry in Cesar were murdered in association with the

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presence of paramilitary groups in the region [63]. In the post-agreement, palm oil production has also been associated as an essential driver of both social conflicts and ecosystems degradation [37]. Currently, after two peace agreements, one in 2005 with the paramilitary group AUC and a second one with the FARC rebels in 2016, the Cesar department still suffers from violence carried out by armed groups and narcotraffickers who stand behind land owners and political elites who opposed land restitution reclamations carried out by victims of the armed conflict, human right activist and environmental defenders [64,65].

2.2. The sustainable land uses systems approach

We use the case of SLUS implementations in the departments of Caquetá and Cesar as the two regional nodes for piloting the SLUS approach in Colombia [66]. The SLUS approach is adequate to analyze the interconnections of climate mitigation and peacebuilding. The SLUS approach incorporates practices at different scales, not only conducting changes at the farm level but intervening at the landscape level and on value chain governance. Broader changes are implemented with financial and non-financial incentives and market approaches, such as climate finance and zero-deforestation incentives [67]. Such implementations' outputs are expected to reduce land-based GHG emissions, conserve forests, restore degraded landscapes and improve rural livelihoods.

The SLUS implementation that we analyze in this research is cacao agroforestry systems (CAFS). CAFS are complex multi-species cropping systems where cacao trees are associated with other permanent or temporary crops and woody tree species. Furthermore, the CAFS seek to integrate people, their culture and interactions with one another in farming and forest [68]. In Colombia, cacao crops are particularly relevant because they have existed for many years and recently, they have been promoted as an alternative for coca production [69]. They are established and managed under a canopy of trees by smallholder farmers with differing production practices dependent upon climate, soils, and household conditions. CAFS tend to include banana plants, fruit trees, and shade trees, mainly with timber specie [70].

In Colombia, cocoa is not a primary driver of deforestation. Instead, different stakeholders have promoted cocoa as a sustainable livelihood alternative to coca production and, more recently, as a crop that can help reduce the pressure on forests that emerged after the peace agreement from other land uses, such as extensive cattle ranching [71]. Recently, the national government and the Tropical Forest Alliance have signed voluntary agreements with five economic sectors, including cocoa, intending to get different actors involved in the chains to commit to eliminating their deforestation footprint along the supply chain. The signing of the zero-deforestation agreement for cocoa, "Cocoa, Forests and Peace", took place in 2018 and builds on the experience of the World Cocoa Foundation, which has developed model agreements in Ghana and Côte d'Ivoire. The agreement, supported by international development agencies, has contributed to increasing the planted areas and improving the quality of the bean, allowing it to be positioned globally. As a result, Colombian cocoa has now been recognized as "fine flavour cocoa" by the International Cocoa Organisation (ICCO) [72]. However, in a post-peace agreement context, cocoa systems must overcome existing barriers, such as weak state presence, land-use competitions between legal and non-legal activities and limited access to markets [71].

The SLUS project agreed with the Colombian Cocoa Federation (FEDECACAO Spanish acronym) to sustain the work piloting organic agroforestry cacao. The agreement allowed a baseline survey (n = 929) to understand and document the current farmers' socioeconomic and environmental conditions and characterize their CAFS farming practices to analyze the enabling conditions and determinants of adoption of SLUS and improve management

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practices in Caquetá and Cesar [73]. Afterwards, a new agreement was reached with farmers' associations to pilot a batch of certified organic cocoa from producer organizations in the municipalities of La Paz, Cesar (n = 25) and Belén de Los Andaquíes in Caquetá (n = 25). Cocoa value chain committees were formalized with stakeholders of the dialogue platform, and local beneficiaries took part in the training on integrated cocoa management. The committees enabled the farmers to define their priorities and co-design this pilot project.

SLUS works at various scales. First, at the farm scale, SLUS requires a prioritization exercise with the farmers to choose the best CAFS practices that work for forest conservation, enhance sustainable livelihood alternatives and diminish the risk of conflict. Second, the SLUS project embraces work at the value chain scale. This is under the recognition of local governance systems and the importance of dialogue among different stakeholders along the whole value chain as a critical factor in aligning with national and global priorities [74].

2.3. Methodological framework

We applied a mixed-methods approach based on three research phases: (i) Conflict analysis: World Café with key stakeholders in Caquetá (n = 54) and Cesar (n = 30), semi-structured interviews (n = 115) and a Do No Harm workshop (virtual) (n = 19). (ii) Development and validation of theory of change and indicators: virtual workshop (n = 19). (iii) Pilot testing of indicators: household survey for illustrating peace-related indicators implementation (n = 929: Caquetá n = 429 and Cesar n = 500) (Fig 2).

2.3.1. Phase 1. Context analysis and conflict sensitivity. We used two methods to identify the current conflict and deforestation drivers according to communities' perceptions and to understand how a SLUS implementation can contribute to addressing those drivers.

2.3.1.1. World Café. The "World Café" approach is a conversational process that promotes building trust, constructive dialogue, and collaborative learning. Whilst initially, the World Café method is a tool widely used as a participatory method for citizen participation and organizational change processes, it also gains in importance as a methodological approach to collecting qualitative data [75,76].
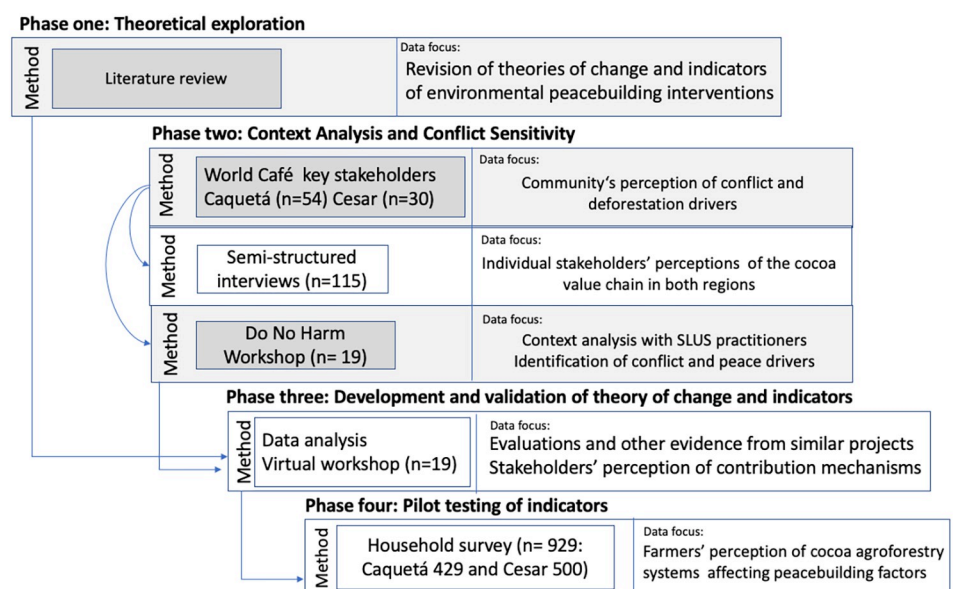

Fig 2. Methodological approach.

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We conducted two workshops using the 'World Café' methodology in Florencia, Caquetá (n = 54), and Valledupar, Cesar (n = 30) at the end of 2019. Each workshop lasted around five hours, with breaks and refreshments provided. Both of the workshops were conducted in Spanish. The World Café has three stages. The first introduces the participants, the methodology and a glossary of terms (including environmental peacebuilding, socio-environmental conflict, community governance and SLUS). In the second stage, participants are asked to position themselves at one of the three tables/subjects (environmental peacebuilding, community governance and SLUS), each table consists of about ten people. Materials such as cards and note paper are provided, consisting of two rotations, each rotation lasting 45 minutes. Participants decided freely on which group to start and were told they were free to switch groups.

The first rotation involves listing the past and present socio-environmental conflicts, their drivers and possible ways to solve them. Socio-environmental conflicts are those focused on the incompatibility of the use of natural resources and the impacts on the environment by different social groups [77]. The second rotation explores the future scenarios and the prioritization of the central conflict drivers of deforestation and local socio-environmental conflict that a SLUS could impact. For prioritization, the participants had three votes per person that they could allocate to any of the drivers listed. The third stage was a plenary to present and discuss the results of the exercise.

We used this method because the World Café facilitates intimate exchange, disciplined inquiry, cross-pollination of ideas, and possibility thinking. Its conversational process helps groups engage in constructive dialogue around critical questions, build personal relationships, and foster mutual learning [75]. By changing tables after a defined period, participants always meet other participants, learn from their previous conservation round and can bring thoughts from their preceding discussions. Thereby, the participants exchange much information and agreements for prioritization can grow [76]. Further, it provides an excellent opportunity to initiate conversation in large and diverse groups, in our case, bringing together local stakeholders, including representatives of governmental organizations, farmers' associations, indigenous communities, and local experts in environmental conservation and peacebuilding.

2.3.1.2. Conflict sensitivity: Do no harm. Conflict sensitivity is an approach that attempts to minimize unintended negative impacts in conflict-affected environments. A conflict-sensitive analysis is an essential building block to understanding the complex layers of conflict. Using the do no harm approach is relevant in this case because it allows for finding possible sources of conflict and successful peacebuilding outcomes within climate mitigation interventions [78].

This methodology is based on conflict context analysis, building on seven steps that start with an understanding of the sources of tension (dividers) and the local capacities for peace (connectors) and concludes with a testing process of the impact of the initiatives [79]. These guidelines should help organizations better understand: i) the conflict dynamics in the region, ii) how their interventions interact with those dynamics, and iii) what are the necessary steps needed in order to ensure their work reduces adverse outcomes and increases positive ones [78]. In this research, we implemented an adaptation of this approach. We developed a new category of "peace opportunities", which is the result of designing adaptations or solutions to activities that may impact increasing the dividers or sources of tension.

A do no-harm analysis was conducted in a virtual workshop held on 25 July 2020, with 19 local experts from the SLUS project to identify a contextualized theory of change for assessing peacebuilding impacts. The workshop started with a presentation about peacebuilding definitions, the cycle of conflict and the Do No Harm approach. Consequently, we presented the conflict drivers extracted from the World Café, and the local experts prioritized conflict drivers by voting. We asked the participants to prioritize drivers according to their evaluation of

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existing local conflict dynamics possibly affected by SLUS. Each participant had three votes that could be given to any driver.

2.3.2. Theory of change and indicators development. A theory of change describes how and why an initiative would work based on the best available information [80]. The theory of change presented in this study is based on:

i. The main objectives and assumptions of how SLUS interventions contribute to peace.

ii. The results of a contextualized conflict analysis: Conflict and deforestation drivers and how each activity contributes to diminishing those drivers (do no harm analysis).

To develop the theory of change and indicators, we recovered previous research conducted in the same project that identifies factors and mechanisms to assess environmental peacebuilding [4]. Furthermore, seven key factors and corresponding indicators were identified from this basis, along with stakeholders' workshops (see Tables 4 and 5).

In the virtual workshop, the participants were asked to identify the central dividers or sources of conflict that can result while implementing CAFS. Then, they identified the possible connectors or factors that bring social cohesion and motivate trust and cooperation during the implementation process. Finally, they identified peace opportunities or strategic action to pro-actively address conflicts and build dialogue for a successful implementation of the CAFS. The local experts discovered the central assumptions about how SLUS activities affect specific peace-building dimensions by identifying the connectors and how to counter the dividers. Finally, the participating local experts identified indicators to measure the peacebuilding contributions of SLUS over time and assess them according to validity, region-sensitivity, and usability [81].

Semi-structured individual interviews were conducted with different stakeholders of the cocoa value chains (CVC) of Cesar and Caquetá to gain more profound knowledge about the possible outcomes of SLUS interventions at the value chain level. The CVC was chosen because the National Government and international development agencies have prioritized cocoa cultivation as an alternative for substituting illicit crops and integral rural development [71,82].

The total sample was 115 actors who provided information on 92 organizations. The interviews took place between 18 November 2020 and 22 February 2021. The sampling design for the semi-structured interviews in each department followed non-probability sampling methods. Firstly, a quota design was used, which sought to select a representative population sample by establishing a proportion to be reached for all the segments that make up the population. In this case, the segments correspond to the relevant stakeholders of the cocoa value chain. The proportion to be reached for each segment was determined either by saturation of the information or by interviewing at least half of the actors or institutions identified [83]. In total, 82 semi-structured interviewees answered questions regarding conflict and peacebuilding in Cesar (n = 58) and Caquetá (n = 24). The average duration was 40 minutes.

2.3.3. Pilot testing of indicators. To test key indicators, we conducted **a quantitative household survey.** We surveyed nine hundred and twenty-nine (929) households, Caquetá (n = 429) Cesar (n = 500) of smallholder cocoa farmers in both study regions. We cover 13 of 16 municipalities in the Caquetá department and 18 of 26 municipalities of the César department. We used a random sampling strategy in the entire array of associated producers that implemented some form of cocoa agroforestry. In this study we present the farmers' perceptions captured by the survey about the contribution of agroforestry systems to peacebuilding in three factors, dialogue spaces, trust and cooperation. The interview was face-to-face in Spanish, based on a closed-ended survey questionnaire. We collected data from March 2021 to Jun 2021. The duration of each interview was approximately 40 minutes. Participation was voluntary, and farmers responded freely and under prior informed consent.

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2.4. Limitations

The study has two types of limitations. The first is the social desirability bias, which is a bias in the responses of workshop participants, who, due to possible social pressure, may prioritize the drivers of conflict or deforestation that are most socially accepted [84]. It can happen even among practitioners. We also recognize that there may be biased limitations in the interpretation of participants' responses. We controlled for this through iteration rounds in the workshops (World Cafe) and by validating the answers with the semi-structured interviews that we conducted individually. Due to the Covid-19 pandemic, we conducted virtual workshops, which can hinder the levels of interaction in a discussion. For example, non-verbal communication is limited. However, virtual scenarios have also been found to hinder unconscious bias from stereotypes such as race and gender [85].

Another limitation is in the pilot to test the peacebuilding indicators. We should clarify that the household survey results illustrate farmers' perceptions of the impact of implementing a cocoa agroforestry system on peacebuilding factors. However, we are not comparing the conditions and variables of implementing agroforestry systems or the change compared to other agricultural practices. We suggest that further research be made to measure this perception once improvements to these agroforestry systems are implemented to see a change in baseline data. Regarding the theory of change and indicators development, even though the peacebuilding factors and the assumptions of how a slus can contribute to peace are grounded in the literature, there is a lack of more consistent and robust data about the mechanisms of natural resource management to contribute to peace. In this way, our theory of change complements the existing knowledge to a certain degree, ratified by local actors implementing the project; however, local implementers may have a desirability bias for showing early victories, thus leaving out other factors that are also important for enhancing peacebuilding drivers.

4. Results

4.1. Context analysis and drivers of conflict and deforestation

In order to answer the question of how and how much SLUS contribute to peacebuilding, it was essential to determine the different drivers of conflict and deforestation in their specific local contexts, at the farm and value chain levels. Following are the results of the in-person consultations with stakeholders at the world cafe:

4.1.1. Stakeholders' prioritization of drivers of conflict and deforestation. In the case of Cesar, the stakeholders reported different drivers of conflict and deforestation. From industrial pollution to desertification due to lack of environmental education. However, most participants identified three key drivers: environmental malpractices such as forest logging and burning, corruption in environmental authorities and conflicts around water resource management (Fig 3). Various environmental malpractices are related to the processes of agricultural expansion. The local experts reported during the workshop that a mentality of unsustainable land uses and exploitation of natural resources dominated development pathways. Such mentality is a combination of economic elites wanting to exploit the land for commercial purposes and a lack of knowledge of local communities to implement sustainable agricultural production practices. For example, local elites established an increase in extensive cattle ranching, carbon extraction and rice monoculture as the primary economic development activities in the region. An important driver of conflict, which also emerged as a consequence of environmental degradation, is the conflict around water management. Stakeholders informed that water management becomes a vital issue because of the ecosystem's characteristics (tropical dry-forest), exacerbated due to climate change's adverse consequences,
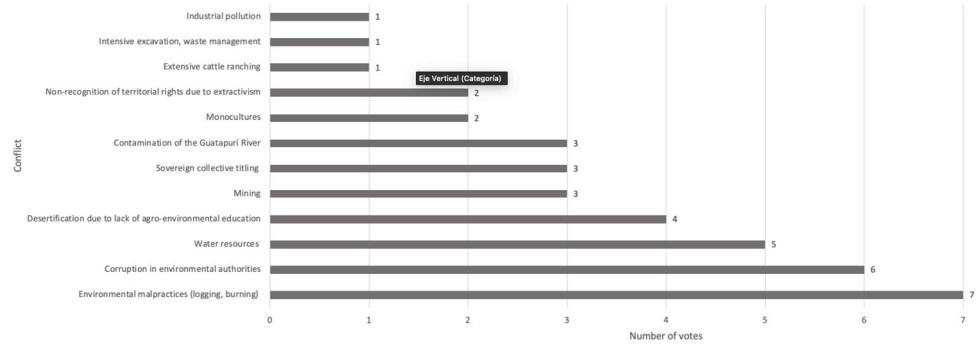
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Fig 3. Prioritization of socio-environmental conflicts in Cesar. Source: Own elaboration based on workshop in Cesar (n = 30) S1 Data.

unsustainable land uses and land access. The best grounds are those that have stable water sources. Unfortunately, as reported by the local stakeholders, large-scale agricultural production has used these lands unsustainably, and environmental authorities do not effectively restrict unsustainable water uses.

In the case of Caquetá, the stakeholders prioritized deforestation as a driver of conflict, followed by land grabbing and extensive cattle ranching (Fig 4). Stakeholders recognized that the latter two are simultaneously drivers of conflict and deforestation. Similarly, land grabbing by different groups (e.g. political elites, landless farmers, armed actors) has traditionally been a way of accessing land through the "colonization" and "cleaning" of wastelands or unexplored lands within the Amazon rainforest. "Colonization" is a term used in Colombia to describe the conquest of peasants coming from the Andes known as "colonos" entering into the Amazon region, changing the landscape and establishing farms and villages. The peasants, often victims of political violence, arrived in this region in the seventies motivated by governmental policies encouraging "cleaning land" in jungle "wastelands" to access land titles. Land tenure concerns peasants and indigenous people who have been settled for more than three decades in the region and have not yet formalized their titles. Later on, land-use conflicts arise around expanding agricultural and livestock activities within areas set aside for nature conservation by the national government. The central government did the establishment of some protected areas with little consultation with the local communities ignoring the existent history of occupancy by peasants and the need of these communities to use the forest for the forest their livelihoods [86]. All stakeholders share concerns about oil and mining exploitation in the area.
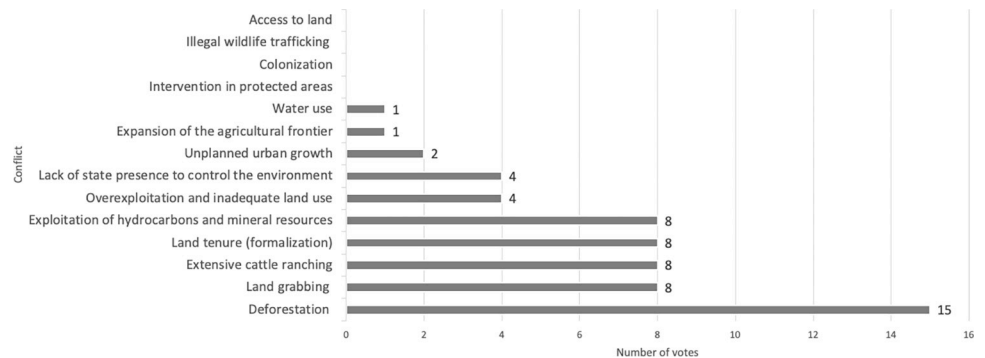

Fig 4. Prioritization of socio-environmental conflicts in Caquetá. Source: Own elaboration based on workshop in Caquetá (n = 54) S1 Data.

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They know the department's vast water resources and see these extractive activities as a significant threat in the next ten years. They fear that since some areas are no longer affected by the armed conflict, oil and mining companies may want to exploit natural resources, which would seriously impact water sources and the vast biodiversity. Therefore, other economic models of land and forest use that integrate conservation and agricultural production are seen as a great opportunity.

4.1.2. Semi structured interviews. Conflict and peacebuilding in the Cocoa Value Chains (CVC) of Cesar and Caquetá, Colombia. In the interviews, we asked whether the structure and dynamics of the cocoa value chain have given rise to resentments or grievances in the past that became violent or have the potential to become violent in the future. In Caquetá, only one person answered in the affirmative and the rest said no. The person that answered in the affirmative referred to potential conflicts in the cooperatives but no significant disputes. However, in the case of Cesar, it is possible to find conflictive situations around water and its use with the harvest, a situation that worsens in the dry season. In Cesar, 43% of the interviewees said that the cocoa value chain might have water access and management conflicts. Many said that "there is a lack of water concessions by the regional water authority Corpocesar". Rural territorial planning also brought problems when decision-makers developed a new value chain using land uses unsuitable for the activity. Finally, respondents recognized that violent displacement had brought issues to the department. For example, possible conflicts can happen if people are dispossessed and encouraged by the transitional justice mechanism of land restitution to return to their land and find others that have already bought the ground, but the seller was not the owner. It is significant for the research because it is crucial to tailor the different technical interventions to fragile contexts, such as the studied regions emerging from a conflict and trying to transition to peace.

Regarding CAFS' peacebuilding contributions. The actors in both departments agree that, in the post-conflict period, *"Cocoa has been an inclusive alternative for generating income for peasants"*. Among the participants are mainly victims of the armed conflict and farmers cultivating illegal crops. Thus, contributing to regional peacebuilding through the opportunity to cut dependences on illicit crops. Furthermore, the stakeholders said it could create dialogue spaces and foster cooperation and intra-communal social cohesion. Respondents highlighted that the cocoa sector had received much support from the Colombian Government and international development. This recognition implies for both regions and their vulnerable peasants' population the rise of opportunities for improving their livelihoods in case they can fairly connect to markets. Farmers in both regions mentioned that the cocoa value chain can also *"motivate and integrate younger generations into the rural work*, *preventing their involvement in illegal activities"*. The interviews with stakeholders of the cocoa value chain highlight the potentialities of a crop suitable for forest protection and agricultural production, which does not create social tensions and supports regional peacebuilding initiatives.

4.1.3. Conflict sensitivity and Do no Harm approach in SLUS implementations. We presented the following drivers derived from the world café with local stakeholders to the SLUS project members in the virtual workshop. We asked SLUS project members to prioritize three conflict drivers, which are related the most to SLUS project interventions (Table 1).

4.1.4. Do no harm virtual workshop: Understanding the connectors and dividers. In the workshop, we asked relevant project members what they could foresee in the SLUS' step by step implementation as potential connectors (capacities for peace) and dividers (sources of tension) to understand the context further. The workshop exercise with SLUS collaborators permitted identifying how they co-designed each specific pilot implementation with the communities. SLUS project members identified different connectors or capacities for peace within the regions (Table 2).

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Table 1. Votes for the top three drivers of conflict in Caquetá and Cesar, Colombia.

Drivers of Conflict	Number of votes
Land degradation/loss of agricultural productivity	10
Irrational use of resources	7
Absence of state in the territories	5
Limitations in access to resources (knowledge)	5
Illegal economy of drug trafficking	4
Lack of added value & transformation process (raw material and local products)	3
Poor water-management in the area (e.g. weak formal institutions)	3
Social inequality	2
Corruption that prevents fair and equitable access to public resources	2
Lack of capacity and knowledge transfer about natural resource use and management.	2
Lack of water (Cesar)	2
Lack of infrastructure for sustainable use and management of natural resources.	2
Land Property (Registration)	2

Source: Authors own elaboration based on Virtual Workshop–n = 19; up to three options could be chosen S1 Data.
Based on Table 1, SLUS practitioners prioritized the following drivers of conflict that can be tackled by SLUS pre-defined objectives and activities.

Land degradation/loss of agricultural productivity.

Irrational use of resources.

Limitations in access to resources (knowledge).

Absence of state in the territories.

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They are clustered in three main factors, i. participation / co-design ii. Spaces for dialogue. Exchange and cooperation, and iii. Co-benefits of climate mitigation and trust and cooperation. The participants reported that the project implements its intervention with a participatory approach at the farm level. The co-design of the different technologies allows ex-change and cooperation at the community level since a community of practice is built. For example, when a committee of "environmental leaders" is created to monitor animal species, these people generate a sense of ownership and collaborate to enforce the signed nature conservation agreements via social pressure. Communities of practice generally make people respect agreements out of conviction and feel more identified with making initiatives work over time. At the value chain level, the participants mentioned that mapping all the actors within the CVC is vital. This allows the actors to have equal participation and voice in the design of cero deforestation developments. Because actors mapping in the value chain is the first step to creating policies for value chain development. A consensual diagnosis of the actors' roles in a value chain opens up spaces for dialogue around price negotiations between firms and suppliers. According to a stakeholder: *"These new spaces enable the participation of farmers that usually do not*

Table 2. Potential connectors in SLUS (Project).

Participation / Co-design	Spaces for dialogue, ex-change and cooperation	Co-benefits of climate mitigation and social cohesion
• Participatory methodologies to determine adaptation to their own context • Participatory monitoring, feedback • Participatory research—including community members in the scientific process	• A new dialogue space is generated • Exchange of experiences. Peasant to peasant • Farm visits to monitor progress	• Investments at value chain to scale up production in a sustainable manner generate cooperation of farmers to keep up with standards • A commitment is generated as a contribution to the community, forest protection • A conservation monitoring system can generate social ownership to enforce agreements. • Safeguards to avoid unsustainable land use

https://doi.org/10.1371/journal.pclm.0000075.t002

Table 3. Potential dividers in SLUS project.

Exclusion	Individualistic culture	Expectations
• If the producer is not within the organization/project, exclusion can occur • Exclusion may exist at the municipal level • Producers do not always feel recognized in the process	• Ranchers work more individually. It is a challenge to generate association amongst beneficiaries	• The visions of welfare concentrated only on the farm can generate false expectations • If financial resources are not sustained in time deforestation occurs. Thus different incentives and financial mechanisms should be in place

https://doi.org/10.1371/journal.pclm.0000075.t003

have a saying in price negotiations", for example. Further down the path, the government can facilitate the exchange between buyers and suppliers and grant incentives and regulations to multinationals to develop value chains with sustainability standards such as zero deforestation and respect for labour rights. Companies can pay price premiums and, in return, may receive tax concessions. Besides, the SLUS members reported a set of potential dividers or sources of conflict (Table 3). They were clustered into three groups: i. exclusion, ii. Individualistic culture, and iii. Expectations. The participants argued that it is imperative to be transparent and clear when choosing the farms to intervene, presenting valid criteria for identifying beneficiaries. On a similar note, participants mentioned that if the incentives are not maintained when signing deforestation agreements with the farmers, it could create a perverse incentive to reactivate deforestation. Therefore, it is crucial to lower some expectations in particular interventions at the farm level.

Another reported divider was the individualistic culture of the farmers as a barrier for implementing SLUS and connecting farms in a landscape. This divider is attractive because the participants also mentioned that a participatory approach might bring down individual farmers' barriers and create a sense of community. The SLUS collaborators also identified the strategies to lessen the dividers and enhance the connectors.

4.2. A theory of change for measuring SLUS contributions to peacebuilding

Fig 5 explains the theory of change of how the SLUS project would contribute to climate change mitigation and peacebuilding. Specifically, how SLUS implementation at the farm and value chain levels responds to the existing deforestation/degradation and conflict drivers in Caquetá and Cesar, Colombia. As seen above, SLUS project implementation seeks to address three main drivers of deforestation and conflict, intervening at the farm and value chain level. However, factor number 3 (absence of the state in the territories) falls out of the project's main goal and direct scope because they neither intend to replace the government nor offer public services.

The theory of change for SLUS intervention is formulated as follows.

IF SLUS builds capacity, grants investment in rural communities to improve agriculture and extends monetary incentives via conservation agreements with farmers at the farm level THEN, the forest can be successfully conserved, along with water, soils, and other natural resources upon which all people depend for their food, air, water, shelter, and different basic human needs, enabling lasting conditions to improve local communities' wellbeing. BECAUSE by bringing people together around SLUS co-design and developing inclusive business models in the cocoa value chain, farmers' socio-economic inclusion is ensured, and a community of practice is established, promoting trusted relationships and preventing conflicts around natural resources.

This theory of change presented in Fig 5 shows the expected outcomes from the specific interventions (Sustainable Agricultural Practices and Net Zero Value Chain Development)
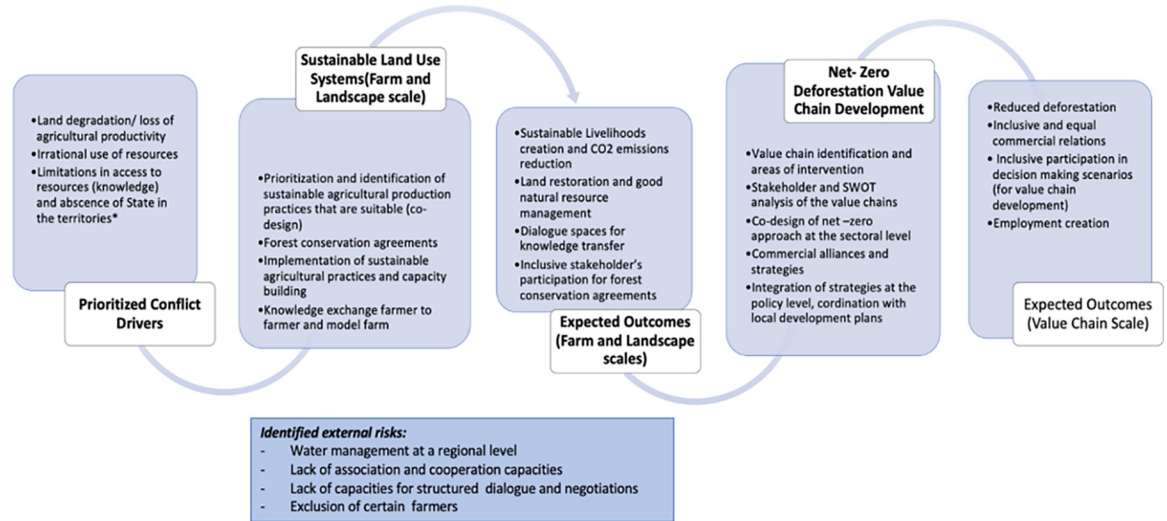
Fig 5. Theory of Change for SLUS co-benefits to climate change mitigation and peacebuilding. Source: Authors own elaboration based on literature revision and workshop's results.

represented in co-benefits for climate change mitigation and peace. Furthermore, it recognizes the possible contextual risks present in the implementation areas, as exposed by the project members and stakeholders. For example, when the national or regional government does not grant water access, it could put an external risk that falls out of the scope of the project's intervention. However, when it is recognized that a possible source of conflict is access, use and management of water. The project can implement irrigation technologies and promote water use, and management plans appropriate to the context to prevent conflicts. Additional activities can also be promoted. For example, the project can advise governments on generating investments and water governance policies that promote new crops as a local peace-positive and development strategy based on promising value chains, including institutionalized mechanisms to solve water-related conflicts. Another example is the importance of building dialogue and association capacities among farmers to foster better results at the value chain level.

4.2.1. How to measure contributions?. Based on this research, seven core factors structure the possible contributions of SLUS to climate mitigation and peacebuilding: sustainable livelihoods, food security, conflict transformation and dialogue, increasing trust and cooperation, gender balance, political and social participation and building institutions for natural resource management.

Tables 4 and 5 show the operationalization of the theory of change. It summarizes the effects of selected SLUS interventions into climate change mitigation and peacebuilding factors, their assumptions, and the indicators to measure the expected outcomes considering the SLUS project intervention and how the peacebuilding factor is affected by the intervention.

4.3. Household survey: SLUS contribution to peacebuilding

We present the descriptive results of a survey of 429 farmer households in Caquetá and 500 in Cesar by illustration. We asked farmers about their perception, at the societal level, of three peacebuilding factors: the opening of spaces for dialogue, cooperation and conflict resolution. The surveys show that the performance of agroforestry systems impacts the three. First, most agroforestry systems have increased the spaces for community dialogue. To the question, in the process of implementing the agroforestry system, have the spaces for dialogue at the

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Table 4. Peacebuilding factors, mechanisms and indicators at the farm level.

SLUS project Intervention	Peacebuilding Factor	Mechanisms and Assumptions	Indicator
Sustainable production practices	Sustainable Livelihoods	SLUS will improve livelihood and increase income, preventing families get involved in illegal economies and deforestation.	• Amount of monetary income reported per farm as increased. • Number of jobs created per farm. • Number of farmers committing to sustainable agricultural practices that lead to reduced emissions of greenhouse gases. • Annual forest area change rate (percent) • Above-ground biomass in forest (tonnes per hectare)
	Food security	Food access and stable food prices create trust and social wellbeing and prevent families fell down forest for producing food.	• Percentage of food produced in the farm. • Increased percentage of perceived food access per month (e.g. food consumed at home).
	Gender balance	Gender inclusion creates trust and stability at household level and generates the environment for scaling SLUS.	• Percentage of women participating in decision making and dialogue processes • Percentage of women that are directing certain activities. • Number of forest conservation agreements signed by females. • Percentage of women participating in training activities
	Conflict Transformation and Dialogue + Natural Resource management, governance and institutions	Sustainable land use systems improve management of natural resources and decrease the number of conflicts due to over use of natural resources (e.g., land).	• Annual forest area change rate (percent) • Above-ground biomass in forest (tonnes per hectare) • Number of dialogue processes created around efficient use of land and water.
Forest conservation agreements (CO_2 emission reduction)	Conflict transformation and dialogue /Natural resource management	A conservation agreement recognizing farm's livelihood priorities creates trust. Agreements could potentially contribute to reducing the causes of conflict versus natural protected areas that forcibly constrict the uses of land, which may increase conflict.	• Number of conservation agreements signed. • Perceived increased levels of trust in conservation agreements (Ex-post).
	Political and Social Participation	Inclusive participation in the design of SLUS and conservation agreements increases social cohesion.	• Percentage of participation of farms in the design of SLUS • Percentage of participation on forest conservation agreements. • Number of farms with participatory farm planning
	Governance and Institutions	Adoption of SLUS in farms, which are members in associations promote social cohesion and facilitates SLUS out scaling	• Percentage of farms participating in associations.
Knowledge Transfers	Conflict Transformation and Dialogue / Governance and Institutions	The process of transferring knowledge and exchange creates social spaces for dialogue and cooperation.	• Number of spaces for dialogue created to discuss conservation agreements and exchange of knowledge with an inclusive approach (e.g. participatory methodologies). • Number of practices transferred to other farmers outside the ones that participated in the project that promoted cooperation (e.g. price negotiation) (applies also for the value chain level).

community level increased? 261 households in Caquetá responded affirmatively, and one 168 responded negatively. In the case of Cesar, 358 responded positively and 142 negatively (Fig 6).

Second, the SLUS contributes to reducing conflicts over access to natural resources. According to the survey, 59.4% of Caquetá 255 households consider that SLUS decreased disputes over access to natural resources in their environment and 65.2% in Cesar, corresponding

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Table 5. Peacebuilding factors, mechanisms and indicators at the value chain level.

SLUS Intervention	Climate Change and Peacebuilding Factor	Mechanisms and Assumptions	Indicator
Market Development Analysis	Governance and Institutions /Political and social participation	Stakeholder dialogue helps understand the drivers of emissions and the interest of all parties. This in turn will facilitate the development of strategies for reducing deforestation and prevent conflict through inclusive dialogue.	• Number of dialogue spaces created for market development analysis. • Percentage of participation of farmers (women and vulnerable population such as former combatants and victims of violence) in market development analysis exercises.
Governance Interventions to foster value chains with cero deforestation	Governance and Institutions	Fostering inclusive participation of all stakeholders of the value chain to intervene at the policy level creates long term institutions and a better management for sustainability co-benefits.	• Percentage of stakeholder's participation (especially vulnerable population) at policy making scenarios for value chain development. • Number of dialogue scenarios created to discuss possible conflict over natural resources, prices, priorities at the value chain level. • Number of stakeholder platforms created taking into account levels of inclusion and horizontal relations. • Perception of participants of good quality (multi-group) cooperation initiatives • Number of policies, programs and financial and nonfinancial incentives to enable economic actors to adopt practices or change their processes in order to reduce deforestation along the value chain. Economic actors refer to farmers, other suppliers and companies in the case of agricultural value chains. • Number of multistakeholder platforms that have been created and are operational to reduce deforestation along the value chain. Operational means that the platforms receive funding and meet regularly to establish/develop a strategic plan
	Gender	Gender is a key factor in conflict and peacebuilding, and in determining people's positions of relative power or vulnerability, and thus having a better understanding of how different women, girls, men, boys, trans- and intersex persons are affected can only help in better grasping both conflict and peacebuilding	• Number of women, girls, men, boys, trans- and intersex persons participation in formal and informal decision-making structures and governance processes related to natural resource management and peacebuilding; • Number of women, girls, men, boys, trans- and intersex persons participation in workshops to foster capacity for productive and sustainable use of natural resources.

to 362 families (Fig 7). This is significant because one of the risk factors identified in the do no harm workshop was the water access and management conflicts.

Finally, the implementation of SLUS also effectively contributes to cooperating with other community members. 251 of the total interviewed households in Caquetá responded positively, and 359 of five hundred 500 in Cesar (Fig 8). The survey results show that a majority of people perceive that implementing CAFS within the SLUS approach has opened new spaces for dialogue, prevented conflicts over natural resource management and helped community members cooperate with each other. According to the respondents, implementing these systems contributes to peacebuilding at the community level in a progressive manner. It starts with creating more dialogue spaces to solve conflicts peacefully, and the second step is an amount of cooperation initiatives started as a result of the new spaces.

5. Discussion and conclusion

This study shows that SLUS designed for climate mitigation can contribute to peacebuilding. According to the reported theory of change, SLUS affects three core factors. That is (i) socio-
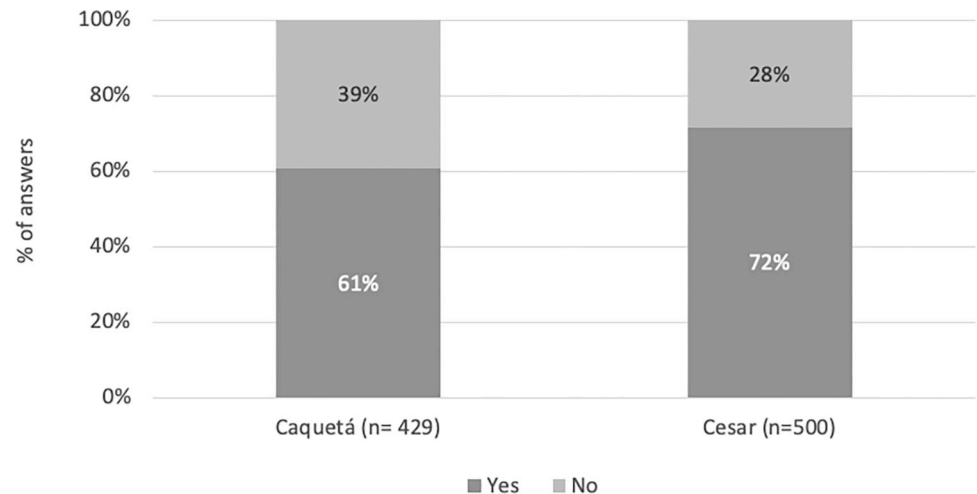
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Fig 6. Agroforestry has increased community dialogue spaces.

economic inclusion, (ii) conflict transformation and dialogue, and (iii) Building institutions for natural resource management. The proposed indicators address the most relevant contributions where SLUS project interventions in Caquetá and Cesar affect the drivers of deforestation and conflict, such as extensive cattle ranching and inefficient water use, which is in line with the literature [50,71,87,88]. However, structural drivers such as land access colonization and lack of governance structures are out of the scope of these kinds of projects.

5.1. SLUS increases socio-economic inclusion

First, creating sustainable livelihoods that promote the socio-economic stabilization of an area after a peace agreement has been signed is fundamental to sustaining peace [89,90]. Second, since rarely the governance scenarios to plan and scale-up SLUS are neutral [4,91–93], a conflict sensitivity analysis of connectors and dividers works best when carried out in a participatory manner among a group of actors involved in the process, directly or indirectly. It is
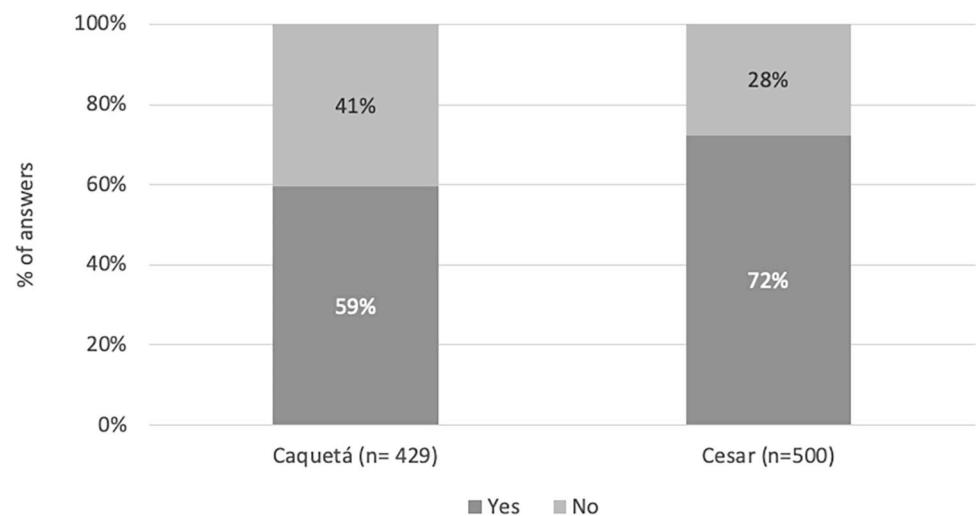

Fig 7. Agroforestry has reduced conflicts over access to natural resources.
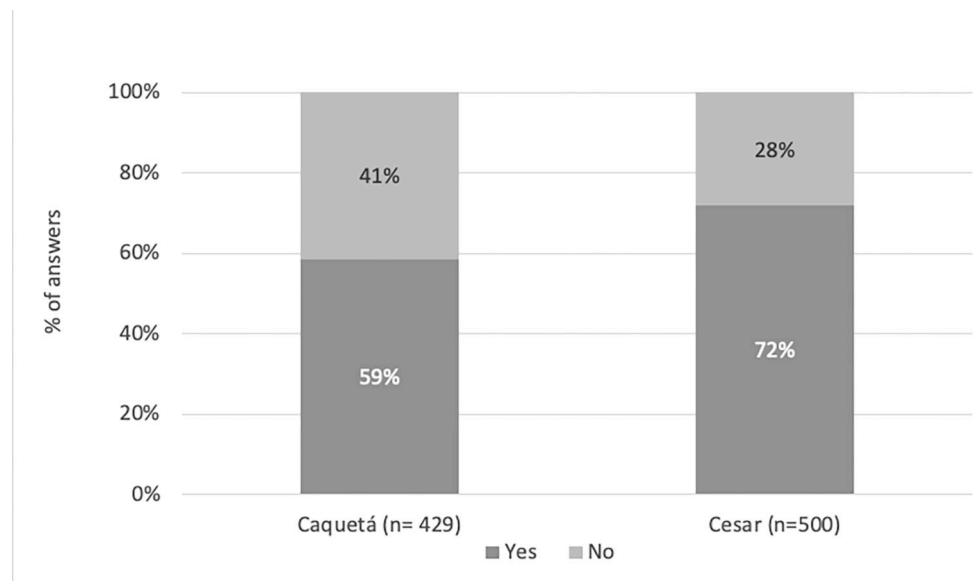
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Fig 8. Agroforestry has enabled cooperation with other community members.

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essential to develop strategies for conflict transformation, including co-design solutions and capacity building in negotiation to avoid unintended effects. Third, SLUS pilots' implementation shows that its approach to natural resource management, including the cocoa value chain scale, fosters environmental peacebuilding, as several authors discuss [94–96]. It is essential to include vulnerable populations (e.g. rural women and youth), ex-combatants and other groups of the territory to foster social cohesion. Furthermore, natural conservation agreements must be co-designed with farmers reconciling economic needs, food security and environmental protection, thus increasing trust, social cohesion and resilience against illegal economies and violence [97]. Income generation and fostering ownership in a group or community of practice can contribute not only to generating resources with which families can reject involvement in illegal economies [98]. In addition, it generates mutual aid systems, social networks and informal community support mechanisms that help reduce vulnerability. Further, they can extend their activities to manage early warnings and social denunciations of armed threats.

The research shows that the co-design of sustainable livelihoods using conflict-sensitivity enhances sustainability impacts. In line with the literature, SLUS implementations at the farm level take account of sustainable agricultural practices as an alternative to extensive cattle ranching or even illegal crops [99]. Conservation agreements by farmers with a participatory approach contribute to forest protection and natural restoration, the way in which the farms are designed. Convening community meetings to jointly decide on the type of arrangements on the farm and the best techniques to improve production generated a sense of belonging to a community of practice on the farms in Caquetá. This feeling gives people a positive reception to the productive projects of agroforestry cocoa. They see it as an initiative that is a product of the peace agreement with the guerrillas and favorable to consolidating a climate of peace that also improves production alternatives that do not involve deforesting the forest (S1 Data). Second, scaling SLUS based on participatory approaches creates spaces of dialogue to sign conservation agreements for climate change mitigation and ex-change knowledge among farmers and relevant stakeholders. At the farm level, these dialogue scenarios build trust facilitating cooperation among peers. Third, institutional arrangements that promote access and effective management of natural resources impact sustainable solutions for climate mitigation and

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contribute to peacebuilding by promoting participatory mechanisms and inclusion of vulnerable populations (e.g. victims of the conflict, youth, ethnic minorities and rural women). Fourth, creating employment within a net zero-deforestation CVC at the cocoa value chain level is critical to improving livelihood and diminishing grievances and rural populations' participation in armed conflict. The proposed indicators help assess participation in dialogue spaces to create equal and horizontal zero-deforestation value chains and participation of vulnerable populations such as rural youth and women.

However, root causes of conflict such as land access and the lack of presence of the government are factors where SLUS intervention may not directly impact. The contribution of SLUS does have the potential to coordinate policies from environmental and agricultural authorities after land restitution programmes or rural development plans. These factors are also expected to be considered among different stakeholders' platforms such as value chains, governmental agencies and actors engaged in climate mitigation, adaptation and peace promotion to up-scaling SLUS. More importantly, the SLUS and value chain upgrading strategies need to inform existing local development plans and enhance the capacities of local and national government officials, safeguarding possible sources of conflict such as water access and land tenure insecurity.

According to the results, SLUS interventions present an opportunity to design new sustainable agricultural practices that contribute to the global goals of climate change mitigation. At the national level, SLUS provides opportunities for local farmers to enhance their income and detach themselves from the risks posed by illegal economies [3]. This goes in line with the literature about socio-economic inclusion. It implies improving the terms on which individuals and groups participate in society, improving those disadvantaged' ability, opportunity, and dignity [100]. Further, valuing and preserving local culture and heritage while providing jobs to farmers (both men and women) at the individual/household level and integrating their production schemes to ecological and deforestation-free value chains contributes to long-term peacebuilding. Furthermore, it corroborates the assumption that creating sustainable livelihoods after conflict parties sign a peace agreement is fundamental to stabilization [101].

The connection of the factor of socio-economic inclusion created by SLUS also has to do with its dissemination and up-scaling. Since most of the up-scaling of SLUS require a transfer of knowledge, the implementation of SLUS aims to take into account local knowledge and cultural practices at the farm level. Further, one of the key activities is to promote knowledge exchange between farmers and other stakeholders. This approach may foster dialogue scenarios and the opportunity of farmers to cooperate among them, embracing social cohesion and a culture of peace [74].

5.2. SLUS contribute to conflict transformation and dialogue

The results corroborate that SLUS in the form of agroforestry systems reduces conflicts around natural resources. Also, the participatory approach creates dialogue spaces where trust acts as a social lubricant that enhances and optimizes the climate outcomes. It aligns with the literature about conflict transformation where solving a conflict imply recognizing different cultures and interest and addressing relationships, attitudes, behaviours, interests and discourses in violence-prone conflict settings through creating dialogue processes [102,103]. Thus, the new dialogue spaces where communities are actively involved in decision-making for implementing sustainable agricultural practices to reduce deforestation contribute to build better societal relations based on mutual recognition, knowledge exchange and dissemination for solving common challenges [4].

5.3. Building institutions for natural resource management

The results show that SLUS interventions at the farm level promoting forest conservation agreements with farmers contribute to protecting forest patches reducing biodiversity loss, and mitigating CO_2 emissions. The critical assumption of SLUS agrees with the literature since the governance and inclusive institutions for managing natural resources are essential factors to grant success in a project implementation related to tackling climate mitigation and peacebuilding. Evidence shows that weak natural resource governance triggers adverse social outcomes and conflict [104]. Significantly in conflict-affected scenarios, creating and reconstructing existing local and new governance scenarios is key to scaling agroforestry practices and creating an inclusive agricultural value chain [105]. This process needs to facilitate transparent, open processes so that every community member understands his or her rights the systems and methodologies set in place. For example, in Cesar, the study shows that implementing a conflict-sensitive approach is crucial to understanding local governance structures and preventing extensive resource-intensive agriculture interventions (such as extensive cattle ranching) that may affect natural resources already under pressure, such as water sources. Therefore, it is important to dedicate activities to understand how the institutions or 'rules of the game' structure the power, benefit, and responsive relationships between state agencies, local agencies, the people, and other stakeholders [106]. Another crucial factor is ensuring the nexus between conservation and delivery of local socio-economic benefits associated with natural resources, where multiple stakeholders are involved, 'institutions' (formal and informal) are required to structure patterns of interaction [107]. In Caquetá, for example, a unifying factor among many stakeholders is the recognition that the region's wealth is its vast water availability and that a development model based on agro forestry systems is better than extractive industries of mineral or oil. Furthermore, implementing community inclusion, public participation, and fostering inter-sectorial dialogue are vital approaches for incentivizing long-term investments that protect soils, biodiversity, and ecosystem services [108,109].

Finally, it is worth mentioning that while the SLUS approach is being developed in post-conflict contexts and as a way to prevent conflict, there are fundamental limitations concerning broader governance issues, such as regional water management. Furthermore, there is a risk that SLUS generate depoliticized discussions that do not touch on some of the deeper reasons for armed political conflicts [93]. Even essential issues in the Colombian armed conflict context such as land reform and land access are apparent constraints in the SLUS approach. However, under conditions of legal security and to strengthen the implementation of land access or illegal crop substitution programs, it has excellent potential. Similarly, to extrapolate the results to policy arena it is important that local governments recognize the implementation of SLUS and take advantage of financial mechanisms such as the UN REDD+ [4,30,110–113]. The international community and the local governments must recognize the importance of conflict-sensitivity approaches acknowledging the local context and the communities' priorities (ownership and participation). UNFCCC's safeguards (e.g. REDD+ safeguards) and land-based climate change efforts implemented in areas affected by armed conflicts should ideally consider United Nations' peacebuilding principles to reduce the risk of a relapse into conflict: i) address drivers and root causes of conflict, including those related to inequity in the access to natural resources and income; ii) build institutions and capacities of individuals, communities and authorities to manage conflict and deliver services; iii) enhance social cohesion and build trust among social groups; and iv) build trust in and legitimacy of governments.

In this line of thought, any intervention to address climate change and conflict should recognize ways to apply these principles and make them traceable in monitoring and evaluation frameworks. Further research should be conducted to test and tailor further the proposed

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indicators in other contexts where conflicts and grievances around natural resource use exist. In contexts where economic dependence on agriculture is stark, these kinds of interventions may help prevent socio-ecological conflicts product of the advancement of the agricultural frontier. Also, SLUS is a promising tool to create food security and coordinate policies around land restitution or illicit crop substitution programs where a conservation approach is compatible with agricultural production around dialogue and horizontal governance.

Supporting information

S1 Data. Workshop's Data on prioritization of socio-environmental conflicts in Cesar and Caquetá.
(XLSX)

Acknowledgments

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