Modern Geográfia
Vol. 20, Issue 2, 2025: 1–19
DOI: 10.15170/MG.2025.20.02.01

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Rooftop Agriculture in the Urban Global South: The Experience of Johannesburg[2]

ABSTRACT

Urban agriculture is attracting a growing international scholarship. The objective in this article is to examine the organization and contemporary state of rooftop agriculture in Johannesburg, South Africa's commercial heart and largest city. Current international scholarship on rooftop agriculture is overwhelmingly dominated by research on the experience of North American and European cities. Although urban agriculture has generated a considerable literature in the Global South and especially in Africa, only limited work exists on rooftop farming. This study draws together existing material on the South African record of rooftop agriculture. It is shown that Johannesburg hosts the largest cluster of rooftop farms which have been established mainly for social considerations with smaller numbers of projects for commercial reasons or the image-enhancement of businesses. The importance of partnerships for the establishment of projects emerges as a distinctive element of the Johannesburg inner-city experience. The challenges confronting the rooftop farming projects are investigated.

Keywords: urban agriculture, rooftop agriculture, Johannesburg, South Africa

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[2] The baseline analysis conducted by Warrick Allen at the University of Johannesburg is acknowledged. Thanks are due to the critical comments and suggestions for improvement made by two journal reviewers. Helpful inputs were made by Lulu White, Robbie Norfolk and Betty White in the preparation of this paper.

INTRODUCTION

It is pointed out in several recent reviews that urban agriculture is a globally prevalent practice which encompasses various forms of farming activities and that the topic has garnered a substantial international literature across several different research themes (Pradhan et al., 2023; Srinivasan & Yadav, 2023; Alkhaja et al., 2024). Tornaghi (2014) views urban agriculture as a broad umbrella term which encompasses food cultivation and animal husbandry. The scope of urban agriculture includes an array of different production forms, variously activities such as small-intensive urban farms, food production allotments, restaurant-supported salad gardens, balcony and windowsill vegetable growing, and rooftop gardens (Orsini et al., 2017; Alkhaja et al., 2024; Teoh et al., 2024). Urban agriculture supports the economic, social and environmental sustainability of cities, most especially through enhancing food security (Azunre et al., 2019). Beyond issues of food security, however, a current in recent literature on urban agriculture underscores its importance to include for self-empowerment and learning, and in constituting ways to achieve social justice (Tornaghi, 2017; Horst et al., 2024).

Over the past 20–25 years it has been observed that "urban agriculture has been variously embraced by public authorities, NGOs, research agencies, scholars, and civil society actors, across cities of both, the Global North and South" (Tornaghi, 2024, p. 285). Orsini et al. (2020, p. 1) document that in recent years urban agriculture projects "have bloomed throughout the world, finding large applications" particularly in the developed economies. Indeed, across the Global North there is occurring a surge of policy activities taking root around urban agriculture (Horst et al., 2024; Tornaghi, 2024). In the environment of the Global North grassroots initiatives as well institution-led urban agricultural projects are expanding in many cities "reshaping urban landscapes, experimenting with alternatives to the capitalist organization of urban life and sometimes establishing embryonic forms of recreating the Commons" (Tornaghi, 2014, p. 551). In the urban Global South urban agriculture is a common practice in many cities, most especially in sub-Saharan Africa (Freeman, 1991; Rogerson, 1992; Drechsel & Dongas, 2010; Masvaure, 2016; Mensah, 2023a). Debates around urban agriculture in the Global South mainly focus around poverty alleviation and its contribution to food security (Orsini et al., 2024; Teoh et al., 2024). Mensah (2023b) establishes that in the urban Global South urban agriculture can boost local economic development, assist towards the building of resilient urban settlements as well as contribute towards social inclusivity. Overall, Drescher et al. (2021) highlight the importance of urban agriculture as a fundamental element of the social-ecological resilience of Southern cities.

This international surge in urban agriculture of various kinds has generated a burgeoning literature from scholars in a range of disciplines, most importantly urban studies, planning and development studies. That said, it is argued that research questions around urban agriculture remain "a very marginal and almost unexplored field in human geography" (Tornaghi, 2014, p. 551). It is against this backdrop that the aim in this paper is to offer a modest contribution to human geographical scholarship. The objective is to examine the organization and contemporary state of rooftop agriculture in South Africa's commercial heart and largest city, Johannesburg. Within the Global South the case of South Africa is somewhat exceptional for the existence of a rich geographical scholarship relating to

urban agriculture. From the 1990s urban agriculture became a prominent research focus for many human geographers who were engaged actively with the issues of post-apartheid urban change and the sustainable management of urban growth (Rogerson, 1993a; May & Rogerson, 1995; Webb, 1998a, 1998b; Rogerson, 2003; Webb & Kasumba, 2009; Rogerson, 2011; Webb, 2011). Several contributions authored by geographers have interrogated the role of urban agriculture in poverty alleviation as well as elaborate its importance for urban food security and food justice (Rogerson, 1993a, 1993b, 1998; Thornton, 2008; Webb & Kasumba, 2009; Crush et al., 2011; Battersby & Marshak, 2013; Battersby, 2016a, 2016b; Kanosvamhira, 2019; Kanosvamhira & Tevira, 2020; Kanosvamhira, 2023, 2024a, 2024b). It is observed, however, that these works concentrate almost exclusively on open space and peri-urban cultivation. By contrast, the focus here is upon the issue of rooftop agriculture. The remainder of this paper is organized as follows. The next section situates the South African research within a burgeoning international scholarship on rooftop gardening. A brief discussion on research methods is then presented before turning to a review and analysis of the findings from the Johannesburg experience.

LITERATURE REVIEW

Orsini et al. (2017) pinpoint that one of the greatest unused resources of many cities is flat roofs, especially in inner-city areas and denser settlements where other growing spaces may be limited. Roofs are estimated to account for between 20-30 percent of urban land and as such represent a valuable supplement to land resources and assume a crucial role in promoting sustainability and particularly for cities with limited land availability (Chen et al., 2024). The utilization of rooftop space potentially can offer multiple benefits to cities and their residents, most importantly in terms of urban heat island mitigation, energy saving and water management. The exploitation of unused city spaces such as rooftops can contribute to overcoming barriers to the challenges of urban development (Specht et al., 2014). Rooftop agriculture—plant cultivation on the rooftops of urban buildings—has been isolated as a functional pathway variously to increase ecological services, resilience to climate change, food security as well as contributing to the social and economic inclusion of marginal communities as well as those that experience gender inequality (Orsini et al., 2017; Appolloni et al., 2021). Rooftop agriculture is defined as "a building-based form of urban agriculture that includes both protected and nonprotected practices, such as rooftop greenhouses as well as open air rooftop gardens and farms" (Appolloni et al., 2021, p. 1). Further, Appolloni et al. (2021) clarify that rooftop agriculture is a form of zero-acreage farming or building-integrated agriculture and can include both protected (greenhouses) or nonprotected (open air rooftop gardens) forms of production. The terminology of zero-acreage farming or ZFarming is used especially in European research (Specht et al., 2014; Thomaier et al. 2015; Thomaier, 2017).

Reviews by Thomaier et al. (2015), Thomaier (2017), Appolloni et al. (2021) and Beroske (2022) highlight rising global interest in rooftop gardening for addressing sustainability issues in cities. Projects for rooftop agriculture can be commercial or non-commercial in focus. Thomaier et al. (2015) classify projects for rooftop agriculture based on their main objectives and isolate five types:

(1) commercial, (2) social-educational, (3) image, (4) innovation, or (5) urban living quality. As elaborated by Appolloni et al. (2021) the category of commercial rooftop farms is usually constituted by business-oriented enterprises which target profitability. By contrast, rooftop agriculture practices which are social-educational in character or geared towards urban living qualities are often initiated without profit considerations and instead concentrate on the integration of minorities or marginal groups, the education of young people, and addressing negative aspects of urban living by the offer of recreational and community spaces for personal food production (Nasr et al., 2017). The category of image-oriented rooftop agriculture projects mainly link to hotels or restaurants which use rooftop cultivation for purposes of marketing and/or aesthetics. The final category of innovation projects in rooftop agriculture are linked to the research and development of new technologies for sustainable food production and often are associated with universities or research centres.

It is pointed out in the international reviews on rooftop gardens conducted by Nasr et al. (2017) and by Appolloni et al. (2021) that different rooftop agriculture projects apply varying strategies in terms of their growing systems, design and management which are dependent upon and link to the different objectives of projects. The commercial business-oriented projects integrate rooftop agriculture into existing food chains and apply state-of-the-art technologies and intensive systems for plant cultivation. Often such commercialized production is anchored upon soil-less techniques with inert substrates and hydroponic methods. By contrast, non-commercial rooftop projects apply often low-technology growing systems utilizing inexpensive or recycled materials in order to improve urban food production with the lowest cost of investment. Typically, for food production such projects use soil either in raised beds or directly on rooftop surfaces (Beroske, 2022). Whether commercial or non-commercial in character it is argued that rooftop gardens can support sustainable environmental benefits for cities including water runoff management, biodiversity conservation, and ameliorating urban heat island effects (Whittinghill & Bradley Rowe, 2012; Appolloni et al., 2020; Appolloni et al., 2021; Baroske, 2022; Toboso-Chavero et al., 2023).

The overall picture as disclosed in the major international surveys conducted by Thomaier et al. (2015) and Appolloni et al. (2021) shows the predominance of rooftop agriculture in the urban Global North and using the form of open air rooftop gardens. The largest number of project cases appear to be in North America followed by Europe. The trend was towards the multifunctionality of rooftop agricultural practices in terms of a combination of improving quality of urban living with social-educational goals and image enhancement. For Yang et al. (2024) urban rooftop agriculture, alongside photovoltaic power production, offer solutions for the food-energy nexus in Chinese cities, albeit they are in competition for limited rooftop space. Rawal and Thapa (2022) draw attention to the contrasting situation of green roofs in developed as opposed to developing countries. They point to several success stories in the Global North of concrete roofs in urban areas being transformed into productive green roofs.

Grounded in critical urban geography, urban political ecology and debates related to everyday informal life politics Turner et al. (2024) disclose the complexities surrounding rooftop gardening in the Global South. According to Quddus (2022, p. 120) across cities of the Global South rooftop gardening "may improve foodstuff demand and able to encourage a livable urban community by ensuring

local fresh and safe foods". Indeed, the consensus is that support for rooftop agriculture is highly relevant for the building of sustainable cities (Then & Hong, 2022). Two recent studies of the record of Dhaka in Bangladesh underscore the transformative potential of rooftop gardening (Safayet et al., 2017; Giri & Karmakar, 2024). The broad picture is of limited recorded successes. The typical situation as reported from Nepal is that rooftop gardens in urban areas function at a non-commercial scale albeit "help to ensure food security and aid in ecosystem services from the local level" (Rawal & Thapa, 2022, p. 1). In Pokhara city, Nepal, roof top gardening is contributing to local food supplies as well as an enhanced ecosystem (Kumar et al., 2019). In the case of Hanoi it is elaborated that "rooftop gardeners confront pressing food safety concerns while expressing doubt in formal political institutions' ability to address these anxieties" (Turner et al., 2024, p. 249).

Most Global South research on urban rooftop agriculture is situated in Asia rather than Africa. Recent work on Cairo provides one exception (Shaltout et al., 2024). In another contribution Wesonga (2023) flags rooftop farming as one of a range of approaches to alleviate problems of food security and malnutrition in African cities. Overall, for the small cohort of African studies Appolloni et al. (2021) report a noticeably higher proportion of projects centred on urban living quality and social-educational progress and often promoted by local authorities or NGOs.

METHODS

This study is guided by various research approaches. First, it was informed by the international literature review of the findings of existing scholarship on rooftop gardens. As is demonstrated from the above overview, the African experience of rooftop agriculture is not prominent in a literature which is dominated by Global North case studies and most especially of projects operating in cities in North America and Europe. Second, the paper draws upon the existing studies on rooftop gardening in urban South Africa and in particular focuses on the experience of Johannesburg, the country's major urban centre (Sekonyela et al., 2024; Rogerson, 2025).

The Johannesburg discussion draws extensively from a detailed audit which was conducted of rooftop agriculture and of the production practices across the city (Allen, 2019). Results are summarized from 25 semi-structured interviews which were conducted with select key stakeholders engaged in rooftop agriculture in Johannesburg using a purposive sampling approach comprising a mix of in-person, telephonic and email communications. This material is supplemented by a review of the findings from other recent works that have addressed issues of urban agriculture in Johannesburg inner-city (Ansell, 2017; Shapurjee, 2022; Ngie & Sithole, 2023).

RESULTS

At the outset the point must be reiterated that in addressing the critical challenges of food security or of sustainable urban development in South Africa the extent and contribution of rooftop agriculture is small as compared to the expansion of open-space and peri-urban cultivation practices. Indeed, rooftop agriculture in urban South Africa is in its infancy as compared to the extensive activities which are recorded in cities such as Berlin, New York or Toronto. The discussion is organized into two

sub-sections of material. These relate first to a national profile concerning rooftop agriculture and the state of the policy environment within which the sector functions. The second sub-section shifts to focus squarely on rooftop farming in Johannesburg and deals with the organization and development of projects with a review of current challenges.

The national landscape

The research revealed that rooftop farming is a relatively new phenomenon in South Africa with the first initiative launched only in 2009. The foundation date for the majority of rooftop agriculture projects occurred in the past decade. Arguably, the emergence of rooftop farming is part of a growing response to South Africa's deteriorating economic situation in the 2010s with high levels of unemployment, a chronic crisis of urban poverty, and rising concerns about food insecurity. The period 2009–2018, the years of the Presidency of Jacob Zuma, often are styled as 'South Africa's lost decade' as they were characterised by rampant industrial-scale corruption, state-capture and economic mismanagement which resulted in depressed rates of economic growth and disastrous levels of national unemployment reaching at least to 36 percent.

The national audit disclosed a total of 20 operational rooftop agricultural initiatives and with six additional projects temporarily on hold for reasons related either to renovations or issues of red tape. Of these 20 projects, 12 were greater in size than 100 m². Table 1 shows the uneven geography of rooftop agriculture in South Africa. It is evident that the largest number of operational farms are situated in the environs of inner-city of Johannesburg with two each located in the coastal cities of Cape Town and Durban (Table 1).

Table 1. The uneven geography of rooftop farming projects

City	Operational	Dormant/Non-Operational
Cape Town	2	1
Durban	2	1
Johannesburg	16	4

Source: Adapted from Allen, 2019

Table 2 shows the rationale for establishment of these 26 rooftop projects using an adapted version of the international typology of Thomaier et al. (2015) with the category 'social and educational' segmented into separate groups.

It is evident from Table 2 that the largest number of rooftop projects fall into the classification of social projects which are then followed by commercial and image improvement initiatives. Only isolated cases exist in South Africa of rooftop agriculture initiatives that relate to the categories of education, urban living quality or innovation incubator which are more characteristic features of rooftop farming as observed in cities of the Global North (Thomaier et al., 2015; Appolloni et al. 2021;

Alkhaja et al., 2024). In terms of production methods, the audit disclosed that the majority of rooftop projects are organized as soil-based, open air installations.

Table 2. Reasons for establishment of operational projects

Purpose	Description	Number of projects
Commercial	The overall aim for the farm is economic viability and profit making.	7
Image-oriented	The farm is not a source of revenue but rather offers other benefits, such as growing herbs or produce for a hotel restaurant kitchen, or corporate canteen.	6
Educational	The overall objective is to instil sustainability values within a community or educational context, these are often non-profit	1
Social	The farm can be seen as a community garden, in which tenants of a building produce crops and may eat or sell what they grow.	10
Urban living quality	The farm is used for enhancing a residential, commercial or mixed-use space, which can serve as a recreational area and is open to the public	1
Innovation incubator	Serves as a prototype and promotes novel concepts in food production	1

Turning to the national policy environment surrounding rooftop farming, this is best described as weak and undeveloped. From a policy perspective, whilst there are several city-scale initiatives to support urban agriculture, no progress has been made towards any overarching national policy towards urban agriculture development in South Africa. Policy commitments by national government towards agriculture, as driven by the Department of Agriculture, equate with sentiments about its operations only in the 'rural' environment (Kanosvamhira, 2024a). Further, in relation to policy whilst government has sought to tackle 'big policy questions' concerning challenges to food security, minimal attention has been accorded to the how and where of urban agriculture fitting into the policy framework (Rogerson, 2011). As a result, urban agriculture is viewed often as an extension of other policy and urban development mandates, a small component of much wider policy agendas regarding economic development and associated strategies. Correspondingly, the sector of urban agriculture does not receive the necessary targeted support that it would receive from policy specific directives (Rogerson, 2003; Haysom, 2015).

In South Africa policy issues pertaining to urban agriculture essentially therefore are devolved to the scale of municipal governance where often they become a component of local pro-poor initiatives of economic development programmes (Rogerson, 2011). This can be seen in the municipal level responses to urban agriculture with the City of Cape Town's Urban Agriculture Policy, the City of Johannesburg's Urban Agriculture Support Programme, or Durban's Agro-Ecology Programme. Such local initiatives each have sought to support community gardens and smallholder farms through approaches such as capacity building, skills transfer and the supply of basic tools. Arguably, therefore, South Africa's leading urban municipalities have taken up and are grappling with some of the challenges of open-space and peri-urban agriculture. Nevertheless, whilst acknowledgement is given to the practices of urban agriculture *as a whole* in municipal level responses there remains little explicit consideration for the particular issues around rooftop farming in South African policy discourse.

In the absence of specific policy directives governing its operations, the activity of rooftop farming therefore is most directly relevant to property owners in South Africa (Allen, 2019). It is in this space that rooftop farming exists with a need for cohesive partnerships to be forged between building

owners and farmers for the establishment of projects. Sometimes such partnerships emerge out of a need for large corporates in South Africa to fulfil Corporate Social Responsibility/ Investment (CSR/CSI) obligations, whether enforced through government legislation, or under pressure from company stakeholders. The development of rooftop farming is thus underpinned often by how large corporates may wish to leverage it either to meet Sustainable Development Goals or to undertake social obligations through community development and job creation schemes. The latter are for the legislative fulfilment of Black Economic Empowerment (BEE) criteria, controversial government mandated policies which have been introduced in the post-apartheid period to redress the effects of apartheid and reduce white-ownership of the South African economy (Ponte et al., 2007; Southall, 2007; Tangri & Southall, 2008; Francis & Valodia, 2021). Beyond CSI initiatives another critical impetus is that linked to projects which involve social housing, an important thread in the experience of rooftop agriculture in South Africa's major city.

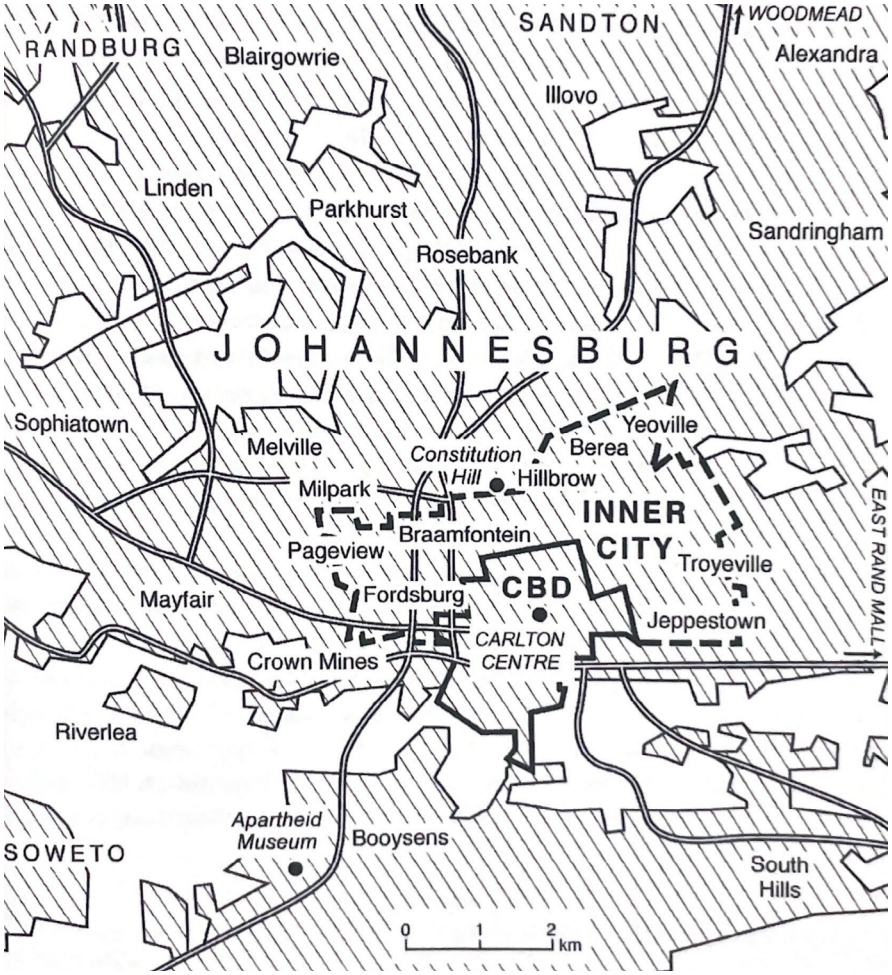
The Johannesburg record

The record of the operation of rooftop agriculture in Johannesburg is that of the city with the greatest cluster of initiatives for rooftop food production in South Africa. The inner-city of Johannesburg is the location for the majority of rooftop farms, a space which has experienced radical change over the past 30 years with dramatic physical and economic decline and readjustment (Figure 1). The location of most of the city's rooftop farms is the environs of the CBD including the surrounds of the Carlton Centre, the former commercial and retailing hub of Johannesburg. This geographical concentration of rooftop farming in Johannesburg inner-city must be understood against the background of the precipitate decline and attempts to revive of what was formerly the economic heart of South Africa's most important city.

During the 1980s the economic and physical condition of inner-city Johannesburg started to exhibit signs of socio-economic stagnation and decline as businesses abandoned the area and relocated to Johannesburg's wealthy northern suburbs (Turok et al., 2021). The exodus occurred of commercial office and retail activities, formerly situated in the CBD, to new decentralized nodes in Rosebank and Sandton (Figure 1). This capital flight resulted in a loss of jobs in the inner-city and the movement of (majority white) middle-income residents from the inner-city suburbs into Johannesburg's wealthier residential areas. It was evident that the central area was becoming a blighted space as a consequence of a cumulative downward spiral (Rogerson, 2020). Murray (2011, p. 88) documents that by the 1990s that "the once thriving central city of Johannesburg had become synonymous with unregulated street trading, poor urban management, abandoned and badly maintained buildings, unauthorized squatting, overcrowding, neglected public spaces and general disorderliness". By 1994, the year of democratic transition in South Africa the historical downtown core of Johannesburg lay in ruins, with decaying high-rise office properties, commercial establishments closed-down, and crumbling buildings invaded by homeless squatters (Moyo, 2020). The former core of a vibrant metropolis, Johannesburg

inner-city had "sunk into a state of suspended animation, transformed into a derelict and dangerous place during the day and a virtual ghost town at night" (Murray 2011, p. xiii).

Figure 1. The location of Johannesburg inner city



Since the new millennium these deteriorated physical and environmental conditions "have prompted the City of Johannesburg to implement programmes and activities which target renewal or regeneration of the inner city" (Moyo, 2020, p. 202). One of the most significant agencies for revival is the public benefit organization, Johannesburg Inner-City Partnership (JICP) which was established in 1996 and works with inner-city stakeholders to create a clean, safe and welcoming inner-city, part of broader urban regeneration initiatives. Many of the rooftop farming initiatives originated from partnerships established between different inner-city stakeholders consolidated in the JICP, the central role of which is to forge collaborative relationships between government, the private sector and community groups. One manifestation of this partnership was the establishment in 2017 of The Urban Agriculture Initiative (UAI), a non-profit social enterprise incubated by the JICP to drive the development of urban agricultural projects in the city, including of rooftop projects with a social focus (Urban Agriculture Initiative, 2020). The stated aims of the UAI are to localise food systems, to generate new economic activity and contribute to the greening of unused spaces (Urban Agriculture Initiative, 2020). The UAI initiative encouraged various property companies to utilise their rooftop spaces for urban agriculture initiatives (Ngie & Sithole, 2023). Ansell (2017) argues that components

of green infrastructure, agriculture and landscaping potentially intersect in planning for rooftop gardening in Johannesburg.

The interviews disclosed that the 20 rooftop farms in Johannesburg were established variously for social reasons, business motivations or image-enhancement considerations. The largest share—nine in total—relate to social motivations, seven for entrepreneurial or profit considerations, and four projects which are best categorized as image-related. It was revealed in the stakeholder interviews that production methods of projects split equally between a group that uses hydroponics and another group that uses soil-based mediums for food production; two projects apply a mix of these approaches. Of note is that Johannesburg is the only South African city which has examples of soil-less hydroponic projects in operation and that all these hydroponic projects are profit-motivated. Of the 20 rooftop farms 16 were operational and four were dormant, the reasons for which will be explored as part of the discussion around the challenges of rooftop farming.

From the interviews it was evidenced that the majority of Johannesburg rooftop farms driven in their establishment by social considerations are associated with property companies that own multiple buildings in the city. A group of rooftop farms in inner city Johannesburg relate directly to corporate social responsibility programmes (linked to Black Economic Empowerment) for social upliftment with support for initial project start-up costs (such as soil and containers). The largest share of social initiatives for rooftop gardens, however, are associated with non-profit companies which have been initiated by the municipal government in order to provide social housing. Allen (2019) documents in further detail the range of these initiatives and shows that a leading role is played by the Johannesburg Housing Company (JHC). It was observed that JHC owns 29 buildings and manages an additional five properties providing in total 4300 rental units and shelter for nearly 20 000 people in low-income brackets. Likewise, the Johannesburg Social Housing Company was established by the City of Johannesburg to provide and manage affordable rental housing and contribute towards reducing the city's severe housing problems. Both these entities (and others) have engaged in programmes which include the establishment of farms at the top of several of their buildings. For the JHC—which is responsible for six socially-driven farms—these initiatives were initially part of recycling awareness programmes designed to encourage tenants to be environmentally-friendly. The JHC conceived of the rooftop gardens in 2011 as a greening strategy to be anchored on encouraging environmentally-friendly lifestyles; this aligned also with motivations for enhanced food security.

The principal agency responsible for operating projects is a JHC subsidiary company (Makhulong A Matala) which functions as an NGO provider of community development services. The goal of this agency is to enhance the quality of life of building tenants with the development of rooftop gardens and using recycled waste for food production. This project runs alongside its other initiatives which include improving playgrounds and internet facilities for school learners. The rooftop farms grow produce out of plastic containers or old tyres and with soil covered by straw as the growth medium. The farmers that maintain the rooftop gardens are all tenants in the JHC buildings and assisted both by volunteers and a service provider that provides skills advice as well as recommendations on what crops to plant. The farmers are afforded opportunities to attend training workshops before given the responsibilities for tending the farm. The rooftop farms are engaged with producing a range of

different crops such as spinach, cabbage, peas, beans, sweet potatoes, onions, mint, rosemary and basil. Several farms use shade netting in order to safeguard crops from birds and pests as well as seeking to maximise the use of as much roof space as possible. The core focus for project participants is to have access to fresh produce but with any excess production sold to generate an income through the hosting of regular market days and produce sales to other building tenants.

A second group of rooftop farms in Johannesburg which are not directly profit-oriented are those supplying fresh ingredients for use (and cost offsets) in hotels, restaurants or the canteens of leading corporates in the city. For example, at the Saxon Villa hotel, located outside the inner-city in the wealthy area of Sandton in Northern Johannesburg (Figure 1), a soil roof farm has been established on top of one of the hotel's undercover parking complexes. The entire rooftop has been covered by soil and used to produce ingredients to supply the hotel restaurant. Produce includes specialist ingredients such as a variety of herbs, 20 different types of tomatoes, broad beans, Jerusalem artichokes, peas, beans and an assortment of heirloom marrows, spinach, beetroots and turnips. In this case the rooftop garden is an adjunct to the chef's demand for specialist ingredients that set apart the hotel's cuisine from other upmarket restaurants in the city. At the Troyeville Hotel the farm is situated on a rooftop terrace accessible to the public. This farm is mixed in its production methods. As Allen (2019: 138-9) elaborates, it "consists of two vertical growing walls, which is the hydroponic component, and then several pots and upcycled polystyrene prawn packaging containers that are used to grow parsley in soil". A third example of an image-related rooftop farm is that which is on the top of the offices of one of South Africa's largest banking concerns. The farm produce is used to supply the company's canteen as well as provide fresh food to staff.

The third group of Johannesburg rooftop farms are those which are profit-oriented and mainly use hydroponics. Of note is the distinctive role played in the establishment of these enterprises by a business innovation enterprise which functions as an incubator for entrepreneurs. In particular, this enterprise targets capacity building for youth entrepreneurs drawn from what in South Africa are designated as 'previously disadvantaged' (ie. black) communities in the apartheid era. Capacity building is given in the form of training for establishing a business start-up and with mentorship on how to run a business. The work of this business innovation enterprise (titled WIBC or 'Wouldn't It Be Cool') is directed to ensure that initiatives for corporate social responsibility are closely aligned with objectives for Black Economic Empowerment. It focuses broadly on a range of initiatives around urban agriculture including for rooftop farming. In one pilot project to demonstrate the possibilities of creating a sustainable business model around rooftop farming the production focus is basil, a high value crop that is produced using hydroponic methods. Support for the wider roll out of such entrepreneurial rooftop farming projects came from the Kickstart entrepreneurship support programme which is funded by the international brewing conglomerate SAB Inbev (formerly South African Breweries). Support consists of a skills upgrading programme in which individuals receive a five month training course on how to maintain and operate a hydroponic farm. The course further includes components on business management and issues around establishing a market, which products to sell, and how to develop market linkages (Allen, 2019). Essentially, the WIBC business innovation enterprise seeks to produce urban farmer graduate entrepreneurs to be part of the agri-business value chain. Graduates

from the five month training programme are encouraged to network and form business relationships with each other, thereby to construct a cohesive market system that might support urban agriculture (including rooftop farms) across Johannesburg. This thrust is the result of frustration with previous failed initiatives in urban agriculture and rooftop farming which were the result of the absence of the development of market linkages.

Extant research on the performance of rooftop farming in Johannesburg points to the existence of a number of challenges that impact the sector and its participants (Ansell, 2017; Allen, 2019; Shapurjee, 2022). The first, already alluded to, is the weakness of the policy environment concerning urban agriculture in general and then the almost complete absence of policy frameworks for support of rooftop gardening. This weakness of policy support even extended to the municipal levels. The interviews conducted with stakeholders underscored issues of general disinterest and lack of engagement by the municipal authorities. The responsible department was styled by one interviewee as "one of the most unorganised, unmotivated and unengaging departments". The damning critique continued as follows: "it's almost like a fronting scenario where they just want to do something to look like they are doing something. But they don't have a genuine interest or intention to take this into something sustainable" (cited in Allen, 2019, p. 145).

A second set of challenges relate to issues of weather and that of climate change. Projections point to far reaching impacts for the city of climate change in terms of warming trends and increased levels of humidity (Nana et al., 2019). For rooftop farmers the impact of wind and extreme heat events are issues of greatest concern. It has been observed that in Johannesburg wind is most problematic for hydroponic farms as the growing tunnels are mainly made of shade cloth or plastic sheeting which can buckle under high wind conditions. The threat of hail damage to crops is also of concern in Johannesburg summers. Arguably, climate change is one of the major stressors on urban development in Africa and therefore a risk factor for rooftop farmers (Hetz, 2016). The impacts for crops of extreme temperatures during summer months are heightened as none of the hydroponic projects applies air conditioning. Three, the situation has been exacerbated in recent years by power shortages in the South African electricity network and regular episodes of loadshedding in Johannesburg. Unstable power supplies have contributed to crop failure (Ngie & Sithole, 2023). As hydroponics requires electricity to circulate water, without a power source plants have dehydrated and died, one of the factors leading to the non-operational status of at least one rooftop project. Four, problems are highlighted by the implementing agencies concerning the poor or unreliable participation of tenants in farmer training programmes in social projects. Participation by tenants was often irregular and inconsistent. The research by Shapurjee (2022) at the Coronia Gardens Berea project also discloses the problematic issues of limited involvement and engagement in an inner-city rooftop farm. This finding underlines the important point of the need to address limited resident awareness of the potential benefits of engagement with urban agriculture projects including for rooftop farming.

Finally, another vital constraint in Johannesburg relates to projects that were geared to financial viability. The challenge concerns market access difficulties which resulted in some rooftop projects failing to be operational due to the absence of established market linkages. It was evidenced in the stakeholder interviews which were conducted in Johannesburg that, notwithstanding the activities

of The Urban Agriculture Initiative, only a handful of rooftop farmers that were engaged in business-oriented ventures were able to sell excess stock through the Johannesburg Fresh Produce Market.

CONCLUSIONS

Across the international experience, urban agriculture has emerged as a crucial strategy for ensuring sustainable food access (Alkhaja et al., 2024). Questions surrounding the role of urban agriculture and sustainable cities continue to attract a growing literature in the Global North albeit with only a small contribution observed from geographers (Tornaghi, 2014; Turner et al., 2024). One component of this Global North scholarship is debates around the practice and merits of rooftop farming (Appolloni et al., 2021). In the urban Global South, whilst there is a rich and vibrant literature on open-space and peri-urban agriculture, including from human geographers, there is a paucity of material about the state of rooftop agriculture.

It is against this backdrop that this paper contributes to an emergent scholarship for the urban Global South concerning rooftop farming. More specifically, it addresses a knowledge gap by contributing a state-of-the-art overview on rooftop agriculture in urban South Africa where the leading cluster of initiatives exists in and around inner-city Johannesburg. Although a range of different motives underpin the appearance of this cluster of projects the most significant relate to social considerations for improving the access of lower-income groups to fresh food. The importance of partnerships for the establishment of projects emerges as a distinctive element of the Johannesburg experience. Further monitoring and research is needed of the progress of rooftop agriculture in South Africa's major cities and in particular of evaluations of resource efficiency and sustainability actions. In addition, for geographers an enhanced understanding of the ramifications of climate change for rooftop agriculture sector is a matter of special interest. Furthermore, in terms of looking to the future, the development of policies that might support adaptation to climate change are of critical significance for enhancing the prospects of the rooftop farming sector in urban South Africa.

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Modern Geográfia
Vol. 20, Issue 2, 2025: 21–43
DOI: 10.15170/MG.2025.20.02.02

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Factors Shaping German Identity in the Settlements of Dombóvár and Its Surroundings

ABSTRACT

During the censuses conducted between 1990 and 2011, the number of people identifying as German ethnicity consistently grew. Some researchers attributed this rise to a process of dissimilation. In the 2022 census, a methodological change was introduced, allowing individuals to identify as both Hungarian and German in terms of mother tongue. Despite this, the census revealed a significant decrease in the number of people identifying as German ethnicity in the Dombóvár region. Based on these findings, we decided to conduct a questionnaire survey. The sample focused on the German ethnic population primarily residing in the Dombóvár area. According to the analysis, the younger generation has shown a sporadic tendency to identify with German ethnicity. The vast majority of those identifying as German tend to emphasize their ethnic affiliation more as they age, while only rarely acknowledging German as their mother tongue. Our analysis of the survey results indicates that dual identity is prevalent among respondents. The questionnaire survey unequivocally confirms that most individuals identifying as German possess a symbolic ethnicity, meaning that German identity is not strongly tied to the preservation of the native language or cultural traditions.

Keywords: German, identity, nationality, ethnic geography, language skills, Hungary

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INTRODUCTION

In recent decades, research on nationalities and ethnicities has experienced a renaissance (Farkas, 2016; Németh, 2009; Aranyosiné, 2014; Barics, 2004; Bucher et al., 2004; Hasanovic-Kolutácz, 2010). The field of ethnic geography has gained particular attention, especially due to the complex origins of current war conflicts.

In 2023, the Dombóvár German Ethnic Community published a volume focusing on research into German ethnicity (Szenyéri, 2023). This publication was the culmination of nearly six years of research, with parts of the material appearing in earlier works (Szenyéri, 2018, 2019). The book is based on a background study commissioned by the Municipality of Dombóvár in 2017, aimed at providing a foundation for the creation of a nature park in cooperation with several municipalities.

The Kapos-Hegyhát Nature Park seeks to explore and protect the natural and cultural values of the landscape. The program includes the following municipalities: Csibrák, Dombóvár, Döbrököz, Dúzs, Hőgyész, Kalaznó, Kisvejke, Kurd, Lengyel, Mágocs, Mekényes, Mucsi, Nagyhajmás, and Závod. This region, however, is an artificial construct, with its settlements historically lacking unity based on administrative, natural, or Germanic cultural factors (Szenyéri, 2023).

In 2020, the data set for the aforementioned 14 settlements was supplemented with statistical and archival data for Jágónak, Kaposszekcső, and Csikóstőttős. These three villages, located near Dombóvár, have historically significant German communities, making their inclusion essential for a comprehensive understanding of the German community's historical and present circumstances around Dombóvár.

The volume, like its predecessors, analyzes population changes for these settlements based on census data up to 2011. The 2022 census data are processed and interpreted in this work. To ensure reliable conclusions, a detailed analysis of earlier census data is also included. The first half of the paper examines official census data from 1990 to 2022 for the municipalities listed, with a focus on data concerning German nationality and mother tongue. The methodologies of individual censuses are briefly discussed to address challenges related to methodological inconsistencies. The results of the 2022 census are presented in detail, accompanied by tabular data and a map illustrating the distribution and proportions of the German community. Compared to the 2011 census, the number of self-identified ethnic Germans has significantly decreased. This decline prompted the use of a questionnaire survey to explore potential reasons behind this trend.

The primary aim of this study is to identify the factors contributing to the decline in self-reported German nationality in the latest census. A preliminary hypothesis suggests that increased assimilation among younger generations is a key factor. In contemporary society, traditional closed village communities are rare, resulting in diminished differences in language use and cultural preservation between rural and urban settings. Consequently, significant discrepancies between rural and urban responses were not anticipated.

Previous censuses did not allow dual identity reporting, whereas the 2022 census does. It is presumed that a substantial portion of the data reflects dual identity. However, the Hungarian Central Statistical Office (HCSO) has not provided municipality-level data distinguishing respondents who identified solely as German from those reporting dual identity. Before analyzing the responses, the following hypotheses were proposed:

1. Identification with German ethnicity has decreased, particularly among younger age groups.
2. The prevalence of native German speakers is higher among individuals aged 61 years and older.
3. No significant differences in nationality declarations are expected based on settlement type.
4. A considerable proportion of respondents will report dual identity (Hungarian and German).

METHODS

The questionnaire sample primarily targeted the German nationality population of Dombóvár and its surrounding areas. Dombóvár hosts a relatively large German community and an active national minority self-government, which has significantly contributed to previous publications and supported the dissemination of the questionnaire. Based on our network of contacts, two neighboring villages, Kaposszekcső and Csikóstőttős, were also included as key locations where we anticipated a higher response rate.

The German Nationality Municipality of Dombóvár assisted in involving other nearby municipalities in distributing the questionnaire. However, experience showed that its reach in these villages was more limited. In Dombóvár, the German community is relatively substantial yet small compared to the town's total population, whereas the surrounding villages are characterized by smaller but tightly-knit micro-communities. This led to the preliminary assumption that the distribution of responses between urban and rural areas would be roughly balanced. Given the non-random sampling method, a balanced representation of different age groups was not expected.

While our study sought to minimize self-selection bias, it is based on the assumption that individuals willing to complete the questionnaire are also more likely to express their identity during a census. This assumption, however, cannot be definitively proven, and the potential for bias remains.

The questionnaire incorporated elements from research conducted during our doctoral studies in the 1990s. However, the inclusion of dual identity options, consistent with the methodology of the most recent census, was a crucial update. Our aim was to develop a database capable of providing scientific insights into trends observed in official surveys.

The pilot phase of the questionnaire was conducted primarily within the German community of Dombóvár. Respondents had the option to complete the questionnaire in digital or printed form. Following the successful pilot, the survey was expanded to other municipalities and forums. To reduce respondent burden, the questionnaire was kept brief, taking no more than 10 minutes to complete.

The primary tool for data collection was a Google form, shared on social media and optimized for various devices, including mobile applications. Software tools facilitated data capture, processing,

and visualization, allowing for efficient management and analysis of responses. Particular care was taken to ensure respondent anonymity. Instead of asking for the exact municipality name, respondents provided population size categories, ensuring full compliance with data protection standards.

Building on our 2023 publication (Szenyéri, 2023), book launch events were organized in municipalities with significant populations, including Dombóvár, Mágocs, Kaposszekcső, and Hőgyész. During these events, attendees were invited to complete the questionnaire. A QR code allowed for easy access to the digital form, while older participants could use traditional printed questionnaires. Approximately 20% of responses were collected through the traditional method, with the remainder preferring the online format. For consistency, manually completed questionnaires were digitized for analysis.

Respondents primarily hailed from municipalities where scientific lectures were held, reinforcing population categories for these locations in the sample. Smaller towns, particularly Mágocs, showed high response rates, likely due to strong attendance at the book launch. Additionally, support from the teaching staff of Bonyhád High School encouraged student participation, further enriching responses from municipalities with populations exceeding 10,000. This inadvertently introduced a bias favoring urban respondents in the sample.

The survey specifically targeted individuals who still identify as German to some extent, intentionally excluding those who, despite having German ancestry, have fully assimilated and identify as Hungarian. To ensure this, the questionnaire required participants to select „German" or „dual identity" when answering questions about nationality and mother tongue. Respondents choosing „other" were not allowed to proceed.

Out of 302 participants, 256 met the preliminary criteria, and their responses were included in the analysis. The questionnaire's first nine questions were straightforward multiple-choice items, designed for quick completion. Questions 10 and 11 addressed oral and written German proficiency, with clear and graded response options. Even-numbered choices ensured respondents actively selected a preference rather than defaulting to the midpoint. The survey concluded with additional questions about language proficiency, enabling a comprehensive assessment of language use and identity.

RESULTS

Changes in the number of Germans between 1990 and 2022

In 1990, the official census data revealed that more people identified as native German speakers than as ethnic Germans. Specifically, 43% more individuals identified as native German speakers than those who declared themselves as ethnic Germans. This discrepancy was particularly noticeable in settlements with larger German communities. In Dombóvár, for example, there were 104 native German speakers and only 54 ethnic Germans. In Hőgyész, the figures were 146 native German

speakers and 52 ethnic Germans, and in Mágocs, 158 native German speakers compared to 141 ethnic Germans, all favoring the mother tongue (Table 1).

The 2001 official census, conducted using a completely new methodology, introduced additional questions to better understand language use. In addition to asking about mother tongue and nationality, respondents were also asked: (a) which language is used in family and friendship circles, and (b) with which nation's cultural values and traditions they associate their language. The results showed that most respondents prioritized national cultural attachment over national identity (Szenyéri, 2019, 2023). The influence of nationality organizations on shaping the new methodology played a key role in these changes (Lakatos, 2024).

By the beginning of the 21st century, the negative associations linked to post-WWII experiences had faded for younger generations. Even though many people no longer spoke their national languages fluently, they still felt it was important to express their origins and chose to declare their nationality. In contrast, the mother tongue, though still widely used, had become less emphasized as Hungarian increasingly dominated in most families and communities (Szenyéri, 2019, 2023).

Between 1990 and 2001, the number of people declaring their mother tongue decreased by 13%, while the number of nationality declarations nearly doubled. The increase was particularly significant in larger settlements: in Dombóvár, the number of nationality declarations rose from 54 to 215; in Hőgyész, from 52 to 566; in Mágocs, from 141 to 161; and in Kaposszekcső, from 58 to 76. The most notable case was Hőgyész, where the number of nationality declarations increased more than tenfold (Table 1).

Some researchers have proposed that the steep rise in nationality declarations could be attributed to a phenomenon of dissimilation, especially in ethnically mixed families. Tóth and Vékás (2008) examined responses from these families and found that 52% of men and 44% of women in mixed marriages reported some German affiliation. Additionally, the proportion of children with at least one parent who identified as German increased, particularly in Pest County.

In villages with smaller populations, where there were only a few German inhabitants, the 2001 data may have shown that the number of people declaring German as their mother tongue was slightly higher than the nationality declarations. For example, in Döbrököz, 11 people declared themselves as native German speakers, while 7 declared themselves as German by nationality. In Jágónak, the ratio was 3 and 1, in Kalaznó 4 and 3, and in Kisvejke 8 and 4. In the latter three settlements, therefore, a few more people declared their mother tongue as German than declared German nationality. It can be assumed that in these villages, it was the older age group who declared themselves as native German speakers (Table 1).

The questions „Who are Germans?", „How German?", „What are they German for?" were also posed by other researchers who dealt with the issue in detail (Hoóz, 2002). Even at that time, the question of whether people who were fully assimilated linguistically and almost fully assimilated culturally could be considered members of a national minority based solely on identity claims was a major methodological and scientific challenge.

Table 1. Number and proportion of German speaking and German ethnic population in settlements around Dombóvár in 1990 and 2001

Settlement	A (1990)	A (2001)	B (1990)	B (2001)	C (1990)	C (2001)	D (1990)	D (2001)
Csibrák	0	1	0,0	0,2	0	2	0,00	0,4
Csikóstőttős	86	40	9,0	4,0	79	57	8,20	5,7
Dombóvár	104	126	0,4	0,4	54	215	0,20	1,5
Döbrököz	4	11	0,1	0,5	1	7	0,04	0,3
Dúzs	11	13	4,1	4,2	10	20	3,70	6,6
Hőgyész	146	183	4,6	5,8	52	565	1,60	11,3
Jágónak	3	3	0,9	0,0	0	1	0,00	0,3
Kalaznó	0	4	0,0	0,4	0	3	0,00	1,4
Kaposszekcső	64	43	5,6	3,1	58	76	5,00	5,5
Kisvejke	3	8	0,7	1,7	1	4	0,20	0,8
Kurd	33	19	2,4	1,3	23	18	1,70	1,2
Lengyel	13	37	1,2	5,4	17	63	1,60	9,2
Mágocs	158	87	5,8	3,1	141	161	5,20	5,8
Mekényes	30	25	8,5	7,5	36	29	9,80	8,7
Mucsi	9	15	1,9	2,7	8	19	1,70	3,4
Nagyhajmás	42	15	10,0	3,4	20	16	4,80	3,7
Závod	49	27	1,8	7,6	25	22	1,00	6,2
Összesen/átlag	755	657	1,9	1,7	525	1065	1,30	2,9

Comment: A = number of people whose native language is German (head) B = proportion of people whose native language is German (%) C = number of German ethnicity (head) D = proportion of German ethnicity (%).
Source: Digital database of censuses.

The 2011 census again used a different methodology. The question about cultural affiliation was removed, leaving only the option to indicate the language used in the family, in addition to the traditional categories of mother tongue and nationality. Of course, it was still possible for individuals to declare their identity according to all three criteria. Unfortunately, the data at the municipal level were not published separately for each category; all we know is how many people indicated their German origin „in at least one of the answers."

Tóth and Vékás (2013) published settlement-level data that showed their conclusions broken down by age groups. Their research was based on a comparison of official surveys from 2001 to 2011, looking only at individuals who had lived in the same municipality throughout, thus eliminating the potential biasing effects of natural reproduction and immigration. In particular, data from Pilisvörösvár were analyzed in detail. The results clearly showed that there was a significant increase in the number of German nationality declarations in the younger age groups. Additionally, there was also a significant increase in the number of ethnic Germans in the country, which the researchers considered evidence of dissimilation.

Others, however, did not fully identify with the concept of dissimilation. Referring to other studies (Biczó, 2011; Kiss, 2011), Tátrai considered the notion of hybrid identity more likely, according to which more and more people in the population have dual identities (Tátrai, 2014). According to him,

dual admissions alone do not explain the spectacular increase in the number of ethnicities, and therefore Gans (1979) proposed the concept of symbolic ethnicity. According to the guiding idea of this concept, ethnicity declarations do not require active practice or knowledge of culture and language, and thus do not necessarily imply ethnic revival (Gans, 1979, as cited in Tátrai, 2014).

In his other methodological studies, Kapitány collected data that are comparable across the three most recent censuses. His important conclusion is that „only among Germans are there signs of a national revival" (Kapitány, 2015, p. 84).

The changes between 2001 and 2011 in the settlements around Dombóvár were also in line with the trends shown by the cited researchers. In 2001, the permanent population of the 17 settlements surveyed was 36,739, of which 1,179, or 3.2% of the population, declared themselves as German. By contrast, in 2011, the number of people declaring themselves as German ‚by category' increased to 1,874, despite the fact that the total permanent population of the 17 municipalities had fallen to 33,739. This represents 5.5%, which is a nearly 60% increase in the propensity to declare (Hungarian Central Statistical Office [HCSO], 2001, 2011).

Compared to the previous census, the proportion of the German minority has increased significantly in Döbrököz, Csikóstőttős, Kaposszekcső, Kurd, Závod, Nagyhajmás, Mágocs, Jágónak, and Csibrák. Although this increase in numbers does not always represent an extraordinary rise, as Csibrák and Jágónak had very low initial figures, with the exception of Mucsí and Kalaznó, the number and proportion of Germans increased noticeably in almost all areas (Table 2). In Csibrák and Dúzs, the population of German ethnicity is so small that the proportions alone only cover a few people. Of the municipalities with a significant German population, only in Hőgyész was there a minimal decrease in the number of Germans, while in Dombóvár and Mágocs there was a significant increase (Table 2, Szenyéri, 2019).

In the 2022 census, as in the 2001 and 2011 surveys, there were three voluntary questions: mother tongue, nationality, and language used in the family and friendship circles. For statistical purposes, anyone who indicated an ethnicity other than Hungarian for at least one question was considered to belong to the given nationality.

However, there was a significant change from the previous survey methodology, as two response options were available for all three questions. As a result, those who chose Hungarian in addition to German were included in the database as being of German nationality. Unfortunately, the official data do not provide details on how many respondents indicated a pure German ethnicity and how many chose dual identity.

Based on the trends of previous censuses and the possibility of dual identity, it could be expected that the number of people of German nationality would not decrease but would increase significantly. On the contrary, there was a dramatic shrinking of the German nationality population in the surveyed settlements around Dombóvár: compared to 2011, the number of ethnic German declarations decreased by 52%. Only in Döbrököz did the number stagnate, in Csikóstőttős, Dombóvár, Závod, and Kaposszekcső the decrease was slightly below average, but in many places, it exceeded 60%.

Table 2. Number and proportion of German ethnic population in settlements around Dombóvár based on census taken in 2011

Settlement	Nationality (%)	Nationality (people)	Change 2001–2011 (%)
Csibrák	5,2	14	700
Csikóstőttős	9,1	80	40
Dombóvár	2,8	543	65
Döbrököz	2,8	60	857
Dúzs	3,3	9	-45
Hőgyész	10,9	324	-8
Jágónak	3,7	9	900
Kalaznó	0	0	0
Kisvejke	29,5	121	30
Kaposszekcső	7,6	115	51
Kurd	6,6	85	472
Lengyel	15,7	86	36
Mágocs	12,8	314	195
Mekényes	7,6	22	-24
Mucsi	2,1	10	-48
Nagyhajmás	7,7	29	181
Závod	18,0	53	241

Source: HCSO, 2011

The largest loss of German nationals was in Mekényes, where a 68% decrease was recorded. The number of native speakers remained well below the number of ethnic Germans: the 221 native German speakers in the municipalities accounted for only 24.4% of the total German population (Table 3). In 2011, there were still German communities with more than 300 inhabitants, but by 2022, even in Dombóvár, which has the largest community, there were only 276 inhabitants. In 2011, there were still municipalities with a German population of more than 20%, but by 2022, only Závod and Kisvejke remained above 10% (Figure 1).

In settlements where there was already a small German community in 2011, the decline of a few individuals represented a larger percentage of the population. Outside Mekényes, examples of this type include Nagyhajmás, Mucsi, and Dúzs (Table 3). The variation in the number of different nationalities in the country is not only an academic issue. The number of ethnic groups is a fundamental determinant of their chances of gaining political representation in the Hungarian Parliament (Tar, 2015).

Census data and trends are summarized in Table 4. The data show that the way in which identity is assumed has changed significantly over the decades. After the dominant role of mother tongue in 1990, nationality declarations gradually increased and eventually surpassed those of mother tongue by a significant margin. Methodological changes emphasized cultural attachment and later the role of language within the family. The 2011 survey revealed a growing German identity among younger generations, but this trend declined dramatically in the 2022 survey. The possibility of dual identity

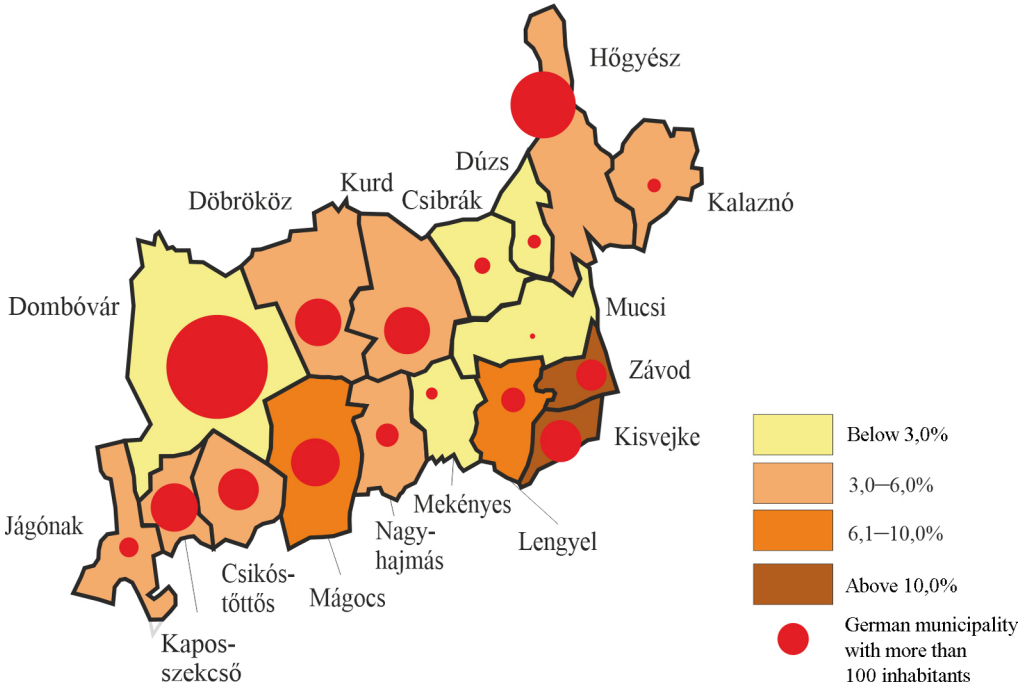
has not been sufficient to halt the decline in both the proportion and number of people identifying as German nationals.

Table 3. Number and proportion of German ethnic population in settlements around Dombóvár based on census taken in 2011

Settlement	Nationality (%)	Nationality (people)	Change 2011–2022 (people)	Change 2011–2022 (%)
Csibrák	2,1	6	-8	-58
Csikóstőttős	5,8	43	-37	-47
Dombóvár	1,5	276	-267	-49
Döbrököz	3,3	59	-1	-2
Dúzs	1,7	4	-5	-56
Hőgyész	4,3	113	-211	-65
Jágónak	4,0	9	0	0
Kalaznó	3,3	4	+4	uninterpretable*
Kisvejke	12,4	44	-77	-64
Kaposszekcső	3,8	58	-57	-50
Kurd	5,4	55	-30	-65
Lengyel	6,5	32	-54	-63
Mágocs	6,6	140	-174	-55
Mekényes	2,6	7	-15	-68
Mucsi	0,9	4	-6	-60
Nagyhajmás	3,6	10	-19	-66
Závod	15,9	39	-14	-26

Comment: As the data from Kalaznó (2011) is 0, it cannot be interpreted in relation to the increasing index, as it is impossible to multiply or divide by 0. Source: HCSO, 2022

Figure 1. Number and proportion of German ethnic population in settlements around Dombóvár based on census taken in 2022



Source: Own edition based HCSO, 2022

Table 4. Cummulative data of sensus method and its results (1990–2022)

Methodological features	1990	2001	2011	2022
Number of questions	2 (mother tongue, nationality)	4 (mother tongue, nationality, family/ friend language, cultural attachment)	3 (mother tongue, nationality, family language)	3, but you can choose between two answers (mother tongue, nationality, family language)
Methodological change	Traditional categories	New methodology including cultural attachment	Cultural attachment issue abandoned	Introduction of the possibility of dual identity
Trends in ethnicity data	Native language declarations > Nationality declarations	Duplication of ethnicity data	Growth in younger age groups	Dramatic reduction
Changes in mother tongue data	Native language data dominated	13% decrease in mother tongue declarations	Mother tongue remains less important	Only 24.4% native German speakers compared to German nationalities
Trends in ethnicity rates	German communities dominated in larger settlements	Increase (Examples: Dombóvár +3.2%, Hőgyész 10-fold increase)	Significant increase, (5.5% average rate in the study area)	Significant decrease (average: -52%)
Ethnic phenomena	Assimilation (language dominance: Hungarian)	Dissimilation (strengthening cultural identity)	Dissimilation, symbolic ethnicity	Further hybrid identity, decline of German communities
Demographic effects	Significant number of mixed marriages	Ethnic growth by age group, local stability	Decreasing population but increasing ethnicity	Decrease in population accompanied by decrease in proportion
Significant consequences after the census	Social changes along linguistic dominance	Possibility of ethnic political representation strengthened	Phenomena of ethnic revival among Germans	Decline also affects political representation

Socio-demographic and geographical characteristics of the target group

The vast majority of respondents to the questionnaire are women. There are two main reasons for this: firstly, there is significant national over-representation of women in the over-60 age group. On the other hand, single women were also the majority among the participants in the lectures and the respondents reached through the various channels. Additionally, there was a noticeable increase in the number of girls among the students of the Bonyhád and Dombóvár high schools, which contributed to the female surplus in the younger age groups (Figure A2, see Annex).

In the censuses, citizens under the age of 18 are not allowed to be official respondents, but it was considered important to gather data from this age group. Therefore, they were included as one of the surveyed age groups. Unfortunately, we were unable to recruit a sufficient number of respondents in this age group, despite my efforts as a secondary school teacher to invite my students to participate. The only 6 respondents represent 2% of the total respondents. Few responses were also received from the 19–30 age group, while the vast majority of completions, 75%, were from the 31–60 age group (Figure A3).

Around two-thirds of respondents are urban dwellers. In addition to the small town categories of over and under 10,000 inhabitants, there were also a smaller number of respondents from the county and the capital. A more significant proportion of respondents living in villages came from municipalities with a population of over 1,000. This is mainly because one of the promotional lectures,

in Kaposszekcső, is located in this population category, and many people completed the questionnaire there (Figure A4).

If we relate the population size to the age composition of the survey respondents, meaningful conclusions can mainly be drawn from the 31–60 and 60+ age groups, due to the sufficient number of respondents in these groups. In the 31–60 age group, the proportion of urban dwellers in municipalities with a population over 10,000 is 45%, slightly over-represented compared to the average (43%). In the 60+ age group, however, the proportion is 39%, below the average (Figure A5).

One of our preliminary hypotheses was confirmed, as a fraction of respondents indicated a purely German nationality. Out of 256 respondents, only 42 (16%) declared themselves as exclusively German. Furthermore, this hypothesis was confirmed among the older age groups, where pure German nationality declarations dominated. The proportion of dual nationality declarations may decrease with age, as evidenced by the fact that, for the 60+ age group, dual declarations account for only two-thirds of the responses. At the same time, 85% of respondents aged between 31 and 60 said they were both Hungarian and German (Figure A6).

The hypothesis that pure German mother tongue declarations would be sporadic and primarily among older people also proved to be true. Out of 256 respondents, only 10 declared themselves as native German speakers, which represents only 4%. In our previous publications (Szenyéri, 2018, 2019, 2023), we also raised the question of to what extent someone can be considered part of a nationality if they no longer have a connection to the language as their mother tongue. This holds true even when we consider the fact that knowledge of German is widespread and high among the respondents (Figure A7).

The ten native German speakers are evenly distributed between the two oldest age groups. Proportionally, this is 10% for the 60+ age group and only 3% for the younger age group. There is clear evidence that age has a significant influence on pure German mother tongue declarations. This is further confirmed by the fact that dual mother tongue speakers were only found in these two age groups, with 34 people, representing 13% of the respondents. The total number of respondents who had any form of German mother tongue was 42, representing only 16% of the respondents. These proportions are not surprising, as in today's modern society, people tend to adopt Hungarian as their first language, so that even in a family with ethnic roots, it becomes the true mother tongue (Figure A7).

As the German mother tongue has virtually disappeared in the younger age groups, and nationality declarations are mostly limited to dual identity with a few exceptions, it is clear that assimilation has accelerated among them. It can be argued that this trend is largely responsible for the decline in German nationality declarations in the official census data. The primary role of German in everyday use has virtually disappeared, with only 3 out of 256 respondents indicating that they use the language regularly (Table 5). The data in the table also clearly show that within each age group, there is an almost identical distribution of responses in terms of the number and proportion of people using German as a mother tongue and as a language used in everyday life. Only among those who marked

German as their mother tongue is regular use expected. In essence, only in the older age groups was there a higher proportion of Hungarian and German used together as mother tongues (Table 5).

Table 5. Distribution of respondents based on mother tongue and language used in family according to their age (people and %)

Age group	Mother tongue data			Used language data		
	Hungarian	Hungarian and German	German	Hungarian	Hungarian and German	German
Under 19 years	1,95%	0,39%	0,00%	1,17%	1,17%	0,00%
19–30 years	3,52%	0,39%	0,00%	3,13%	0,78%	0,00%
31–60 years	62,50%	10,55%	1,95%	62,11%	12,11%	0,78%
Over 60 years	14,06%	2,73%	1,95%	14,06%	4,30%	0,39%
Under 19 years	5 people	1 people	0 people	3 people	3 people	0 people
19–30 years	9 people	1 people	0 people	8 people	2 people	0 people
31–60 years	160 people	27 people	5 people	159 people	31 people	2 people
Over 60 years	36 people	7 people	5 people	36 people	11 people	1 people

This low number is particularly surprising, given that German grandparents on both sides of the family are in the majority in the families of the respondents. 55% of respondents have two grandparents of German origin on the paternal side, compared to 52% on the maternal side. These figures hold true for younger age groups as well, so the presence of grandparents of German origin is still significant. However, these roots are becoming less important in nationality declarations (Figures A8 and A9).

We also examined the number of people in each age group who have all four grandparents of German origin, i.e., who can be considered fully German in principle. No such individuals were found in the younger age groups, while 45 people (23% of all respondents) in the 31–60 age group belong to this group. In the 60+ age group, those of entirely German origin account for 58% of the age group. These proportions further demonstrate the progression of natural assimilation, with more and more mixed marriages as age decreases. Nationality declarations do not necessarily reflect origin accurately.

Among those aged 31–60, fewer declared themselves to be of pure German nationality than those of pure German origin. Only 18.5% declared themselves to be exclusively German, which is about 5% lower than the proportion of those with only German ancestry. The difference is even greater for those aged 61 and over: only 33% declared themselves as exclusively German, whereas the majority of them have exclusively German grandparents. This shows that a shift towards a partial Hungarian identity is evident even among those who would not have been expected to do so based on their ancestry (Figure A10).

Language use characteristics

Although German ancestry persists to a large extent, as a result of assimilation, most respondents assume only a dual national identity, and the German mother tongue has almost disappeared. This trend could not be offset by the fact that the majority learned the language at school and/or at home. 51% of respondents (131) indicated that they had learned German in this way, while 39% had learned

it exclusively at school, and only a few said that they did not speak German at all. The role of the family and school in language development and cultural transfer is important, but in 21st-century Hungary, these alone are no longer sufficient to halt the assimilation process (Figure A11).

An important aspect of the questionnaire was the precise and nuanced definition of the level of language proficiency. Many might have opted for a 5 or 7-point Likert scale as the method of analysis, but we deliberately divided the response options into six categories. One of the main reasons for this is that by eliminating the middle option, respondents are forced to make a meaningful choice, thus avoiding the automatic selection of a neutral response, which could bias the results. This solution provides a more accurate picture of the participants' actual language skills and preferences.

The two questions with six qualitative response options, which aimed to assess the respondents' oral and written proficiency levels, also had the advantage of helping to answer the research questions. In fact, they allow for more subtle distinctions between respondents than a typical Likert scale. Since there is no middle „neutral" response option, each respondent has to select a specific level, providing a more precise picture of the overall level of knowledge and its distribution. This method encourages participants to think more carefully about where they stand on the scale, thereby enhancing the quality of their responses.

The use of a six-point qualitative scale provides an opportunity to explore the subtle differences in language proficiency more precisely. This was particularly important for us as we analyzed the data by age group. This type of qualitative scale ensures that responses are well-separated and not clustered around the mean, thus providing more accurate and detailed results.

Out of 256 respondents, 237 rated their own language proficiency, while 19 (8%) indicated that they did not speak German at all (see previous question). More than half of the respondents (57%) chose the two lowest levels of proficiency, indicating that they spoke only minimal or intermediate German. 16% of respondents declared themselves to be at an intermediate level, while 14% indicated fluency in German at a non-native level. Only 30 respondents selected levels at which they considered their knowledge of German to be above that of Hungarian, and only 2 respondents declared that they spoke German better than Hungarian (Figure A12).

The responses suggest that high levels of proficiency in German are rare, indicating that German is not a mother tongue. This aligns with the fact that language proficiency is often linked to issues of national identity, cultural heritage, and ancestry. The results show that although the average language proficiency is higher than expected based on identity commitment, higher language proficiency does not necessarily imply a commitment to an exclusive German identity. Instead, it indicates the co-presence of Hungarian and German identities.

The written use of a foreign language requires considerable language skills and practice, so we anticipated that many people would not use German in writing. Surprisingly, 41% of respondents (99) indicated that they did not write in German at all (Figure A13), confirming that German is primarily spoken, while writing has taken a significant back seat.

The two lowest levels were chosen by the majority of respondents: 51 said, „I write very little German; I can barely understand myself," while 43 said, „I write quite well, but my knowledge is far from perfect." Due to the low response rate of respondents under 30, no significant trends can be identified in this age group. However, more robust conclusions can be drawn for older age groups. The response, „I am good in German, but I am much better at writing in Hungarian," was given by 32 respondents. A higher level of writing in German was chosen by 22 respondents, who selected „I write much better in Hungarian, but I express myself perfectly in German." It is interesting to note that 30 respondents indicated a fluent, almost native-like level of German writing. However, only three respondents, mostly from the older age groups, indicated that they preferred writing in German over Hungarian (Figure A14).

In the 31–60 age group, level 2 was the most frequently chosen option, with no significant differences between levels 3–5. The weakest and strongest categories were chosen by few. The responses of those aged 61 and over were more balanced between levels 2 and 5, indicating that higher levels of written German are still present in this group.

Documented language skills and language test results

The questionnaire also examined the existence of documented language proficiency, as language exams represent a standardized level, making the results readily comparable with self-reported language use data. Younger age groups were expected to have more language exams due to work and higher education requirements. However, the responses partly contradicted these expectations: 118 respondents had a language test, while 119 did not. The „no" response was predominant among those under 30, especially among those under 19, where the presence of a language exam is rare. Those aged 31–60 performed the best, with 55% having a language test (97 out of 175). Fifteen of those aged 60+ had a language test, which accounts for 33%. This is a relatively high figure, given that they are less likely to have achieved the required levels of further education and qualifications (Figure A15).

The high proportion of respondents with a language test confirms the reliability of the results on written and oral language skills and supports the above-average knowledge of German. Responses to the last question show a negligible proportion of non-complex language tests, highlighting the importance of full knowledge of the language. Only 16 people (7%) had a basic-level language exam, while there was an equal share of intermediate and advanced-level exams (46 each). A surprisingly high proportion of people have an advanced level of language proficiency, which confirms the high average level of language proficiency. The data also indicate that older age groups are more likely to have higher-level language exams: intermediate-level exams dominate among those aged 31–60, while higher-level exams predominate among those aged 61 and over (Figure A16).

CONCLUSIONS

The data from the questionnaire survey largely confirmed our preliminary expectations. In younger age groups, the assumption of a German identity is more likely, but it almost exclusively indicates a dual identity, meaning Hungarian and German nationality simultaneously. For those under 30, using German as a mother tongue is uncommon, and their language skills and usage are generally lower than those of older generations. In this group, the process of assimilation is faster, particularly if they marry and start families with non-German ancestors. In such cases, German is retained more as a foreign language, important for further education and career opportunities, but the cultural and moral commitment to the language is marginalized.

Among 31–60-year-olds, using German as a mother tongue is also rare. Although some may define themselves as exclusively German, the majority hold dual identities. They are of German origin, with at least two or three, and often all four, of their grandparents having German roots. In their childhood, German was more commonly used within family circles than it is for younger generations, but school-based language learning became dominant. Their stronger attachment to German culture is reflected in their higher average language proficiency compared to younger generations.

It can be stated that the majority of those aged 61 and over have neither learned nor use German as a mother tongue. This is clearly supported by official data and our questionnaire results. Most of their ancestors on both sides of the family are of German origin. For these individuals, the assumption of a German identity is primarily reflected in their nationality declarations. This age group contains the largest proportion of individuals identifying exclusively as German, though dual identities remain predominant. German is used more frequently and at a higher level, both in speaking and writing, as evidenced by the large number of language exams.

The conclusions above highlight that in today's modern, digital age, it is increasingly difficult to pass on cultural heritage to younger generations. As an educator, I find it more challenging to encourage their participation in traditional associations or groups. In their home environments, German no longer plays an active role. While the majority of parents still expect their children to learn German as a foreign language, it is no longer seen as a national language but rather as an opportunity for further education and career development. Given these circumstances, it is expected that future official surveys will show a steady decline in the number of people declaring German as their nationality.

Previous censuses showed an increase in nationality declarations, leading some researchers to hypothesize the possibility of increasing dissimilation among the German population in Hungary (Tóth & Vékás, 2008, 2013). However, recent trends unfortunately lead us to refute this assumption. Today, the vast majority of people who consider themselves of German nationality have at most a dual identity, and the current tendency to declare German as a nationality suggests that increasingly, people will identify as Hungarian in the future. Reversing this trend would be difficult, given the lack of systematic cultivation of cultural heritage and traditions in everyday life, and often a lack of knowl-

edge and use of German. Agreeing with the concept used by Tátrai following Gans, we can say that the majority of today's German nationality declarations are symbolic ethnicity (Gans, 1979, as cited in Tátrai, 2014). This suggests that mere self-declaration is no longer connected to the preservation of linguistic and cultural traditions, and in most cases, a higher level of language proficiency is absent.

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APPENDIX

Figure 2. Gender distribution of participants in the questionnaire survey (head count and percentage)

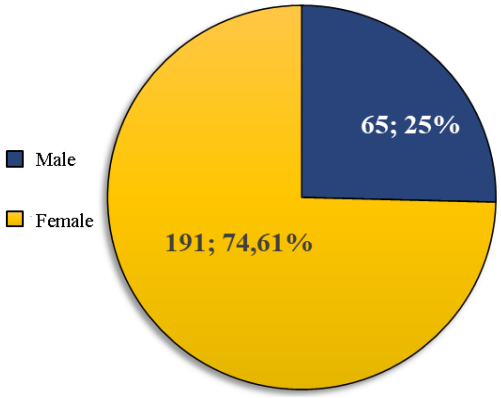


Figure 3. Age distribution of participants in the questionnaire survey (head count and proportion)

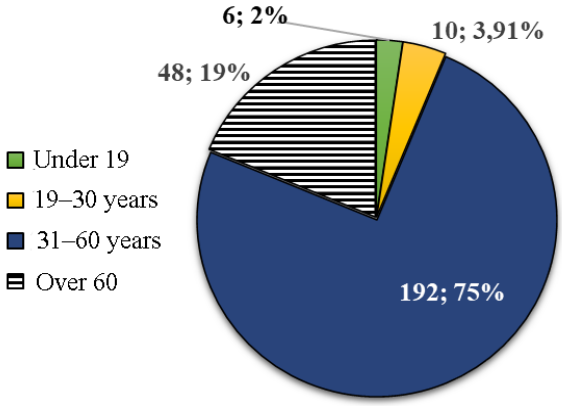


Figure 4. Distribution of participants according to their settlement types

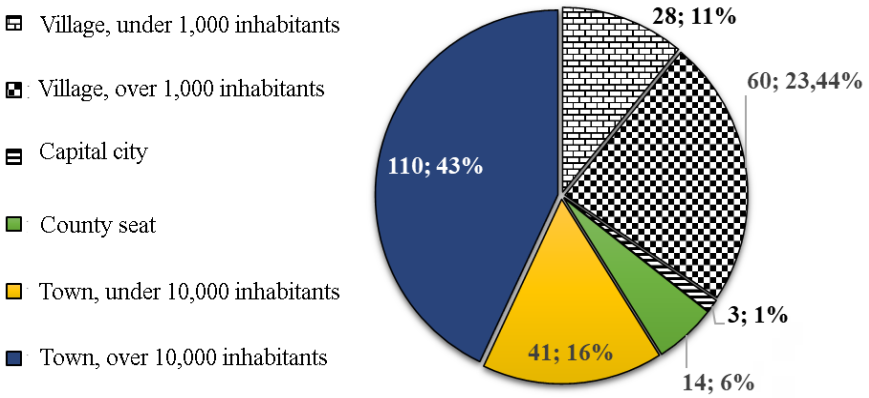


Figure 5. Age distribution of participants according to their settlement types

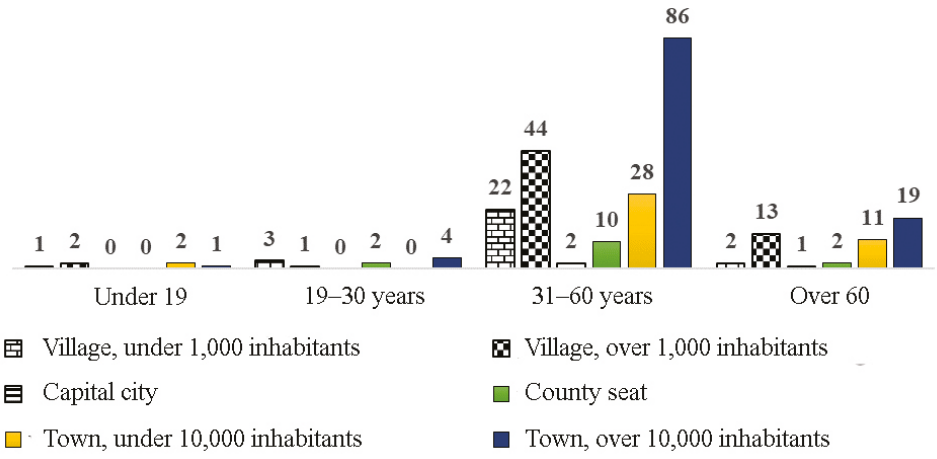


Figure 6. Distribution of participants based on self-identified ethnicity

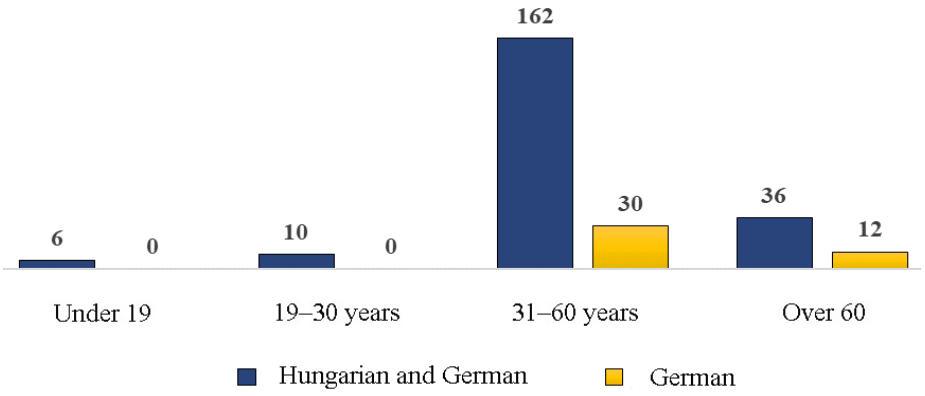


Figure 7. Distribution of participants based on self-identified mother tongue

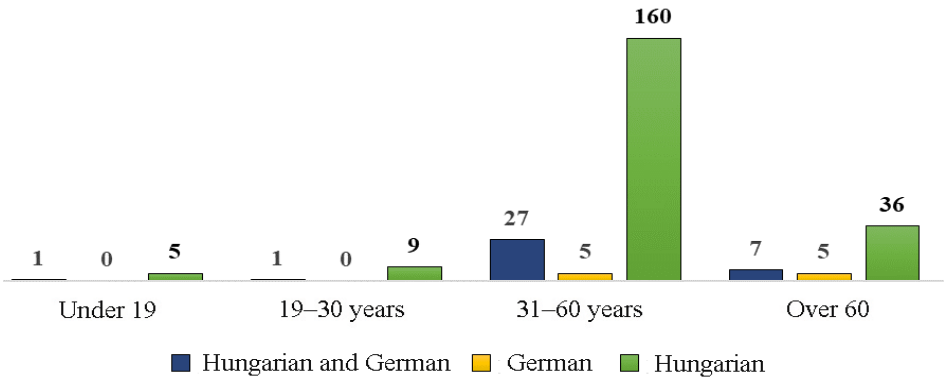


Figure 8. Age distribution of participants based on paternal ancestry

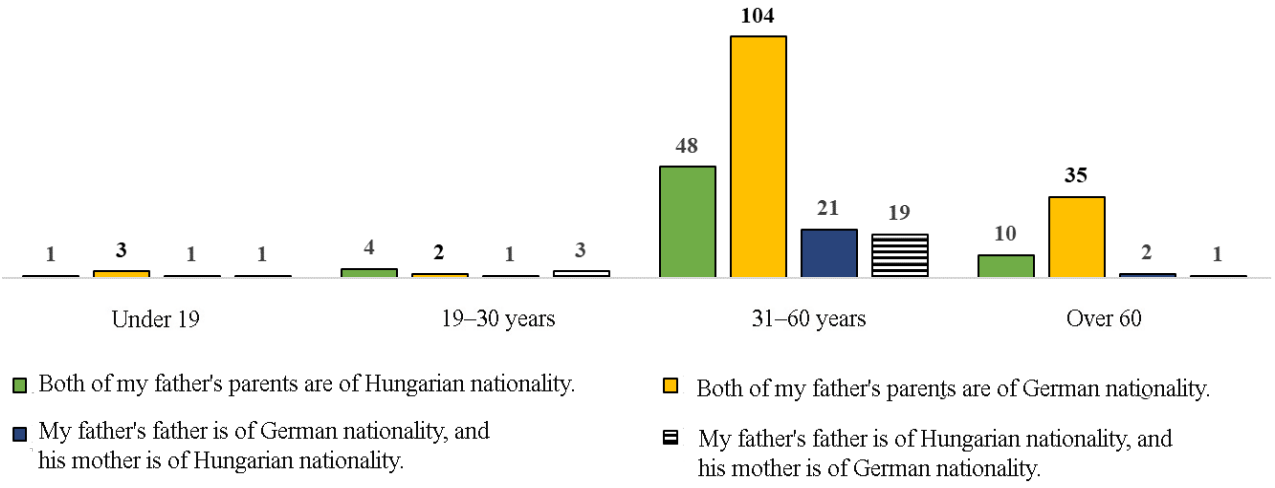


Figure 9. Age distribution of participants based on maternal ancestry

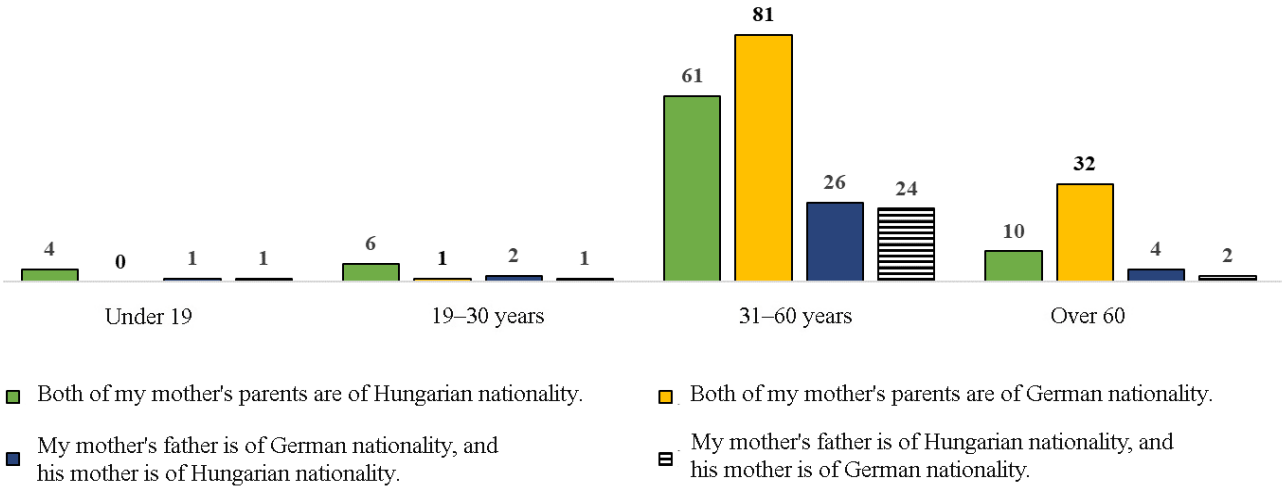


Figure 10. Age distribution of participants with full German ancestry (four German grandparents)

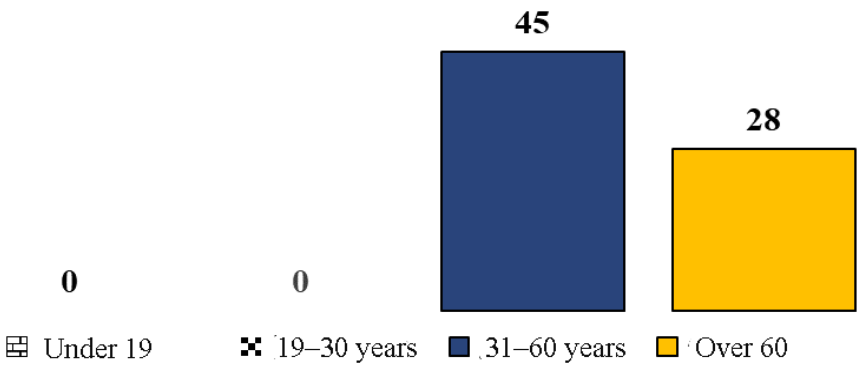


Figure 11. Age distribution of participants based on German language acquisition

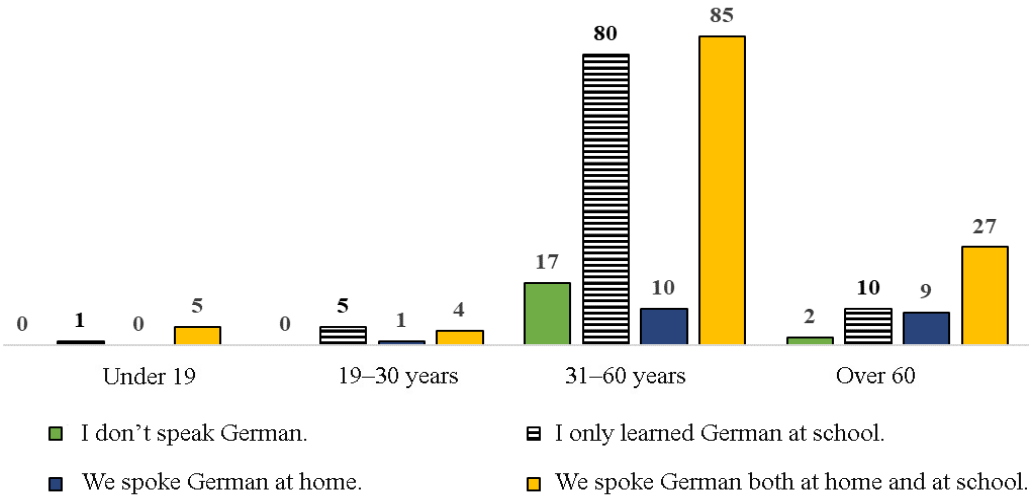


Figure 12. Age distribution of participants based on level of spoken German proficiency

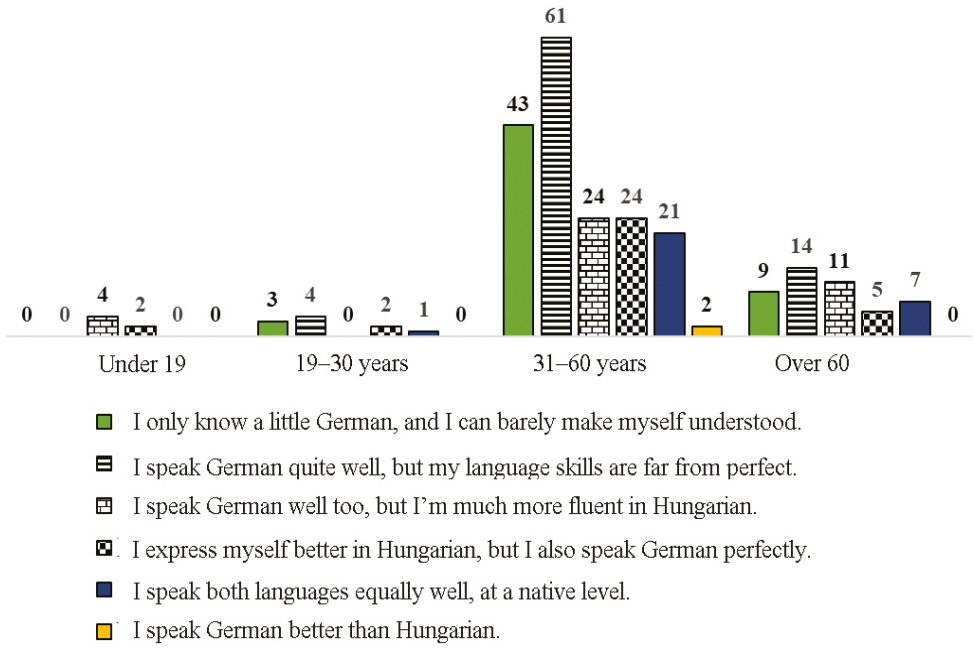


Figure 13. Age distribution of participants based on frequency of German language use

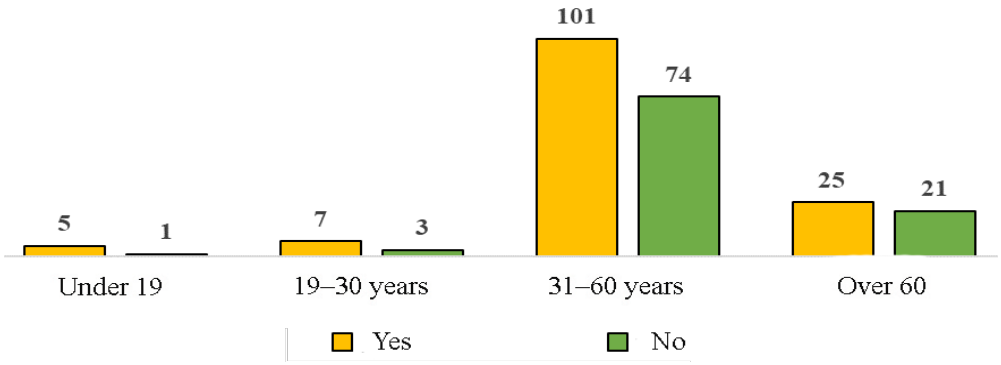


Figure 14. Age distribution of participants based on level of written German proficiency

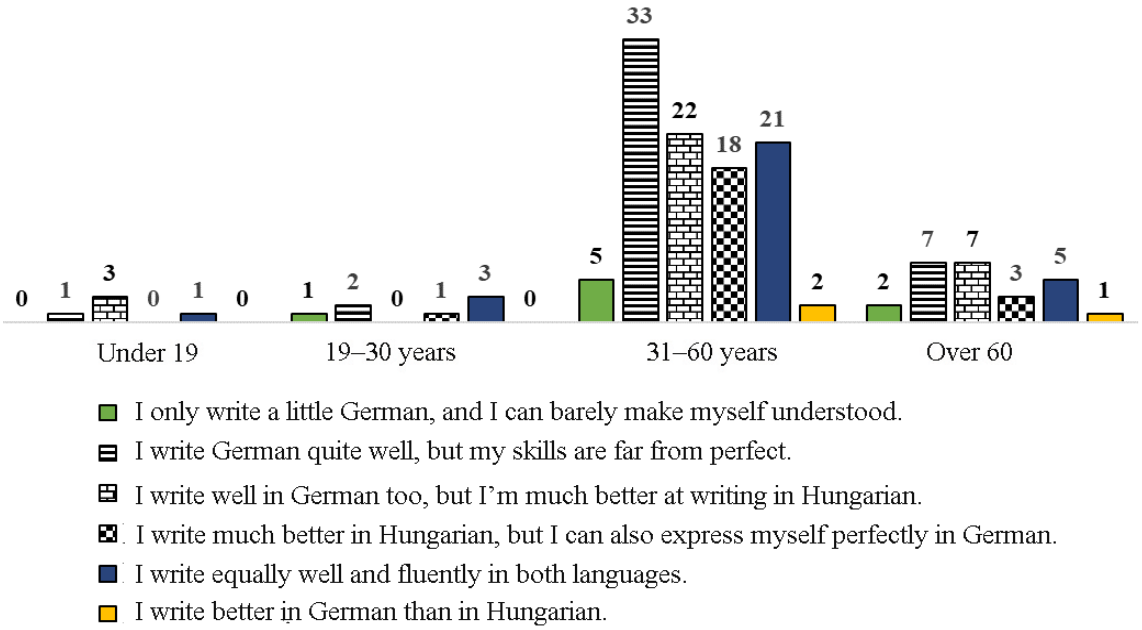


Figure 15. Age distribution of participants based on having a German language exam

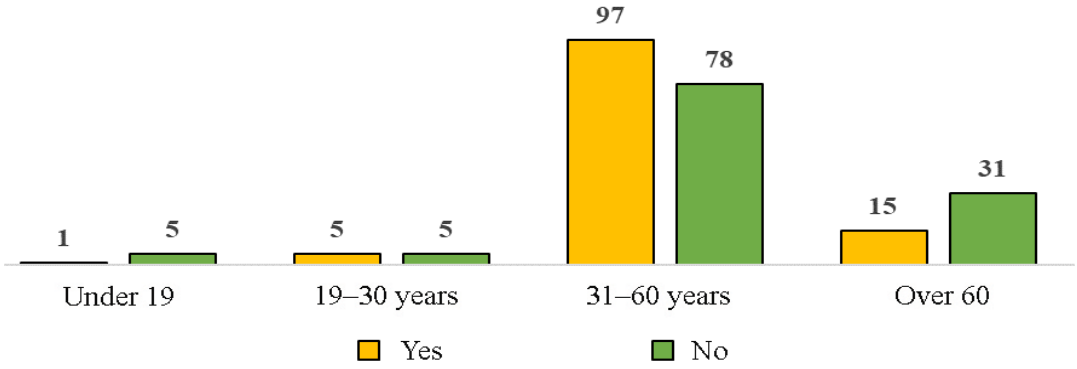
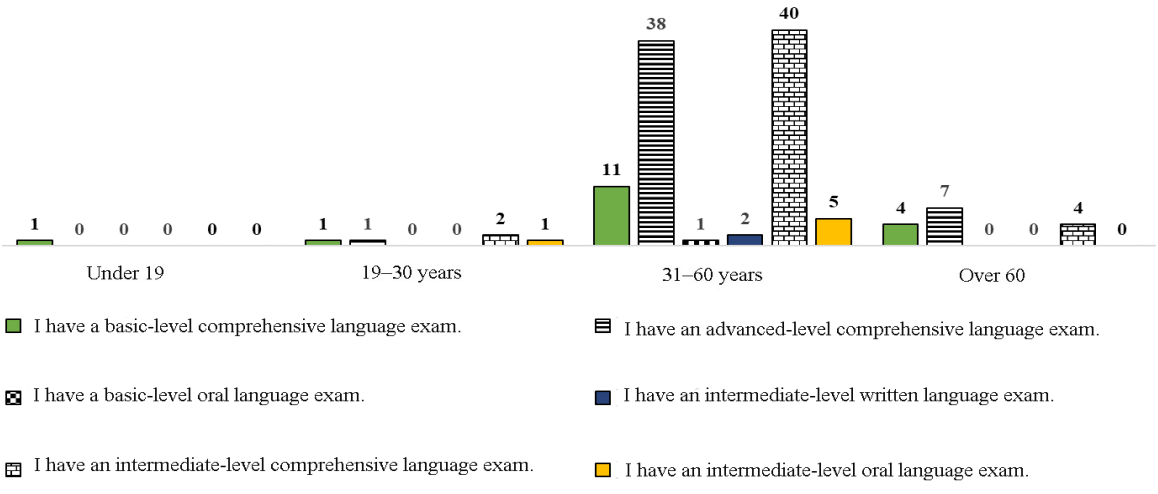


Figure 16. Age distribution of participants based on the type of German language exam they hold



Modern Geográfia
Vol. 20, Issue 2, 2025: 45–64
DOI: 10.15170/MG.2025.20.02.03

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Local Realities and the Adoption of Piecemeal Planning Practices in Mlandizi and Sirari, Tanzania

ABSTRACT

Urban planning through local governments is constrained by challenges that place significant burdens on planners. Local realities have a profound influence on planners' implementation of urban planning policies. This paper draws on the concept of street-level bureaucracy to examine how local realities shape the adoption of piecemeal planning in two small towns in Tanzania. Data were collected through surveys, in-depth interviews, focus group discussions, document reviews, and geospatial analyses of town planning drawings and satellite images. The findings indicate rapid and informal urbanization, evidenced by annual average population growth rates exceeding the national average. Additionally, the proportion of the population living in informal settlements is higher in small towns than in cities. Customary land rights and the informal land market have emerged as the primary drivers of informal settlements. Local governments exhibit low institutional capacity for urban planning, while local politics and market forces further influence the adoption of piecemeal planning practices. The results suggest that these local realities and their interplay create multifaceted complexities, compelling planners to implement urban planning policies in alternative ways. Consequently, piecemeal planning is employed as a strategy to navigate the complexities of urban planning in these two small towns. It is recommended that collaborative efforts between the public and private sectors are essential to integrate structure planning with piecemeal planning, thereby promoting orderly urban development.

Keywords: local realities, piecemeal planning, small towns, street-level bureaucracy

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INTRODUCTION

Urban planning practices are guided by universally advocated planning approaches, which, in turn, are grounded on diverse philosophies and in theoretical and conceptual contexts (Watson, 2016). The approaches typically include master planning, strategic planning and integrated urban development planning, which are generally referred to as general planning schemes. The approaches are aimed at guiding urban development and improving the liveability of urban settlements. The approaches are not static; they evolve in response to the changing social, economic and political conditions obtained in urban settings (Oldfield, 2014; Watson, 2016). One specific type of planning practice, namely piecemeal planning, is predominant in Tanzania, particularly in its small towns. Many small towns in Tanzania have been planned using the piecemeal planning approach to provide minimum planning solutions (Yamungu, 2022). Again, Yamungu (2019) found that piecemeal planning has a likelihood of advancing sustainability. Sustainability is used here to mean the ability of the urban plans to promote harmony with nature, promote place-based economies and provide housing built in planned areas. It draws on the Sustainable Development Goals 2030 to advocate comprehensive analysis as an integral part of the urban planning process. However, piecemeal planning has certain shortcomings, production of incompatible land uses, uncoordinated spatial organisation, urban sprawl and unfriendly environmental practices (Chigara et al., 2013; Sawyer, 2014; Yamungu, 2022). These shortcomings make piecemeal planning unsustainable; this planning approach also departs from the principles of urban planning which require the setting of future development goals which are based on past and current situations (Chigara et al., 2013; Keeble, 1964; Ryser & Franchini, 2015). However, piecemeal planning can be enhanced to provide practical planning solutions for small towns and emerging urban centres.

The criteria for categorising human settlements indicate that any human settlement with fewer than 30,000 people is considered a small town, provided it has the minimum required array of urban services and the potential to urbanise (Donaldson & Marais, 2012; Knox & Meyer, 2013; Satterthwaite, 2016). Small towns are generally 'sidelined' by research and urban development strategies, which put them on the periphery of the urban development agenda. Cottyn (2018) calls for the directing of efforts to address urbanisation challenges towards both cities and small towns. Therefore, the role of urban planning in achieving sustainable urban development cannot be overemphasized (Duminy et al., 2014; United Nations, 2015a). It is projected that the world's urban population will reach 70% by 2050. The bulk of the global urban population increase will occur in developing countries whose combined population increase is expected to reach 80% by 2050 (UN-Habitat, 2022; Berdequé & Soloaga, 2018). Apart from these global projections, scholars have also noted that a considerable portion of the world's urban population will be living in small towns and that intermediate-sized urban centres will have populations ranging from 5 000 to 100 000 people (Cottyn, 2018; Emran & Shilpi, 2018; Satterthwaite, 2018).

Small towns should be considered part of the global urban landscape as they play an important role in urban and regional, local, and economic development (Donaldson et al., 2012; Emran & Shilpi, 2018). They also serve as intermediary places for urban and rural settlements, thus helping to define functional relationships in human settlement hierarchies (Cottyn, 2018; Hsu, 2012; Mulligan et al., 2012). Small towns provide numerous services in the urban landscape including trading and market centres (Taylor et al., 2010; Satterthwaite, 2016; Berdegué & Soloaga, 2018), as well as heritage and tourism destinations (Rogerson & Rogerson, 2024; Köbli, 2021). Such functions have the potential to reduce rural-to-urban migration. To effectively play their role, small towns need to be planned in a manner that ensures their sustainability. Thus, planned and managed small towns can lead to the development of orderly and serviced urban centres capable of reducing the rate of migration to larger urban centres.

Tanzania's planning procedure requires the preparation of general planning schemes (GPS) in the form of master plans or interim land-use plans for both large and small urban centres. Such comprehensive plans should then be implemented through a series of detailed planning schemes (DPS). It is a requirement that DPS conform to GPS to promote sustainable development (United Republic of Tanzania, 2007). The current planning practices in Mlandizi and Sirari small towns involve the preparation of DPS in the absence of GPS, which contravenes the country's urban planning policy (Yamungu, 2019). On the contrary, the two-tier planning approach is not adhered to, which raises questions about the contribution of local realities to the adoption of piecemeal planning in Mlandizi and Sirari and whether council planners have any discretion while implementing urban planning policies. This paper investigates the local realities that influence the adoption of piecemeal planning by the council planners in the Kibaha and Tarime district councils through the theoretical lens of street-level bureaucracy.

Street-level bureaucracy, developed by Michael Lipsky in 1969, is about the dilemmas of front-office workers which result from work pressure as the associated influence on policy implementation. According to Lipsky (1980), street-level bureaucrats are civil servants who interact directly with citizens during the discharge of their responsibilities. They have substantial discretion in that process, which impacts the way they implement policies. Lipsky's ideas are drawn upon to reflect on the local-level implementation of planning policy by the council planners. In Tanzania, the Urban Planning Act of 2007 provides planning responsibilities to local government authorities. Local government authorities have employed town planners to discharge planning responsibilities on behalf of the councils. This makes the planners responsible for translating planning policy into local planning actions and outcomes through interaction with the general public. The town planners in the local governments find themselves at the interface between institutional procedures and the perceived local realities (Hudson, 1997; Lipsky, 1980). Thus, as street-level bureaucrats, they invent new routines to cope with uncertainties resulting from their working conditions.

The adoption of piecemeal planning is one such new routine. Piecemeal planning results from planners' implementation of planning policy in the way they think makes planning better (Proudfoot & McCann, 2008; Yamungu, 2019). Besides, the new inventions by town planners constitute a new

policy which can have an impact on a given urban area. Scott & Stroper (2015) regard urban areas as containers with specific social, economic and political realities, which define their nature. Thus, local realities are not constant and are not the same in all urban planning contexts because "the specificities of any urban governing context are produced by the confluence of a locality's institutional, political, socio-cultural and economic settings" (McGuirk, 2000, p. 654).

Understanding local realities and their influence on urban planning practices is central to examining the role of town planners in bridging the gap between planning theory and practice (Storper & Scott, 2016; Watson, 2002). This paper focuses on the planners working in local government because they constitute the largest proportion of registered town planners in Tanzania. Their interaction with the general public exposes them to what Watson (2012) refers to as stubborn realities. As planning authorities, local governments face certain challenges relating to urban planning. Such challenges fall on the shoulders of the responsible planning officer, who is subjected to a periodic performance review. Institutional challenges put such town planners in dilemmas that make the adoption of piecemeal planning as a coping strategy unavoidable. This is exemplified by the current planning practices, including those used in the Mlandizi and Sirari small towns. The discussion aligns with Buchanan's (2024) discussion of the capacity and competency of local government in implementing built heritage conservation policy. Certainly, institutional expedience and professional discretion are significantly related. As such, they provide additional elements necessary for discussing the adoption of piecemeal planning by urban planners.

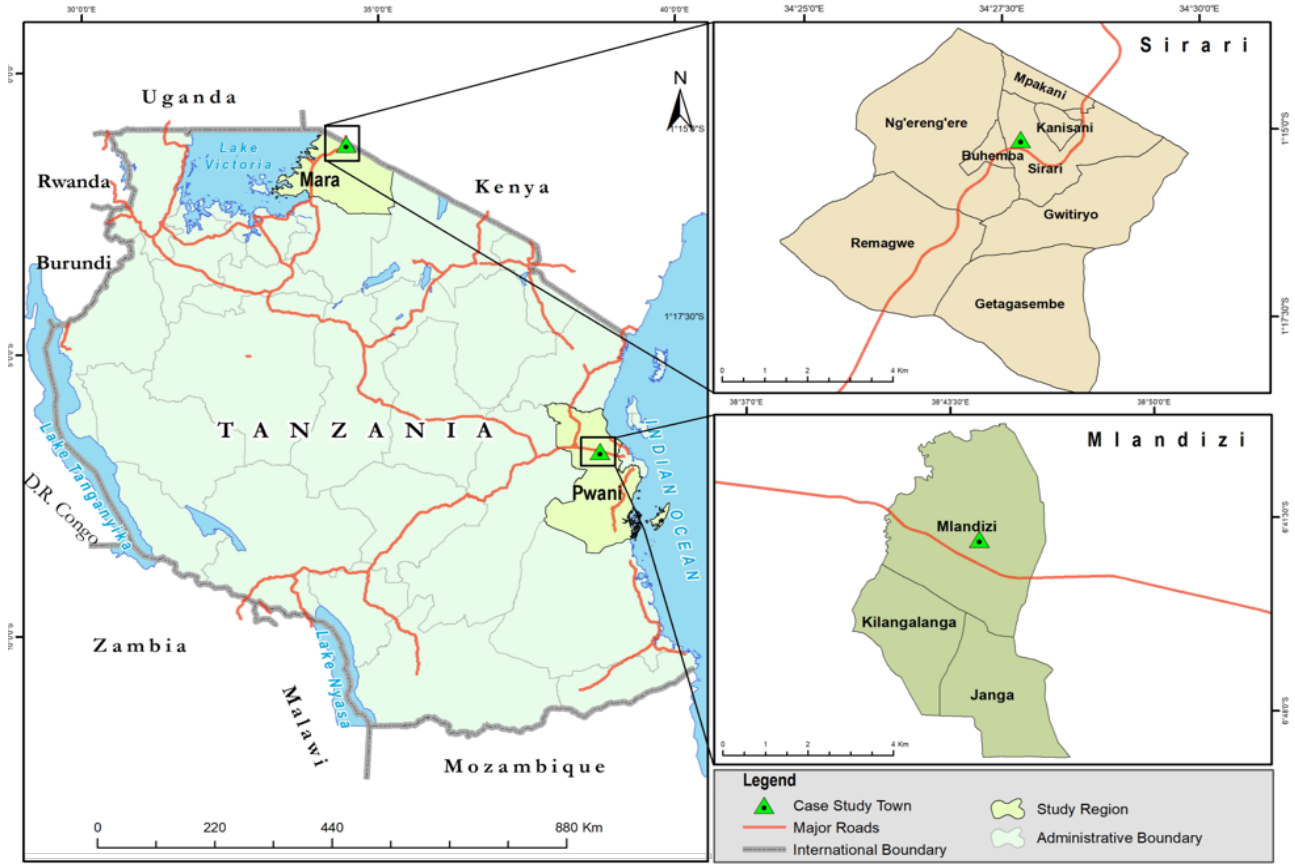
METHODS

A mixed-methods research design was adopted to integrate qualitative and quantitative methods based on multiple case studies. Two small towns were selected, namely Mlandizi and Sirari, (Figure 1) based on their exhibiting rapid informal urbanisation, being national strategic locations, being planning areas, adopting piecemeal planning practices, and their representation of local, political regimes. A list of the areas that were declared urban planning areas in 2001 (GN 217) was obtained from Kibaha District Council and all the potential case studies were ranked according to the criteria. Mlandizi and Sirari qualified, since they met all the criteria.

Qualitative data was obtained using in-depth interviews, which involved ten key informants. Specifically, the key informants were council planners, ministerial planners, councillors and private planners. Two focus group discussions were conducted with 14 ward and sub-ward leaders. Quantitative data was obtained using a household survey; 378 household interviews were conducted in the two small towns. A spatial analysis of layout plans was done to establish land-use compatibility and connectivity of linear infrastructure. A review of documents provided both qualitative and quantitative data. Qualitative data was transcribed and scripts were manually coded and analysed through pattern matching, while quantitative data was processed using the Statistical Package for

Social Sciences (SPSS). Finally, triangulation was used to integrate the results from both strands into themes that answered the research question.

Figure 1. Location of the study areas



Source: Based on spatial data from Tanzania

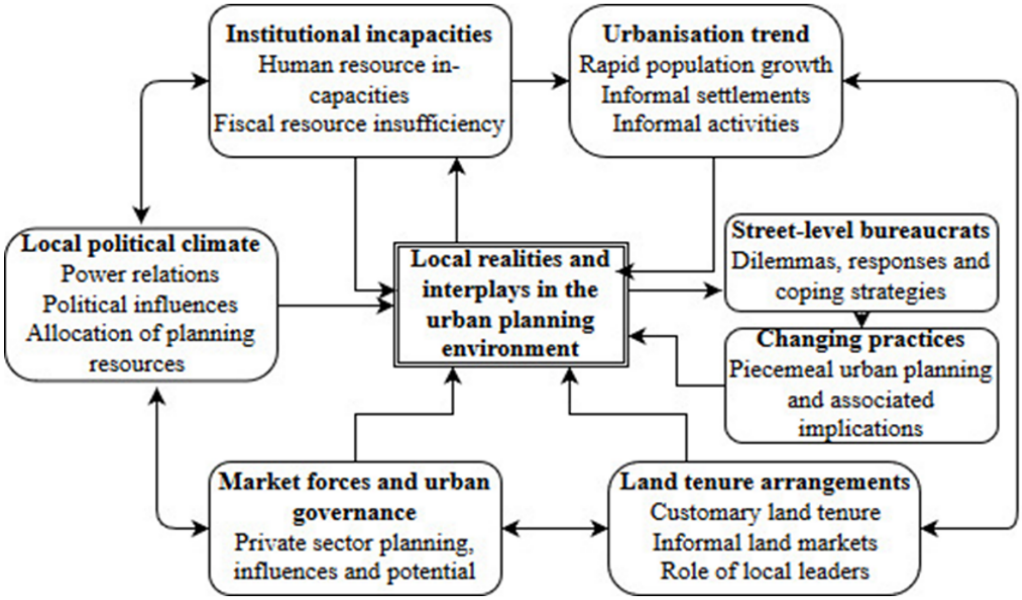
RESULTS

The planning context

Although the local realities in Mlandizi and Sirari are multifaceted, they are clustered in five themes, namely rapid urbanisation and spatial growth, planning institutional characteristics, local politics, market forces and land tenure arrangements. These factors affect the urban planning environment directly and indirectly. Indirect influences result from the interplay between factors which create webs of intertwined elements. In their totality, they form the conditions under which town planners in the two small towns do their jobs. The pressure exerted by the realities puts the planners in a dilemma. To cope with the dilemma, they adopt differential implementation of urban planning strategies. This is where piecemeal planning practices and associated implications enter the urban development picture. While piecemeal planning has become part of institutional planning practices, the implications add to

the realities in the planning environment. The interplay between local realities in Mlandizi and Sirari is shown diagrammatically in Figure 2.

Figure 2. Manifestation of local realities and their interplay



Source: Adopted from Yamungu (2019, p. 120)

Even though many factors are used to assess the growth potential of small towns (Donaldson et al., 2012), population and spatial growth have always been used to determine the rate of urbanisation. Population is used because it is a determinant of human needs like housing and social services. In turn, the need for housing and social services by growing populations determines the spatial development of small towns. The interplay of local realities in small towns and its complexity can be addressed by comprehensive planning interventions.

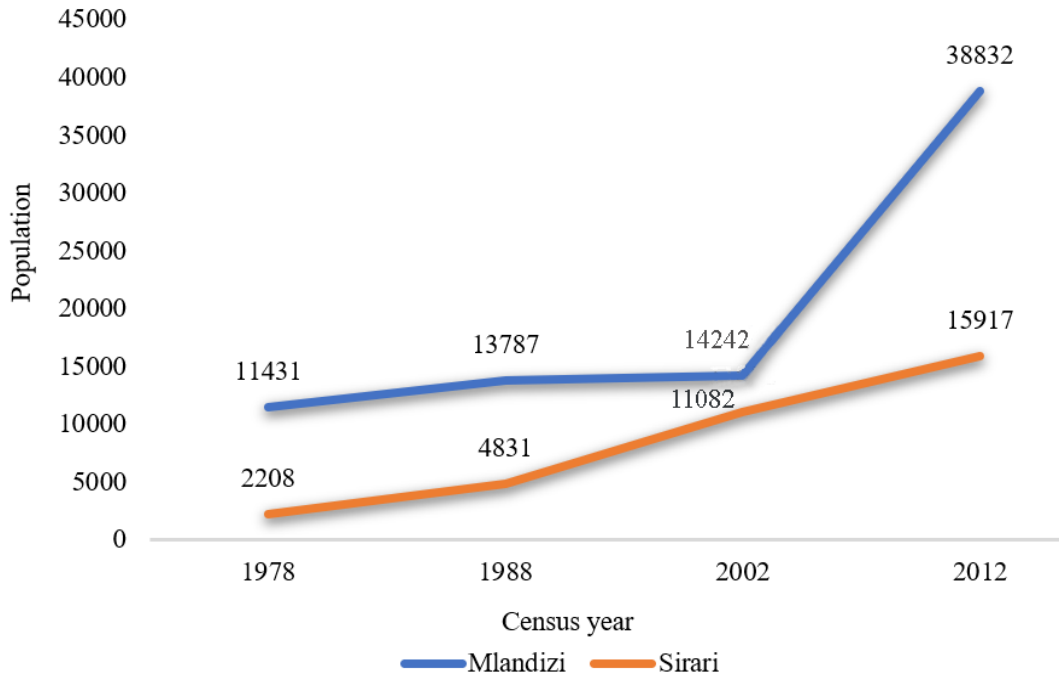
Population and Spatial Growth Trends

The populations of the two small towns have been growing steadily since 1978; Mlandizi's population doubled between 2002 and 2012. The two small towns experienced average annual population increases of 6.5% and 8.5%, respectively, from 1978 to 2012. This average annual population growth in Mlandizi and Sirari is more significant than the national, urban, annual, average population growth, which stands at 5.2% (Tanzania Urbanisation Laboratory, 2019). The result provides an indication of a more rapid urbanization rate in small towns than secondary cities except Dar es Salaam. Consequently, the rapid urbanization trend in small towns attracts planning attention if goal 11 of sustainable development is to be achieved. The towns' population growth is shown in Figure 3.

The population growth in the two small towns significantly resulted in a natural increase and migration. The findings from the household surveys indicate that 63% and 49% of the surveyed households had migrated to Mlandizi and Sirari, respectively. In addition, it is established that

migration contributes 70% to the population of Dar es Salaam and 50% to the populations of the other cities in Tanzania (Otieno et al., 2016; United Republic of Tanzania, 2013). This means that migration is the second contributor to urban population growth in both cities and small towns. The higher rate of migration to Mlandizi than to Sirari may be attributed to the former town's location along the central transport corridor and to its being very close to Dar es Salaam. The other small town is located on the border with Kenya.

Figure 3. Population growth trends of Mlandizi and Sirari



Sources: Summarised from population censuses of 1978, 1988, 2002 and 2012

Two main factors may explain the rapid population growth in Mlandizi between 2002 and 2012. The first is the enactment of Land Acts No. 4 and No. 5 of 1999 and the associated land commercialisation approach (United Republic of Tanzania, 1999a, 1999b). Before the enactment of the two land administration laws, it was illegal to sell land in Tanzania. The legal instruments eased land transactions and promoted informal land markets owing to the low pace at which the local authorities delivered land. Secondly, the declaration of Mlandizi as a township in 2004 fuelled in-migration (Kibaha District Council, 2007). The household survey revealed that the migrants came from the hinterland (18%) and other parts of the country (82%). The majority of immigrants came from outside the Kibaha District and Pwani Region. This indicates the attractiveness of Mlandizi to people from other parts of the country. In addition, the declaration made in 2004 enlarged Mlandizi by adding two more administrative wards, namely Janga and Kilangalanga (Kibaha District Council, 2007).

Migration to Sirari has an international face; its immigrants come from the hinterland (44.6%), other parts of the country (44.6%) and other countries (10.8%), mainly Kenya, which it borders. The rapid population growth in the town is one of the planning challenges faced by the town planners in the effort to provide planned shelter and curb the development of informal settlements. However, ad

hoc and piecemeal solutions to urbanisation challenges create more problems than solutions (Berke & Conroy, 2000; Hills & Schleicher, 2015). Unless there is a careful implementation of piecemeal practices, Mlandizi and Sirari are likely to have "urbanisation without growth" (Rakodi, 2005, p. 50). Piecemeal planning is reactive and, as such, does not provide a long-term vision for promoting an urban economy and the well-being of the urbanites. In short, the findings presented in this section show a close relationship between population growth and the spatial development of the two small towns.

The extent of spatial development

Satellite images for 1995 and 2016 were used to determine the spatial extent of urbanisation in Mlandizi over the past two decades. The area increased in size from 219 hectares in 1995 to 1099 hectares in 2016, i.e. an increase of 401.8%. Other forms of land cover are farming (93%), bushland (44%), grassland (-20%), water resources (-77%) and woodland (-98%). Urbanisation involves converting areas initially covered by grassland, water bodies or woodland into urban land uses. The urban area of Sirari increased from 87 hectares in 1995 to 160 hectares in 2016, which is an 84% increase. For the other land cover types, the percentage point increases or decreases were farming (48%), grassland (4%), bushland (-11.5%) and forest (-34%). Sirari has nearly doubled in size over the past 20 years and is likely to expand further, considering the observed population growth rate. Rapid urbanization in the context of piecemeal planning is likely to lead to the expansion of informal settlements.

Informal urbanisation in the small towns

Informal settlements characterise the urbanisation trends in the two small towns. The findings indicate that 90% and 97% of the people in Mlandizi and Sirari, respectively, live in unplanned settlements. These figures are considerably higher than the national and regional percentage points (70%) of urban residents in developing countries in general and in the sub-Saharan region in particular (Boanada-Fuchs et al., 2024; UN-Habitat, 2022; Cockhead & Hemalatha, 2016). During an interview, the town planner in Mlandizi acknowledged that the local authority supported the preparation of layout plans in a piecemeal manner as a strategy for controlling the development of unplanned settlements. He further insisted that, where layout plans had been prepared and implemented, the development of informal settlements was controlled. The development of informal settlements was controlled in Kisabi, Vikuruti, Kilangalanga and Misufini.

Customary land tenure and informal land markets

The interplay between customary land rights and the informal land market is evident in the two small towns. Land legislation in Tanzania recognises formal land ownership (granted right of occupancy) and informal land ownership (customary right of occupancy). The findings from the household survey

indicate that the proportion of land under granted rights was 31.8% and 9.4%, and that of land under customary rights was 68.2% and 90.6% in Mlandizi and Sirari, respectively. The findings show the dominance of customary land tenure in the two small towns. While the transfer of the granted right of occupancy is subjected to strict legal procedure, customary rights were not strictly legally bound to any established procedure.

The land owned under the customary arrangement is normally transferred through an informal land market. The size of the land owned by the respondents varied as already indicated. However, about 76% of the respondents owned plots which are smaller than one acre in size. The process involves subdividing land for those with large plots, and then transferring land ownership rights to the new owners. In addition, piecemeal planning made a significant contribution to the transformation of the administration of land in Mlandizi (31.8%) more than in Sirari (9.4%). This contribution should be integrated with other development aspects to promote sustainable development. This requires a planning approach which provides an appropriate spatial structure and land-use distribution and has the potential to produce efficient transport networks, compatible land uses and environmental protection (Dai et al., 2010; Song & Zheng, 2002).

Facilitation of land transactions by local leaders

Local leaders at village and hamlet levels play a major role in facilitating informal land transactions. Local leaders play a facilitation role in transacting land under granted and customary rights. However, their role is important for the land that is under customary tenure. Their role includes site verification, which involves confirming ownership, boundaries and third-party interests, as well as witnessing and certifying sale agreements. The confirmation of third-party interests involves establishing whether there are any claims on a piece of land before the sale agreement is concluded. This verification process can be undertaken by one local leader or may involve the committee responsible for land administration.

In such transactions, local leaders are normally paid 10% of the transaction value as administration fees. The fees are contributed to by the buyer and the seller at some agreed proportion. The money collected from a land transaction is supposed to be used to support local development initiatives. However, such money was not fully accounted for and sometimes ended in the pockets of local leaders. The practices about the transaction of the land under the granted right of occupancy are different from those about the transaction of customary land. Their differences are in legalities as the transfer of the land under granted rights must follow the procedure established by Land Act No. 4 of 1999. The procedure requires statutory payment of fees and taxes to the government. This process is in most cases done by the Local Government Authorities (LGAs) and legal practitioners. As such, the role of local leaders is minimal, and so there is limited opportunity for them to pursue personal gain. Consequently, the local leaders focus on the land under customary rights, which contributes to the development of informal settlements in many areas.

Land tenure and piecemeal planning practices

Landowners take advantage of Land Act No. 4 of 1999 and Urban Planning Act No. 8 of 2007 to enter the formal land market by preparing layout plans for their parcels of land. The current laws allow for land commercialisation and the involvement of private planners in the preparation of urban development plans. They hire planners to prepare layout plans for them and, in the process, determine and influence land use by designating land uses which are economically beneficial to them. It was revealed in an interview with a town planner in Mlandizi that, out of the 109 layout plans that were obtained, 104 (95.4%) of piecemeal land plans were prepared by private practitioners, while only 5 (4.6%) were prepared by the LGA. The preparation of layout plans by the private sector was normally through partnerships between landowners and planning or real estate agencies. However, the proposed layout plans are submitted to the planners in the local government for scrutiny and submission to the council meetings for approval. The town planner also mentioned that the local government cannot stop the preparation of layout plans by private sector actors because the practice is legally acceptable and helps to provide a minimum planning solution for controlling the development of informal settlements in small towns.

The contribution of customary land tenure to piecemeal planning in Mlandizi and Sirari is noteworthy. The layout planning process is considered to be easier and smoother for customary land than for the land under granted rights of occupancy. Planning on the latter involves a long process, which includes revoking the previous survey on which granted rights were given as well as changing the existing land use to allow for a new plan and multiple uses to be introduced. The revoking of the survey and the land-use change process are subjected to cumbersome and time-consuming bureaucratic procedures, which are unfavourable to private sector planners. Private sector agencies have facilitated the institutionalisation of planning and formal land delivery in small towns like Mlandizi, where 31.8% of the area is planned. This is a substantial contribution to the efforts to control the development of informal settlements and improve formal land delivery (Kasala & Burra, 2016). Since the practice provides both planning and business opportunities, the private sector can be used to facilitate master planning processes so that layout plans become more coherent than they currently are.

The contribution of the private sector to planning in Mlandizi and Sirari provides the potential to strengthen urban planning in the two small towns. However, this potential is not tapped for improving planning in the small towns. A comparison between the number of surveyed plots and that of plots proposed in the existing layout plans for Sirari provides evidence of the deficiencies of the local governments. It was found that, out of the 3850 plots proposed in the layout plans for Sirari, only 145 plots (3.8%) were surveyed and that the remaining 3705 (96.2%) had not been surveyed and had been informally developed. The role played by private planners in piecemeal planning can be transformed to facilitate the preparation of master plans or structure plans. The planning potential in the private sector is not tapped into by local governments. Again, the presence of informal settlements in piecemeal planned areas shows a major weakness in urban governance. Local governments are

unable to tap into urban planning resources from non-state actors to strengthen planning capacities for the two small towns.

Low institutional capacity for urban planning

The study looked at the sufficiency of fiscal resources, the availability of appropriate skills and the experience of town planning professionals. Institutional capacities are a prerequisite for local authorities to operate within their institutional frameworks.

A shortage of human resources

The availability of skilled personnel is at the heart of the functioning of an institution. Capacity needs assessments for Kibaha and Tarime indicate that the two district councils have more than 65% of the required human resources that can have a meaningful planning impact. Local government authorities are responsible for planning. In that case, the district councils of Kibaha and Tarime are responsible for planning in Mlandizi and Sirari, respectively. About one-third to nearly three-quarters of the two district councils' planning personnel requirements have been met (Table 1). However, the low capacity seen is attributed to a lack of master planning skills and experience among the town planners in the two district councils. Town planners said that it was the reason for the inefficient delivery of planning services. However, the town planner was expected to be open-minded to address the capacity challenge by engaging with the private sector through Public Private Partnership (PPP). Thus, planners in the two small towns were supposed to transform the engagement of the private sector from the preparation of a layout plan to at least a structure plan.

Table 1. Human resources at the two local planning authorities

Profession	Kibaha District Council			Tarime District Council		
	Required	Available	Deficit	Required	Available	Deficit
Town planners	3	3	0	2	1	1
Other land sector professions	9	5	4	8	7	1
Supporting staff	8	5	3	4	2	2
Total	20	13	7	14	10	4
Percentage	**100.0**	**65.0**	**35.0**	**100.0**	**71.4**	**28.6**

Source: Field survey conducted in 2017

According to the capacity assessment conducted for the Tarime District Council, the council needed two town planners, while they had only one. The town planner in the two local councils holds a Bachelor's degree in urban and regional planning and has four years of working experience. Apart from fulfilling the town planning responsibilities related to Sirari and three other small towns, she also serves as the head of the department. In addition, she assists with planning responsibilities in the

newly established Tarime Town Council, which does not have a town planner. Like the planners in Kibaha, this town planner could not do master planning. During the interview, she stated that she had neither master planning skills nor planning experience.

The lack of master planning skills and experience can be attributed to a paradigm shift, i.e. from rational comprehensive planning to collaborative planning, which has affected planning practices and training. The paradigm shift towards collaborative planning, which started in the 1990s, resulted in a change in planning practice from master planning to strategic planning. Accordingly, accordingly Ardhi University (University College of Lands and Architectural Studies) changed its curriculum to a strategic planning curriculum. As a result, the planners who were trained during the period of strategic planning, that is, from 1995 to 2018, lacked master planning skills. This shortcoming affects planners' abilities and those of their respective local governments, so they cannot properly guide the master planning process.

Shortage of financial resources for urban planning

Apart from the shortage of human resources, town planners in Mlandizi and Sirari pointed out the shortage of financial resources as being among the constraints on the preparation of master plans. In small towns, urban planning activities are underfunded because of the failure to comprehend the contribution of urban planning to council revenue and local economic development. In the two local governments, urban planning activities received less than 17% of their set budget in five years, from 2013 to 2017 (Table 2). This is partly attributed to dependence on locally generated revenue (the council's sources), whose allocation is politically motivated.

Table 2. Summary of a planned budget and provided funds

Local Council	Budget set (in TZS)	Budget set (in USD)	Funds provided (in TZS)	Funds provided (in USD)	Percentage of funds provided
Kibaha DC	1,207,388,196	533,063	31,554,000	13,931	3 %
Tarime DC	351,812,434	155,326	55,820,000	24,645	16 %
Total	**1,559,200,630**	**688,389**	**87,374,000**	**38,576**	**19 %**

Sources: Extracted from the district councils' budgets for 2013–2017

The presented figures were extracted from the council's Medium-Term Expenditure Frameworks, specifically sub-vote 512E, which is the budget item for urban planning and rural land use planning. The intention here is to compare the budgets set with the actual amounts of money provided. The results indicate variation in different years but, on aggregate, less than 17% of the money requested was provided from July 2013 to June 2017. According to the town planner in Tarime, the funds were not enough even for hiring a consulting planner to facilitate the preparation of a master plan for Sirari and the other three small towns in the district. The hiring of a consultant would have been an alternative for enhancing planning capacity for the preparation of the master plan in the two small towns. This was impossible due to the inadequate financial resources.

Furthermore, decisions on the allocation of resources are made at council meetings, where bureaucrats' proposals are either accepted or rejected. Bureaucrats and councillors consider the shortage of financial resources as the main reason for not preparing master plans for Mlandizi and Sirari. Problems exist in the councils concerning the allocation of locally generated revenue. The two district councils have resources for doing socio-economic development activities. The Tarime District Council receives an average of 1.2 billion shillings a year (equal to USD 550 000) in in-service levies from the North Mara Gold Mine. These financial resources are normally used to provide social services to the communities. By contrast, the Kibaha District Council receives 10% fees charged on each plot of land sold in partnership with private sector companies. Although the actual amount of the fees was not disclosed, the volume of private sector planning and land delivery in Mlandizi suggests that this is the main source of local revenue for the council.

Political influences on planning

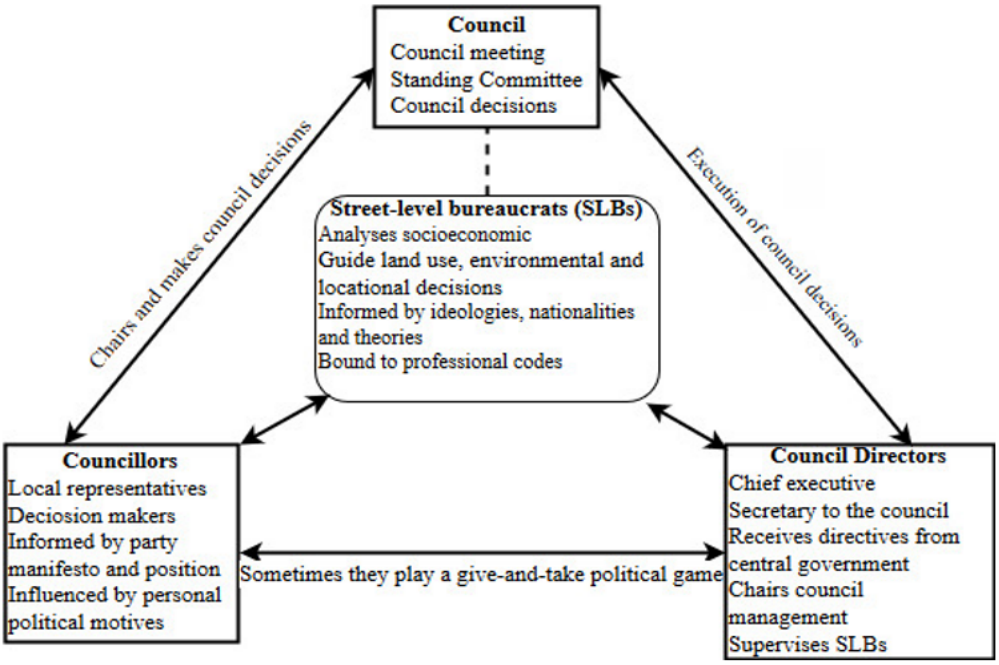
Both in Mlandizi and in Sirari, urban planning activities were affected by politics, particularly the power relations between councillors and the council's staff. Councillors and bureaucrats are two opposing sides and are involved in making decisions on urban planning. As a result, the decision-making process concerning urban planning is deeply rooted in this political environment. The political system and the administrative structure adopted by the Kibaha and Tarime district councils give decision-making powers to councillors because they are representatives of the people. This system regards street-level bureaucrats as advisors to the council through the council director (Figure 4). The relationship between the district councils' decisions and politics puts the street-level bureaucrat at the centre of the local political environment.

Institutional arrangements require that street-level bureaucrats' opinions and proposals to the councils be channelled through the director, who is the chief executive and secretary of the council. This requirement enables the councils to make rational and informed decisions. The extent to which the proposals are considered depends on the political rationality of the councillors and the chief executive. The conflict of rationalities was very intense in Tarime, where by the time of this research the council was ruled by an opposition party, while the council directors are appointed by the President. As presidential appointees, the directors are perceived by the opposition councillors to be submitting proposals favouring the interest of the ruling party.

Again, street-level bureaucrats, who implement public policies, are at the centre of the political environment. Their opinions and proposals are accepted or rejected without interfering with the council's decisions. The rationality of this system is based on the belief that the councillors will make decisions which are beneficial to their electorate. The town planners in Kibaha and Tarime pointed out that, sometimes, the technical proposals submitted to the council meetings for endorsement are rejected on political grounds. Street-level bureaucrats, therefore, face internal and external political pressure, which sometimes results from the councillors' and chief executives' give-and-take political

games. Frustration arises from the multiple political influences like the delayed declaration of Mlandizi a Town Council. This is one of the local realities influencing town planners' exercise of discretion and decision to implement urban planning policies.

Figure 4. The political environment and power relations in local councils



Source: Adopted from Yamungu (2019, p. 149)

Delayed declaration of urban planning areas

According to urban planning regulations, urban areas are supposed to be upgraded to a higher category after reaching some population thresholds. Accordingly, Mlandizi and Sirari qualify to be a town council and a township authority, respectively. However, because the declaration process is handled politically, it takes longer than it is supposed to. There is great uncertainty as to when the process of declaring the two small towns will be completed. Mlandizi's town planner initiated the declaration process after recognising that the town qualified to be a town council. The criteria for establishing a town council are a town having a population of 30,000 people, being able to provide at least 50% of its annual budget, having a hospital, a secondary school, 50 licenced shops and a police station, and being the headquarters of a division. The declaration process involves writing a declaration proposal for discussion and approval by the council management team (CMT) and the district council.

The proposal for establishing the Mlandizi town council was accepted and approved by the CMT but was rejected by the council. The rejection of the proposal by the council was based on the argument that approximately 75% of the council's locally generated revenue comes from Mlandizi. Thus, approving the proposal would have necessitated establishing an independent local government authority responsible for Mlandizi. This would mean that the existing council would lose three-

quarters of its local revenue base. Yet, the resources that the council is defending are not used for planning activities in Mlandizi, where the largest share comes from. Certainly, the lack of financial resources for executing planning activities has made town planners face problems which, in turn, have caused them to adopt piecemeal practices.

Sirari qualifies to be a township authority. The criteria applicable to this small town are the town having a population of 10,000 people, having at least one health centre, a secondary school, 20 licenced shops, a primary court, and being the headquarters of a ward or division. According to the classification of human settlements, a township is a transitional status before rural settlements become urban settlements. Small towns, most of which are rural settlements, must go through the re-classification process before they become urban settlements (then Local Government District Authorities Act No. 7 of 1982; Urban Planning Act No. 8 of 2007). When the process of establishing the Sirari township authority was initiated, it involved expanding the township's boundary so that there would be three wards in the area, namely Sirari, Gwitiryo and Legicheri, and not just Sirari.

As with the declaration process for Mlandizi, the declaration process for Sirari was also frustrating on political grounds related to struggles between the ruling party and the opposition. Government officials in Tarime say that solutions to the problems related to the establishment of the Tarime Town Council must be sought before Sirari is turned into a township authority. The councillor for Sirari, who is a member of the opposition, disputed the reason for delaying the declaration, saying that because the two local councils are currently under Chama cha Demokrasia na Maendeleo (CHADEMA), the ruling party thinks that making Sirari a township will be a piece of political credit to the opposition. In addition, the opposition party leaders in Tarime maintain that the issues surrounding the establishment of the Sirari township authority are government actions to frustrate any development initiatives championed by the opposition party.

When compared, the declaration processes for the two small towns are different. While the Mlandizi process is for establishing an independent council, the Sirari process is for establishing an interim township. More importantly, the declaration processes show the relationship between politics and institutions (Pierre, 1999; Tang, 2011). The establishment of urban planning institutions has been turned into products of political processes. As a result, politics has been one of the factors influencing planning, and power is a basic political element which controls societal organisation and actors' relations (Birkland, 2015; Watson, 2012). The power relations between the actors affect the nature of decision-making, which defines urban governance outcomes.

CONCLUSIONS

This paper has discussed the urban governance challenges faced by the Mlandizi and Sirari small towns. It has focused on the local realities and their influence on the adoption of piecemeal planning practices by the planners in the local governments. The realities constrained the implementation of urban planning and development policies by the town planners in Mlandizi and Sirari. The realities

and their interplay are multifaceted and create a web of challenges facing the town planners in doing their job (Figure 1). Mlandizi and Sirari are characterised by rapid urbanisation as the population has grown exponentially throughout the past four decades. Rapid urbanisation influenced the development of informal settlements and urban sprawl. The percentage of the population living in informal settlements is higher than those in the cities. Urban sprawl fuelled land use and land cover changes from the natural landscape to human-induced land cover, which affects sustainable development in two small towns. There is a clear relationship between customary land rights, the informal land market and the development of informal settlements, while local politics and associated power relations influenced decisions on resource allocation and the upgrading of the two small towns to higher categories of human settlements.

The role played by local leaders in the informal land market gives assurance of the right to buyers based on the land sale agreement they witness. These constitute the contextual conditions and realities which influence the adoption of piecemeal planning practices by council planners. Besides, the role of private planners in the preparation of piecemeal plans has untapped potential for improving the capacity necessary for planning in small towns. However, private planners' actions are attributed to council planners because they facilitate the approval process of the layout plans. Given the complexities affecting planning in small towns, piecemeal planning has the potential to continuously be used as a planning strategy in small and emerging urban areas. Thus, it requires integrating with the town-wide structure for defining main infrastructure way-leaves and broad land use designations. In this manner, we can achieve some level of orderly development, which is likely to promote socio-economic development in small towns.

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Modern Geográfia
Vol. 20, Issue 2, 2025: 65–78
DOI: 10.15170/MG.2025.20.02.04

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Geopolitical Complexities of Kosovo: Symbolic and Geographical Tensions in the Western Balkans[2]

ABSTRACT

There is currently limited Hungarian-language scholarship on the geopolitical and political geographic issues of Kosovo. This study aims to fill this gap by identifying the most critical thematic areas based on international literature, thus presenting both Kosovo's current issues and relevant research trends and approaches. Within the framework of classical geopolitics, the study outlines Kosovo's position in the international sphere, noting that, despite the prominent roles of UNMIK and EULEX as central actors, Kosovo's geopolitical interpretation remains complex and multifaceted. Additionally, it examines Kosovo's regional relationships from a political geographic perspective, focusing on the ‚post-Westphalian system,' ethnic geographic issues, and border-related questions. Given the broader political climate of the Western Balkans, the analysis of symbolic political conflicts is also essential; therefore, the study explores these dynamics, particularly through an overview of Kosovar and Albanian identity and the memory politics of Kosovopolje.

Keywords: Kosovo, Western Balkans, geopolitics, identity, symbolic space, political geography, borders

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[2] Research for this publication has been supported by National Research, Development and Innovation Office (NKFIH) through the OTKA grant #146585 (Hungary and the Western Balkans).

INTRODUCTION

Kosovo is one of the entities with the most geopolitical problems in the Western Balkans. Yet there is as yet little writing that attempts to review them. The primary aim of this paper is to present and briefly contextualise the most important current geopolitical and political geographical issues in Kosovo through a literature review; however, it does not aim to provide a comprehensive history of research, but rather to present the most important current thematic nodes. To this end, it reviews the geopolitical and politico-geographical context and challenges of the Western Balkans. Finally, it will also present the symbolic political-geographical conflicts that are important due to the characteristics of the area. Through this, it will also provide insights into recent research approaches and issues within the international literature.

METHODS

The analysis of secondary literature covers international and Hungarian literature from 2000 to the present. I searched the SCOPUS database using the keywords 'Kosovo', 'Western Balkans' 'geopolitics', and 'political geography'. The sources cover articles mainly on geography, history, political science, conflict studies and memory politics. I supplemented secondary literature with other, but not closely related ones, that are necessary for understanding the context, which mainly focused on the activities of the geopolitical branches of the region. The literature was analyzed along the following lines: What are the main areas of focus for current political issues? What geopolitical and political geographic problems are identified by the authors? What symbolic geographic conflicts are associated with these issues?

RESULTS

The geopolitical situation in the Western Balkans

To review the geopolitical situation, first, we need to understand the overall geopolitical significance of the Western Balkans. I will begin with a historical overview of the problem, for which the works of Juhász and his colleagues, and more recently of Márkus and, at the international level, Mohammed (2022) are excellent starting points.

The history of geopolitical and geostrategic thinking on the Balkans is fundamentally determined by classical geopolitical theories which (with different emphases and concepts) consider the Balkans to be one of the key points to the Heartland, the core of the Eurasian continent, and therefore a geostrategically significant area and an important arena for great power competition.

In geopolitical terms, the Western Balkans are not a global priority today. However, its geographical location and the nature of its interconnection (intersection of sea and land routes) make it an area

of interest for great powers to engage in politics (Reményi, 2019). Therefore, there are several great power actors in the region. In addition to the US, there are EU member states, China and Russia, Turkey and, to a lesser extent, some Gulf countries. The study of geopolitics in the region has focused primarily on the form and impact of the activities of these actors. With the culturalisation of politics and the fragile (military) political balance in the region, the geopolitical activities of these actors have been interpreted primarily in terms of soft power through cultural and identity politics and economic-based activities.

The most significant power outside Europe is the US. It has also played a significant role in the post-socialist transformation of the peninsula; the Dayton Peace Agreement and the 1999 NATO bombing of the peninsula were indirectly significant US influences on these processes. The Balkans are also important to the US as an obstacle to Russia's historic geopolitical goal of reaching the Mediterranean (Gibas-Krzak, 2020).

The 2003 Thessaloniki Agenda declared the European integration goal for the Western Balkans. However, progress has been slow and there is a lack of strategic consensus among the EU's main actors on the issue. After the economic and political crisis that emerged in 2008, the issue of integration in the region was reduced and started to be revisited from the end of the 2010s. The enlargement strategy of 2018 already reflects the earlier geopolitical shortcomings, i.e. the rise of Russia, Turkey and China in the Balkans, making the defence of these positions—at least at the discursive level—an important issue in Western Balkans policy (Petrovic & Tzifakis, 2021).

The enlargement process within the EU is essentially influenced by two major rival states, Germany and France. Germany's significant South Slavic minority, business interests and classical geopolitical orientation towards South-Eastern Europe demand a stronger presence. Enlargement would primarily serve the interests of the German state, and therefore, because of its weak position, France is less supportive of it (Outeda et al., 2020), although not clearly opposed.

Among the non-European power factors, China is gaining more and more (economic) influence, which has an economic and geopolitical background, aiming to create Eurasian connectivity (Horváth, 2019), in which the Balkans can also be an important instrument, where the less bureaucratic and less conditional lending policy is also an important factor (Csapó & Reményi, 2018). However, Markovic Khaze and Wang (2021) have shown that China's economic importance is negligible and, although its presence can undoubtedly slow down the European integration process, it should not be a major obstacle.

Turkey is using the region as an important geopolitical arena, mainly through soft power, cultural and (symbolic) infrastructure financing (e.g. the Belgrade–Sarajevo highway). The TIKA (Turkish Cooperation and Coordination Agency) is gaining more and more important (symbolic) influence in the region through cultural heritage protection (Todorović, 2021). While there is no consensus on whether Turkey's foreign policy should be interpreted as a break from traditional Turkish foreign policy in the Balkans (neo-Ottomanism) or as continuity, it is clear that its presence in the peninsula is undeniable. The primary ideological-cultural pillar of foreign policy is the Muslim brotherhood,

as well as, the historical heritage. The latter, however, includes not only the memory of the Ottoman Empire but also the solidarity shown in the Bosnian war. For this reason, the cultural and educational institutions (TIKA and the Yunus Emre Institute, formerly the Gülenist schools) and the (symbolic) redefinition of the urban image are important soft-power factors. It should be added, however, that the perception of Turkey on the peninsula is far from uniform: in Albania, there is antipathy towards the state because of its lagging historical development, and in Bosnia, the perception of the state is also mixed (Koppa, 2021).

Among the Gulf countries, Saudi Arabia and Iran are the two most important actors. Saudi Arabia provided significant assistance to the Bosniaks during the Bosnian war. Although cultural soft-power activities (building cultural and religious institutions) are also significant, they are met with much greater resistance. Their activities are mostly subordinate to the development of their role in the Islamic world, apart from business objectives (Bartlett & Prelec, 2019). Thus, there is rivalry between Turkey, Saudi Arabia and Iran on the peninsula.

The region is also an instrument for Russian geopolitical goals, which are primarily based on the Serbian state and nationalities, Orthodox communities, mainly in the economic field (Serbian energy industry), but also in the field of intelligence/information. However, the Russian presence is indeed significant mostly at the level of perception, and apart from the energy sector, the economic and institutional political presence is minimal compared to EU countries, even in Serbia, Montenegro and Republika Srpska (Panagiotou, 2021). However, Serbia's support for Kosovo has given Russia a significant foothold in the central Balkans, while NATO bombing has also meant NATO's expansion in the Balkans and further on in the east (Hughes, 2013).

It should be stressed that, although the rise of non-European actors has been clear in recent years, their importance is still negligible. In fact, these countries have no alternatives to joining the European Union, nor do their own interests dictate it, and their relationship-building is often precisely because of European accession. Thus, although the Balkan states are symbolically and discursively increasingly open to Turkey or the Gulf countries, or perhaps Russia, a move towards them is not likely (Bieber & Tzifakis, 2019).

After the Yugoslav Wars, the region attracted considerable attention in Anglo–Saxon political geography, particularly in relation to theoretical questions about the relationship between states and territoriality (Agnew, 2005). Scholars examined the Balkans in terms of the geographical organization of space within state geography (Pap & Tóth, 2008), focusing on issues such as the nation-state and the formation of borders.

Kosovo's geopolitical framework

Kosovo's main geopolitical goal was to gain international recognition, and much of the literature has focused on the international legal and geopolitical implications and possibilities of this. The fundamental question that divided the researchers was whether Kosovo could be considered a precedent

for the Westphalian system. Typically, studies published in the early 2000s, Schaub (1999), Tziampiris (2002) and Jha (2000), argue that the 1999 NATO bombing and the Kosovo problem reinforce the further erosion of the Westphalian system. However, a later discourse (Patterson & Mason, 2010) has also emerged which points out that these may not be precedents. The debate has been fundamentally resolved by a review of the concept of the Westphalian system. Sovereignty began to be conceived of as increasingly transnational and hybrid, even within academic discourse (Coleman & Grove, 2009), and as a result, the concept of a post-Westphalian system began to gain currency. Thus, recent literature (Lefteratos, 2023) draws on this theoretical tradition.

Kosovo's situation is therefore part of a highly complex network of powers, which is why the geopolitical analysis of the entity is primarily interpreted in the light of the goals of the great powers, typically the US and the EU. As Siroky and colleagues (2021) have shown, the US and its alliance system were fundamental to international recognition: the speed and extent of recognition of Kosovo's independence were correlated with the presence of US military forces and capital investments in the recognizing country. The European Union also has a significant impact on Kosovo's relationship with Serbia, as both countries are striving towards European integration, and the settlement of their relationship is an important step towards achieving this (Noutcheva, 2020).

Kosovo's sovereignty is limited not only externally but also internally. The Secretary of the United Nations Mission in Kosovo (UNMIK) is effectively a shadow organization with a very strong influence on local politics. The European Union, through EULEX, seeks to 'monitor' and 'mentor' the legal framework of local institutions (Noutcheva, 2020). This partly explains the contradictory EU policy: on the one hand, the EULEX policy points towards Kosovo's path to full statehood, while on the other hand, it does not fully recognize it (Lefteratos, 2023).

Ethnic geography can also be a determining geopolitical factor, especially in the context of Greater Albania, so ethnic mapping is also an important research direction. The majority of Kosovo's population is Albanian, estimated to be around 93% (CIA World Factbook). They form a majority in most of the country, except in the three northern opstinas (local government units) north of Ibar (Zubin Potok, Leposavić and Zvecan), where it is estimated that roughly half of the Serbs live (Reményi, 2012). Ethnic diversity has essentially declined over the last two decades (although there are also subtle changes over time and space), with little diversification observed mainly in the northern and southern peripheries of the state (Reményi, 2014).

A frequent geopolitical question is the vision of a possible Greater Albania. The multiple ethnic and geopolitical complexities in the Balkans have created a relatively intricate network in which a local change can have a major impact on several other states. Therefore, it is foreseeable that the realisation of a common Albanian state would upset the state-geographical balance of the Western Balkans. While the possibility of a Greater Albania is realistic, there are different views on the degree to which the parties really want this. Márkusz (2018), based on the economic and diplomatic rapprochement between Albania and Serbia, and Krasniqi (2016), referring to the relatively high nation-state loyalty shown by the 2011 IPSOS survey, make it less conceivable. This is also reinforced by EU policy:

although the Brussels process is not considered a success, it is likely that if Balkan enlargement goes ahead, Greater Albania will become merely an ideological relict.

Territorial tensions

The entity is divided into the Kosovo and Metohija basins, and its geographical location makes it particularly important for the geopolitical domination of the Balkans. It also has significant mineral wealth, with world-class reserves of lignite, and the Trepča mines contain zinc, lead and copper. Thus there are still prevalent territorial tensions between Kosovo and other states (Figure 1).

Figure 1. Municipal boundaries and regions of Serb majority as of 2000

Albanian toponyms listed above, Serbian versions below. Source: Dahlman & Williams, 2010.

The Preševo Valley and the issue of borders

The geopolitical importance of the valley, which is on the borders of Serbia and Kosovo, is further enhanced by its ethnic divisions. Census data from 1961 to 2002 show a steady increase in the proportion of Albanians (from 44.3% to 72.9%). In Presevo, the proportion of Albanians has reached 94%, providing a good basis for separatist aspirations (Reményi, 2019). This, combined with the condition of being a border region, is causing further inter-state tensions between Serbia, Kosovo and Macedonia.

The Belgrade–Nis–Skopje–Thessaloniki road runs through the valley, providing access to the Aegean region. The valley was already considered by Cvijić to be of utmost importance: a key area for controlling transport, where longitudinal and perpendicular roads intersect; paraphrasing Mackinder's

thesis, those who control the valley (including the Skopje valley) control the Balkans. The theory has gained considerable influence and has become a common argument for Serbian imperialism (Ejupi & Ramadani, 2016). Accordingly, Serbia continues to regard the region as a key area that it cannot, in its view, let out of control (Pap, 2016).

Kosovo's borders are a major problem along almost all borders, especially in this valley. The Macedonian–Kosovo border has been a minor source of tension in the past due to the occupation of strategic, military-political positions. In the area of Kosovska Mitrova, the Serb ethnic areas pose a serious ethno-regional challenge to the central state's exercise of power. There is also a refugee camp in the valley and intensive smuggling activity along the borders, in which Albanian criminal organisations are the main agents, thus playing a major role in the local black economy (Pap, 2016).

Mitrovica and the issue of the northern opstinas

The Serb-majority opistinas in the northern areas, neighbouring Serbia, represent a major challenge to state-building in Kosovo, where the Pristina government's authority is weak and Belgrade's influence is much stronger. In 2009 and 2010, under international pressure, several Serb-majority opistinas were created (through a kind of "ethnic gerrymandering") in order to give Serbs greater sovereignty at the municipal level (Reményi, 2012).

Mitrovica's importance is mainly due to its mining activity in Trepča/Trepçës (Gusic, 2020), its geopolitical position and significant ethnic division (2009 and 2011 data show that the share of Serbs in North and South Mitrovica combined is around 14%, while the share of Albanians is around 84%). A highly divided city, with a predominantly Serb population on the northern bank of the Ibar River and Albanians in the south, spatially segregated, with checkpoints and parallel institutions, it is the most diverse and conflict-ridden city in Kosovo, and also the one that offers the most opportunities for contact between the two ethnicities (Gusic, 2022). Some of its characteristics are similar to Mostar, Jerusalem, Belfast or Beirut, and these examples can help to understand it. Some international, mainly Anglo–Saxon, literature tries to understand them through the concepts of post-war cities and conflict-related violence (CRV). Elfversson and colleagues (2023) have shown, by mapping documented atrocities, that they are mainly concentrated around the main bridge.

The division, based on the contact hypothesis (see Gijberts et al., 2012), is precisely what prevents the easing of social tensions and ultimately peace, but Gusic sees it as a means of peace, based on the premise that the two ethnicities are incompatible because of different political goals. Its long-term development will therefore have a profound impact on the territorial influence of the state of Kosovo and Belgrade–Pristina relations.

Symbolic geopolitics

Although the legal solution to the problems of inter-state relations has now been more or less achieved, research on symbolic spaces has made it clear that further geopolitical tensions remain, which are

manifested in identity and cultural conflicts. In terms of border problems, for example, it is often the symbolic content of spaces that actually constitutes serious mental boundaries (Elfversson et al., 2023), which perpetuate conflict and ultimately make social integration more difficult. An analysis of symbolic policies (e.g. linguistic landscapes) can also point to the visibility of (ethnic) groups in a given locality (Balizs, 2021), and their share of symbolic power. In constructivist nationalism theories (like Hobsbawm and Anderson), symbolic issues are also highly emphasized, so when we want to interpret nationalism manifested in the Balkans, this approach can be useful. In light of these, symbolic geography studies have become particularly important.

Territoriality is fundamental to nationalism, especially in the context of the Yugoslav Wars. This is also reflected in symbolic politics: the creation of a collective memory, which cannot exist without specific sites of memory, is key to the creation of the myth of the nation (Nora, 2001). Today, domination is no longer exercised by political elites through administrative or military means alone, but also through representation: the representation of memory, ideology, and values is also a means of symbolic domination of space. Because of the strong control of external actors, and for historical reasons, symbolic politics will be of paramount importance in the region, and can be understood in the context of repressed tensions. The research on symbolic spaces also focuses on the study of cultural and political images and representations, i.e. how power tries to shape a given territory according to its own (identity political) goals (Ermolin, 2014; Pap & Reményi, 2020). This paper focuses rather on the most important symbolic conflict space, Kosovo's Polje.

Before understanding its nature in more depth, however, it is necessary to review what national narratives dominate on the Serbian and Kosovo Albanian sides, which I base on the work of Márkusz (Márkusz, 2018).

Márkusz identifies four distinct phases in the history of Serbian nationalism, each defined by its primary objectives: (1) achieving complete independence (secession); (2) uniting Serbian-inhabited territories and securing access to the sea (expansion); (3) integrating annexed territories acquired during expansion (assimilation); and (4) reclaiming Serbian territories after the failure of assimilation and subsequent disintegration (irredentism). For this paper, the fourth stage is the most relevant, so it is briefly summarized here.

The most recent phase of Serbian nationalism is deeply influenced by historical experiences of failed assimilation: neither the Serbian monarchist efforts to assimilate Kosovo were successful, nor was the Kardelj-led project aiming for federal state-based and cultural emancipation. Thus, Serbian nationalism has undergone significant changes since the 1980s. Under clerico-nationalist influence, the ideology began to target Orthodox believers, marking a departure from the 19th-century unification efforts and instead shifting towards ethnocentric and divisive identity politics. A defining aspect of the post-Yugoslav Wars is Serbian nationalism which creates the evident discrepancy between national borders and the geographic distribution of Serbian ethnic territories, which fundamentally directs contemporary Serbian nationalism towards an irredentist stance.

Similarly, Márkusz delineates four phases in the evolution of Albanian (and, subordinately, Kosovo Albanian) identity: (1) autonomist phase (1878–1912); (2) nation-building phase (1912–1968); (3) irredentist phase (1968–2008); and (4) unification phase (2008–present). He identifies the current phase as being shaped by Kosovo's independence in 2008, rendering previous irredentist discourses obsolete and fundamentally altering political relationships with other Albanian-inhabited states. Pristina has now emerged as an independent political, cultural, and educational center within the Albanian ethno-national sphere. Additionally, a distinct Kosovo Albanian identity is forming, with its symbolic pillars rooted in the Dardania cult and the memory of Jashari.

Key features of symbolic urban politics in Kosovo

Since 1999, Serbian markers and symbols have come under attack, leading to a radical transformation of public spaces in Kosovo. In addition to the proliferation of mosques, significant changes occurred within urban public spaces. The dominant narrative coalesced around the Kosovo Liberation Army (UÇK, *Ushtria Çlirimtare e Kosovës*), and particularly around the hero cult of Adem Jashari, as this story effectively encapsulated national independence into a positive and personalized tale. Prekaz, where Jashari and his family were executed, emerged as one of the most important "pilgrimage sites" for Kosovo Albanians (Krasniqi & Gëzim, 2013). In 2005, the mausoleum of Sultan Murad I at Kosovo Polje was renovated, becoming a site for Turkish commemorations. From a Serbian perspective, this 2005 restoration symbolized neo-Ottoman influence and, by extension, the further loss of Kosovo (Pap, 2016).

It is essential to move beyond the Serbian–Albanian dichotomy and examine the unique nature of a distinct Kosovar identity. Stiperski and Ejupi (2023) analyzed the toponymy of cities dominated by Albanian populations in both Albania and Kosovo, offering insightful comparisons. Their compilation and brief interpretation of central squares in key cities provide valuable insights, which I will present in tabular form (Table 1, using Albanian names for the cities).

Table 1. Main square names in major cities of Kosovo and Albania

Country	City	Name of Main Square	Explanation by Stiperski and Ejupi
Albania	Tirana	Kastrioti Gjergj Skanderbeg	Fought the Ottomans from 1443; declared the Champion of Christianity by the Pope.
	Shkodër	Democracy	–
	Vlorë	Albanian Flag	–
	Berat	Antipatreia	Named after a former Greek settlement at this location.
	Korçë	Saint George	Named after a Roman soldier and Christian martyr.
Kosovo	Gjakova	Hadum Aga	Named after the Hadum Mosque.
	Peja	Queen Teuta	Named after the 3rd-century Illyrian ruler.
	Pristina	Mother Teresa (also includes a Skanderbeg statue)	Mother Teresa was an Albanian Roman Catholic born in Skopje, North Macedonia, with family roots in Prizren.
	Prizren	Shadervan	Named after the fountains in front of the mosque and caravanserai.

Source: Own edition based on Stiperski & Ejupi, 2023

As can be observed, the toponymic system of Kosovo and Albania cannot be considered a homogeneous symbolic space. This distinction can be explained by the diverging state frameworks in which the Albanian ethnic communities in Albania and Kosovo existed throughout the 20th century. While Albania functioned as an independent state capable of orchestrating its own nation-building efforts, Kosovo was part of a predominantly Slavic state, with a fluctuating legal status, yet ultimately subordinate to an external center of power. These differing state contexts brought distinct societal experiences: the existence as a minority group, bilingualism, and geographical boundaries have contributed to the formation of a unique identity.

Furthermore, although Kosovo's toponyms are ethnically Albanian, they are also rooted in local histories, as is evident in the cases of Prizren and Gjakova. In the case of Pristina, we are witnessing more of a national historical representation, one that may align with the narrative of Greater Albania but, due to its specifically local ties to Kosovo, may also emphasize a sense of distinctiveness. Thus, beyond their ethnic associations, these toponyms at least partially embody a local identity that, although challenging as a basis for identification among local Serbs, may nonetheless possess such potential.

However, Kosovo Polje may be regarded as a source of conflict due to the development of parallel narratives in memory politics. As previously noted, Kosovo Polje/Fushë Kosova (the Field of Blackbirds) holds a key place in Serbian history, with its significance in national history comparable to that of Mohács (Pap & Reményi, 2020). The primary issue is that today, the most important site of memory, Gazimestan/Gazimestani, is located within the territory of a quasi-foreign state, specifically in an area with an Albanian majority. This complicates the organization of commemorations and the maintenance of infrastructure.

Another symbolically charged event was Milošević's 1989 nationalist speech, which focused on Serbian victimhood, the notion of Serbia as the bastion of Europe, and Serbian heroism (Bieber, 2002; Pap & Reményi, 2020). This nationalist rhetoric continues to resonate today, fitting neatly into the discourse of the clerico-nationalist Serbian nation-state. In this context, Kosovo Polje becomes especially significant in memory politics, as the historical theme of Christian Serbs versus Muslims is readily applicable to contemporary situations in which Serbs face ethnic conflict.

The site's potential for further conflict is also heightened by an emerging Kosovar interpretation that increasingly emphasizes Turkish–Albanian relations. This shift is in line with what Reményi (Pap & Reményi, 2020) has reported, namely that, in recent years, a segment of the Albanian elite has proposed transforming this site of memory to reflect a parallel narrative centered on an Albanian hero cult.

CONCLUSIONS

In this study, I have outlined the fundamental geopolitical context of Kosovo and the dominant approaches to geopolitics within the Western Balkans. The Anglo–Saxon literature typically addresses

the region during periods of crisis. Following the Yugoslav Wars, geopolitical issues surfaced both within the framework of a "post-Westphalian" system and amid the emergence of a multipolar world. Consequently, scholars analyzed the roles and influence of various actors in the Balkans, particularly those outside the EU. Both the actions of these actors and shifts within the field of geopolitics studies have brought symbolic and cultural politics into greater focus.

More narrowly defined political geography studies have primarily centered on ethnic mapping and border issues. These studies reveal that almost every area surrounding the central region—such as the northern municipalities near the border, Mitrovica, and the border disputes around the Presevo Valley to the east and south—faces some form of geopolitical challenge. These areas also represent points of significant conflict potential and pose challenges at supra-, sub-, and national levels alike.

The examination of symbolic politics has mainly focused on the relationship between nationhood and identity, addressing the fundamental question of Kosovo's position regarding the Greater Albania issue. This research has largely identified the formation of an independent Kosovar identity. Nonetheless, challenges such as memory politics conflicts (e.g., Kosovo Polje), struggles over the symbolic landscape, and Mitrovica's (mental) division remain substantial tasks to address.

These considerations raise further questions, such as the relationship between divided cities and the study of violence (Boyle, 2010), as this problem remains unresolved. Although symbolic geopolitical research has not yet extensively examined Kosovo's commitment to the European Union and the associated identity patterns, this represents a promising area for geographic investigation in the region.

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Modern Geográfia
Vol. 20, Issue 2, 2025: 79–96
DOI: 10.15170/MG.2025.20.02.05

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Towards a Transformation of Gold Panning on the Tangonie Site, Burkina Faso

ABSTRACT

Mining in Burkina Faso is characterized by both industrial and artisanal mining, commonly referred to as gold panning. In recent years, gold panning has taken on a different form from that described in numerous scientific publications. This article describes and analyzes the transformations in the activity, based on data collected at the Tangonie site in the Boni commune of Burkina Faso. It relies primarily on secondary and field data. The data were collected between January and March 2020. Data processing and analysis reveal a trend towards gold scarcity at the site. Transformations mainly concern the use of chemicals and the role of women in gold panning. In the past, one kilogram of cyanide was used per cyanidation basin, but nowadays, gold miners use up to three kilograms of cyanide. Furthermore, mercury is used by some gold miners during ore grinding. Women no longer own the gold-processing sheds on the site, and their role has become the same as that of men. They now fetch gold ore from the extraction sites and process it in the same way as the men.

Keywords: Burkina Faso, women, gold panning, chemicals, Tangonia, processing

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INTRODUCTION

Artisanal gold mining has been an issue at the heart of African societies for two millennia and on several levels (Rubbers, 2013). The 1980s saw the emergence of artisanal mining outside traditional spheres in West Africa, more generally, and particularly in Burkina Faso (Ouédraogo, 2020). Indeed, there has been a shift in the frontier of this exploitation, which used to take place exclusively in the north due to drought in the Sahel and West African savannahs. Passing through the central areas of the country, the frontier reached the western and southern regions of the country in the late 1990s (United Nations Environment Programme, 2020; Werthmann, 2017). Since the 2000s, global exploitation of this resource has been booming (Petit-Roulet, 2023).

The country's economic activity is heavily dependent on a few sectors and production chains, such as cotton, livestock, and food crops, to which mining production must be added. However, agriculture and mining remain the flagship activities of the Burkinabe economy (Lankoande & Maradan, 2013). Agriculture, one of the main sources of foreign currency for the Burkinabe state thanks to cotton (cotton exports), is faced with two main difficulties, namely climatic hazards and fluctuating commodity prices, particularly those of cotton, which induce a production deficit (Gilles, 2016; Herrera & Ilboudo, 2012; Nana, 1992; UNITAR & UN Environment, 2018). In view of these difficulties, the population regularly looks for additional sources of income. Gold mining is therefore becoming an income-generating alternative for the population (Bohbot, 2017). Gold has become the country's main source of foreign currency and its leading export (UNEP, 2020). Globally, it is estimated that artisanal mining supports (or employs) over 16 million people worldwide. This is due to the fact that the price of gold quadrupled between 2002 and 2021. It indirectly ensures the survival of nearly 100 million people by creating jobs (UNITAR & UN Environment, 2018).

Artisanal gold mining is a rapidly expanding activity in West Africa (Keita, 2001). As such, it offers greater employment opportunities[3] (IRAM–PRODIG, 2024) and is a factor in territorial dynamics (Dessertine et al., 2022). In Burkina Faso, the mining sector is considered one of the most successful on the African continent. Indeed, according to the Organization for Capacity Building in Development (ORCAD, 2018), among African gold-producing countries, Burkina Faso ranks 4th. Yet several leading figures, including French President Georges Pompidou, have been pessimistic about the future of Burkina Faso's mining sector. The mineralogical history of Burkina Faso is consistent with that of the Paleoproterozoic province of West Africa, which is reputed to contain gold deposits (Le Metour et al., 2003). Outside this province, albites also serve as reservoirs containing gold-bearing fluids (Bamba, 1996; Bamba et al., 1997). Gold deposits and showings have been categorized into five groups in Burkina Faso: gold- and sulphide-mineralized shear zones in acid tuffaceous schists; quartz veins occasionally phosphatized; gold- and pyrite-bearing banded quartz and flint (cherts) horizons; Tarkwaïan paleoplacers (showing only); and hill placers or lateritic gold and/or alluvial accumulations (Sattran & Wenmenga, 2005). Gold is not found in the form most commonly seen, i.e., in nugget

[3] According to Traoré et al (2024), stakeholders can be divided into two categories: on the one hand, people in extreme poverty in need of income, and on other, people driven by calculated decisions seeking to become rich in the short term.

form. Instead, it is agglomerated with other rocks, in this case, quartz. This forces players in the gold sector to resort to tedious and polluting techniques to extract the gold (Bohbot, 2017). These techniques require the abusive use of chemical substances such as mercury, cyanide, and acids, in both the industrial and artisanal sectors. As a result, there is a body of laws and decrees governing the mining sector in Burkina Faso. These texts have been updated over the years in line with changes in the country's socio-political context. First, there was the 1997 mining code with law N°023/97/11/AN; then the 2003 mining code under law N°031-2003/AN; followed by law N°036-2015/CNT of 2015 and its application texts, forming a set of decrees. Finally, we have the mining code of 2024 with law N°016-2024/ALT. With this new Code, the country now has general legislation on mining activity, as well as the marketing of gold (The National Assembly of Burkina Faso, 1997; The National Council of the Transition of Burkina Faso, 2015, 2024).

In Burkina Faso, as elsewhere in West Africa, two types of gold mining have long coexisted: industrial and artisanal mining (Grégoire & Gagnol, 2017; Ministry of Mines and Energy, General Secretariat [PADSEM], 2014). The economic impact of artisanal mining is no longer in doubt (PADSEM, 2014). However, it faces serious difficulties and is the subject of debate, given its environmental and social consequences (Keita, 2001; Niang, 2014; Sawadogo, 2011; UNITAR & UN Environment, 2018; Tindano et al., 2024; Zongo & Zerbo, 2019). These impacts result from the digging of holes and the use of chemicals on the various gold sites. Taking these aspects into account, the National Agency for the Supervision of Artisanal and Semi-Mechanized Mining Operations (ANEEMAS) was created by decree N°2015-1420/PRES-TRANS/PM/MEF/MME of November 30, 2015. Its objective is the supervision of the artisanal mining sector. This article analyzes the changes and transformations taking place around artisanal gold mining at the Tangonie site. Before doing so, it highlights the forms of artisanal mining existing on the site, which reveal new data.

METHODS

Gold panning is an almost nationwide practice in Burkina Faso. It is practiced in 12 of the country's 13 regions. However, the activity is unevenly distributed across these different regions. Sites are concentrated in the North, South-West, Centre-North, and East regions. Gold panning is most prevalent in the North and extreme West of Burkina Faso (Institut National de la Statistique et de la Démographie, Direction des Statistiques et des Synthèses Économiques & Service des Comptes Économiques et des Analyses Macroéconomiques, 2017).

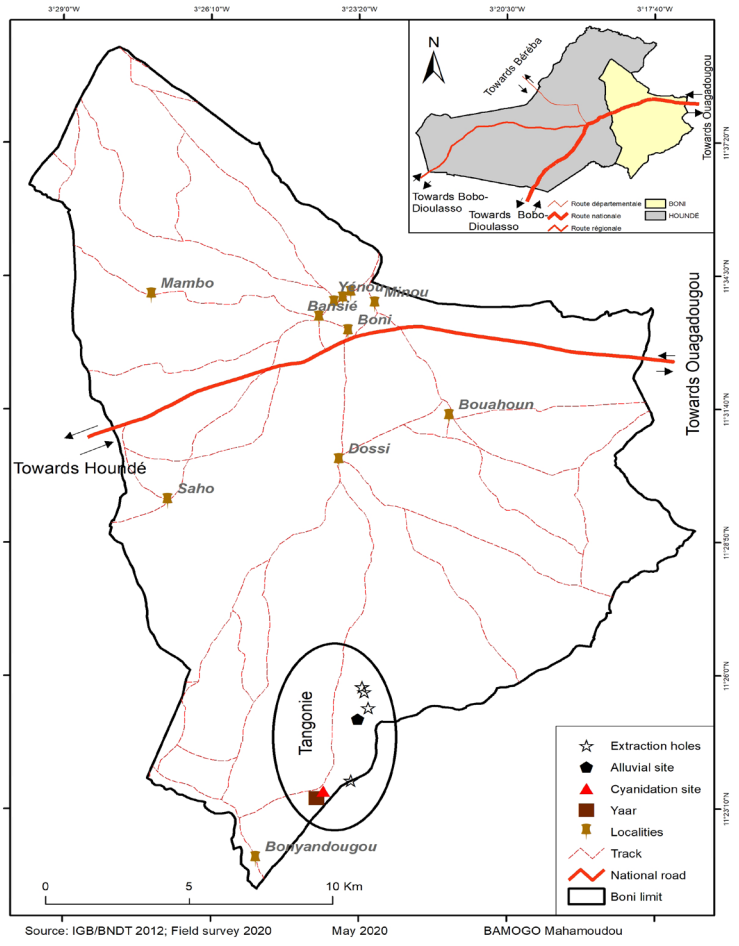
The commune of Boni was chosen as the site for several reasons. Firstly, the province of Tuy is home to several gold-panning sites. A closer analysis of the map of the Tuy province, whose capital is Houndé, and the mapping of gold-panning sites reveals that half of this province, particularly the entire southern and western part, is known for its gold-panning. However, with insecurity prevailing in the North, Sahel, and East of the country, most of the gold panners in these areas have migrated to the far West[4] All these factors combined led to the choice of Boni as the study area for this research

[5] https://lefaso.net/spip.php?article90571 consulted on 05/07/2019

(Figure 1).Secondary data were collected to assess the state of knowledge on the subject. These were progressively supplemented by primary data from field surveys, including a questionnaire and an interview guide. On the one hand, questionnaire surveys were carried out among hole-makers. On the other hand, interview guide surveys were conducted with women involved in alluvial gold mining, women owners of ore-washing sheds, and managers of *Yaar*.

Primary data processing differed depending on whether the data were collected using a questionnaire or an interview guide. Data collected via questionnaires were processed with the help of database software after the creation of an input mask. Recorded interviews were transcribed manually and processed using content analysis. Spatially referenced data were processed with the help of appropriate software.

Figure 1. Tangonie site location



RESULTS

Types of gold deposits and gold washing

Gold panning is the mining of gold-bearing alluvial deposits, and in Burkina Faso, it encompasses several types of mining. It includes the mining of gold-bearing alluvial deposits, which are particles of gold produced by the collection and washing of ore on the surface, as well as lode mining of gold in the subsoil. The study site is no exception, as both types of mining are encountered. Alluvial mining is the artisanal gold mining model favored by women. Lode mining, on the other hand, is a male-dominated activity. Alluvial gold mining will be analyzed first, followed by lode gold mining in Tangonie.

Alluvial gold mining at Tangonie

At Tangonie, as at other gold-mining sites, alluvial mining takes place in two phases: the extraction phase and the processing phase. The analysis of these two phases is the subject of this section.

As far as ore extraction is concerned, it is important to note that a test for the presence of gold in the ore is carried out beforehand. This involves taking a sample of the ore, winnowing or breading it, and washing it. Since alluvial mining is a surface activity, it does not necessarily require you to enter the holes and therefore requires less physical effort. The extraction process is relatively straightforward compared with vein mining. It consists of scooping or scraping the alluvium with tools such as dabas, plastic cups, cut-up oil cans[5], brooms, soap dishes and basins (Figure 2). The daba is used to dig the earth. Ore deemed profitable is recovered with cut-out oil cans and cups. Soap pans are used to separate the ore by particle size. Once the ore has been recovered with the drums and trays, it is placed in basins and transported to the ore processing area.

Ore from alluvial mining is processed differently, depending on whether it is dry or slightly damp. The tools used include basins and a few bowls. When the ore is dry, the women winnow and sieve it to obtain a concentration of ore (Figure 2). This concentration is stirred several times until the gold powder, if present, is obtained, and the rest is discarded on site. However, if the ore is a little damp, it undergoes panning (it may have been sieved long before) by the women and is then poured into a large dish or basin. After this stage, the ore is washed, and at this point, they can already see the gold flakes, which they carefully select and place either in a small bottle or in a corked jar (Figure 2). They are sold to buyers after several days' work, which can last around two weeks. Indeed, as Madame Apomè Safiatou points out: *"The work is not easy, it's complicated, you have to work and wait two (02) weeks to get something"* (A. Safiatou, personal communication, March 18, 2020)[6]. The women do not necessarily need to use mercury for gold extraction, apart from its use by a minority.

Washing the ore requires water, which the women bring to the extraction site. They have a technique that enables them to reuse the water through decantation. To do this, they use the fruit of a plant whose scientific name is *Cordia myxa*, commonly known as *petit cordia*. All they have to do is put the fruit

[6] These instruments are used to protect the fingers of gold miners from injury.
[7] Ms. Apomè Safiatou, alluvial ore operator.

of the plant into the dirty water they have already used and wait until the water is clear before reusing it. Other women take advantage of the water extracted from wells used for lode gold mining (Figure 2). They position themselves downstream on the water flow path. In this way, they do not need to constantly bring water to the gold processing sites.

Figure 2. Stages in alluvial gold mining

Note: a-b) Tools used by women in alluvial gold mining, c) Winnowing alluvial ore, d) Gold powder collected in a jar by a gold panner, e) Gold panner taking advantage of water from the lode gold mine.

Lode gold mining at Tangonie

Lode gold mining at Tangonie follows almost exactly the same stages as at other gold sites in Burkina Faso. The following plate shows the stages of gold mining at Tangonie. As shown in Figure 3, these operations include prospecting, sinking, crushing, grinding, washing, mercury, and cyanide recovery.

Prospecting, i.e., the search for a vein of gold, is generally carried out by experienced gold miners. The procedure involves going into the bush and searching for stones likely to contain gold. Judgment is made by eye and with instruments (small pickaxe, small shovel, cup, water, pestle, and mortar), with which they test these stones for the presence of gold (Figure 3). The next phase consists of digging the holes for the new site. Sinking is the process of digging a vertical hole in the ground, followed by horizontal drifts to reach the gold-bearing ore. Before drilling a hole, research is carried out[7]. The sinking stage is carried out in teams, with the hole leader choosing a team leader to take over in case of absence.

Somé (2004) emphasizes that the contract between the drillers and the hole leader is a verbal one. Remuneration consists of dividing the gold ore extracted in half. Holes are opened on the land or fields of landowners who accept the presence of the miners in exchange for a royalty. Generally, landowners demand 2,500 CFA francs before opening a hole, and for every ten (10) bags of gold ore extracted, one (01) bag is returned to the landowner. The role of the hole manager is to ensure that the work proceeds smoothly and that the hole is maintained (materials, catering, care, and minor needs of the workers).

[8] This scenario corresponds to former lode gold mining sites.

Figure 3. Stages in Gold Vein Mining

Note: a) Gold prospecting tools, b) Sinking/extraction, c) Crushing, d) Grinding, e) Washing, f) Chemical Treatment (cyanide).

Tools such as hammers, shovels, chisels, picks, ropes, torches, handmade pulleys, bags, pick hammers, dynamite, compressors, and wire are used during the jacking process. Equipment such as hammers, chisels, picks, and shovels are used as soon as sinking begins. At a certain depth, ropes and bags are used to extract the dead earth via the pulley system (Figure 3). The pulley is installed to facilitate manual pulling, while the torch is used to illuminate the galleries. The jackhammer is used if muscle power fails to overcome the hard rock in the hole. If the jackhammers fail to break through the rock, a compressor is used. The compressor helps create holes in the rock where dynamite, known as "Far Away", is placed. The person in charge of this task, paid 5,000 CFA francs per dynamite set, is referred to as a "Tempère"[8]. During the sinking process, the divers often encounter water, so they use a motor-driven pump to evacuate the water.

When digging a shaft, the hole is sometimes supported by wooden planks and wire to prevent it from collapsing, hence the role of "wedges". Once the pit boss has obtained the ore, a sack of ore is handed over to the caleur as payment. At a depth of around 20 meters, the hole needs to be aerated to lower the temperature and transport oxygen to the melters. For this purpose, they use a solar-powered stirring head and a very long black bag. This long bag connects the stirring head at the surface to the melters at depth (Figure 4).

The drillers first carry out tests to extract the gold-bearing ore from the hole. If the ore is deemed rich in gold and has a high market value after testing, they proceed with extraction. Not all extraction sites require gold-rich ore to be packed in 50 kg bags. In principle, according to the miners, gold is in short supply, which justifies the lack of interest in packaging it. Figure 4 shows a ventilation system

[9] Name given to those who carefully place dynamite(s) in the right places to explode hard rock in holes.

with an agitation head powered by a solar panel. Air is transported from the surface to the foundries via a long black bag.

Figure 4. The well ventilation system using an agitation head.

Once the ore has been extracted, it is transported to the yaar for processing by crushers. Their main role is to crush the ore to reduce the size of the rock before transporting it to the crushers. Crushing is done by the bag, so the cost of this service varies between 600, 700, or 1,000 CFA francs, depending on the strength of the ore. Crushing is generally carried out by children, and this activity takes place throughout the yaar. The tools used are bags that are rolled up, leaving a hole in the middle into which the ore is tapped.

The ore is tapped with a hammer on an anvil[9]. The rolled bag is a precautionary measure, as it enables crushers to protect their hands. The bag also minimizes the scattering of the ore. In terms of form, they make no use of any protective equipment (Figure 3) on the gold ore extraction site.

The next step is to grind the ore into powder. This facilitates washing for better recovery of the gold powder (Sawadogo, 2011). For ore grinding[10], ore owners who do not have mills for grinding turn to mill owners for grinding. The instruments used for this purpose are grinding wheels and barrels filled with water to cool the mills simultaneously. In Tangonia, they have introduced a new machine they call the "wonbyaaré"[11] (Figure 3). With this machine, the ore is not ground three times before washing, but twice. After the ore has passed through the "wonbyaaré", it is supposed to be ground twice, and the mill (Figure 3) does the final grinding. However, after a first wash, some people decide to grind the washed and slightly concentrated ore a third time to wash it again. The mill shown in Figure 3 is used for this third grinding operation. For the third grinding operation, those who decide to grind their ore again pay the sum of 5,000 CFA francs per flat of ore.

On the site, crushing is no longer done by the sack, as on other sites, but by the barrel, and the price of the crushed barrel varies according to the strength of the rock. The price ranges from 7,500 to 10,000 CFA francs per barrel of ore. This applies to the first two stages of ore crushing.

[9] The anvil here is a large granite stone.
[10] At this level, sometimes the go-getters and the hole leader are no longer together.
[11] In Moré, this term means "crush everything".

The grinding phase prepares the ore for washing. The crushed ore is transported to the washing sheds, where the ore is washed to concentrate the gold. According to Sawadogo (2011), concentration is achieved by gravimetric sluice separation. A variety of ore washing methods are used on-site. The instruments used for the various washings are virtually the same, with a few differences. Ore washing methods differ in the number of times the ore is washed. In addition, the decision to further grind the ore retained after washing in the belts and/or add mercury prior to grinding also constitutes a level of differentiation. Ultimately, the composition of the sluice used for washing also differs.

The instruments used include large bowls, water barrels, sluices, and soap pots. Once in the washing sheds, the ore is mixed with water in large bowls to form a slurry. Gradually, the washer removes this slurry with the soap pot and, using the water in a bowl, adds water and washes the ore over the top of the sluice. The sluice has a top section (Figure 3), which is inclined thanks to a barrel on which this section rests. During washing, the light material is carried down to a hole where it is collected. In the hole, this light matter forms a sludge called "gneika" or "garaga". It may or may not be sold to cyanidation processors. In any case, most gold miners prefer to do the cyanidation themselves or make arrangements with cyanidation site managers. The bottom of the sluice is then lined with black plastic, on which cloth or wool mats are laid. The purpose of these cloth mats is to retain the heavy elements, which are blocked by two or three pieces of iron. This covering is used during the first and second washings.

The first wash takes place just after the first two ore crushings. During this phase, the ore collected in the belts is placed in a cup to be dried. After drying, the ore is ground a third time in a mill they call a "belt-noor machine"[12], before being washed once more. The composition of the sieve is always the same as that of the first wash. Therefore, with this second wash, the ore retained in the mats is put back into a cup. However, the quantity of ore is significantly reduced. This concentrated ore is breaded with pans to further concentrate it by adding the mercury known as "Med"[13]. At this stage of preparation, the ore is kneaded by the goldsmith's bare hands to obtain the gold-mercury amalgam that will be burned later.

The other washing technique consists of introducing a small quantity of mercury into the ore retained in the mats before grinding it a third time. The ore is washed again, and the final result is a black plastic sheet with no mat. The reason for this change in process is that the mercury mixed with the gold makes it heavier. During washing, the gold-mercury mixture and other materials, such as iron filings, remain on the tarpaulin. At the end of the washing process, the contents of the tarpaulin are scraped into a dish. The gold miners add mercury to the contents of the dish before rubbing it down, then compress the mixture with their bare hands so that it sticks together. At the end of the operation, the resulting mixture is placed in a cloth and compressed to remove most of the mercury. Excess mercury is recovered for later use. At this stage, the gold appears white and is burned to obtain spongy gold. This technique was described following an informal interview.

Well before starting the washing process on the sluice, some gold miners decide to mix detergent with the ore to remove the machine oils that have followed the crushed ore. However, in order to reuse

[12] In Moré, this term refers to the machine that crushes the ore held in the belts.
[13] Local name for mercury.

the water used in the first wash[14], other miners do not add detergent and decide to wash the ore in this way. During the second wash, miners typically choose to add detergent. Although this method is not universally adopted, it is the most common practice at the site. According to the miners, it is the most effective technique for achieving better gold recovery, particularly given the rarity of gold and its presence in powder form.

Some gold miners, after crushing the ore a second time and washing it, opt to introduce mercury directly into the ore without proceeding to a third crushing or washing. This approach is generally used when miners believe that the gold recovered without a third wash is sufficiently profitable. The ore residues obtained at this stage are often sold to others who add mercury to the ore before conducting a third grinding and wash, as described earlier.

The ore obtained from the second or third wash is further concentrated using a pan. Once the concentration process is complete, mercury is added. The miners knead the mixture with their bare hands, combining the gold, mercury, and iron filings in a dish. They rub and compress the mixture in the dish to form an amalgam. The next step involves pressing the amalgam in a cloth to extract the gold. Following this, the gold is heated using a torch, gas flame, or charcoal. This process causes the mercury to evaporate, leaving behind spongy gold. The gold is then transported to Houndé for melting.

Cyanidation marks the final stage in the recovery of artisanally-mined gold. This process involves adding cyanide to the sludge from the various washing stages. On the study site, cyanidation takes place at specialized locations outside the yaar. These sites are privately owned, often by anonymous individuals[15]. Like mercury amalgamation, cyanidation is a process performed only by individuals with expertise in the field. However, as noted by several authors (Kouadio, 2016; Roamba, 2014; Sawadogo, 2011), it is increasingly uncommon for individuals to purchase sludge from various washing processes to carry out cyanidation themselves.

Owners of cyanidation sites occasionally buy sludge for this purpose, but on the Tangonie site, such transactions are rare. According to gold miners, the scarcity of gold at the site makes this practice less viable. Instead, sludge owners without cyanidation expertise or their own cyanidation facilities negotiate directly with cyanidation site owners. These negotiations typically concern the rental of cyanidation basins, with prices ranging from 7,500 to 10,000 CFA francs per basin.

The materials required for cyanidation include potassium cyanide, zinc, nitric acid, and sulfuric acid, which are provided by the sludge owner. For the process, two large basins are excavated, each measuring 2 meters in length, 1.5 meters in width, and 80 centimeters in depth. Between these basins, a smaller basin is dug, measuring 90 centimeters in length and width and 1.5 meters in depth. The larger basins are lined with a watertight tarpaulin to prevent seepage, while the smaller basin is coated with cement.

Before cyanidation, the sludge undergoes drying and is then pounded or rammed with wooden tools to achieve a finer consistency. Proper drying is crucial for the sludge to be accepted at cyanidation

[14] The water used for the first wash is recovered in the basin, which is also used to collect light materials.
[15] They are anonymous for outsiders, i.e. for those who are not from the Tangonie site.

sites. The prepared sludge is transported to the sites using tricycles[16]. Upon arrival at the cyanidation sites, the ore is deposited into large basins, each capable of holding the contents of two full tricycles. Four barrels of water are added to each basin, along with 2 kilograms of cyanide, which is securely bound in bags (Figure 3). The mixture is left to stand for 12 hours.

After this period, the openings connecting the two large basins to the smaller basin are unsealed, allowing the cyanide-gold solution to flow into the small basin. Inside the small basin, a U-shaped tube is fitted with zinc shavings that capture the gold dissolved during the leaching process. The cyanidation process continues until miners observe no further changes in the color of the zinc shavings. At this point, they declare that the "hole is dead". If the zinc shavings in the tube are insufficient to capture all the gold, additional shavings are introduced.

The shavings that have absorbed the gold are then collected and placed in a pan. Sulfuric acid is poured over them to remove impurities, particularly iron. This reaction produces a liquid, which is immediately ignited to create a white powder. This powder is then mixed with nitric acid, which dissolves the bronze and leaves behind gold in powder form. The gold is subsequently sent to the foundry in Houndé for further processing. Before reaching this advanced stage of gold transformation, miners have introduced various modifications to their traditional gold panning techniques. But what are these transformations?

Possible transformations and explanations

To address the gold shortage in Tangonie, miners have implemented a series of changes referred to as transformations. These adjustments primarily concern gold processing methods and the evolving role of women on the mining sites. The following sections outline these transformations and the factors that have driven these modifications in Tangonie.

Transformations

According to gold miners, the scarcity of gold has prompted significant transformations, including the incorporation of chemicals in specific processing stages, an increase in the quantity of chemicals used, and an expanded role for women in gold extraction activities. In response to the ongoing gold shortage at the Tangonie site, various stakeholders have pointed to the pervasive issue of gold scarcity as the primary challenge. Kouama Bouba and Zoun Aminata expressed their perspectives, which were further supported by Bougma Kassoum, the drilling manager, who elaborated on the situation:

> *"[...] the fact that there's not much gold in the ore, there's no theft, there's nothing to worry about...". "...before, we didn't use mercury; for processing, we simply blew the ore to get the gold nuggets. The fact that there are gold nuggets, the little grains are left behind"*[17] (K. Bougma, personal communication, February 18, 2020; B. Traoré, personal communication, March 5, 2020).

[16] The tricycles are called "Noda Tan" on site.
[17] Traoré Bila, gold prospector at the Tangonie site.

In the past, gold miners did not rely on chemicals to process ore and extract gold. They simply blew the ore to retrieve the gold, but this practice has now become obsolete. For miners, the scarcity of gold poses a significant obstacle to the smooth running of their operations. However, they offer no concrete explanation for the underlying causes of this scarcity. These challenges have triggered a series of changes to adapt to the new reality.

The transformations at the Tangonie gold site are evident on several fronts. Foremost among these is the increasingly aggressive use of chemicals. Previously, miners would wait until the ore had been fully washed after grinding before adding mercury. Today, however, the amalgamation method has evolved at Tangonie. Miners now add mercury to the ore immediately after washing for more efficient concentration. After drying the ore, they add additional mercury to facilitate crushing before amalgamating it during a subsequent washing stage.

Telmer and Stapper (2012) identified two modes of mercury use at gold panning sites. According to their findings, miners either add mercury directly to the raw ore, a method they termed Amalgamation du Minerai Brut (AMB), or mix mercury with ore only after it has been concentrated using a washing table or sluice, known as Concentrated Ore Amalgamation (CMA). At Tangonie, the Amalgamation of Concentrated Ore (AMC) process is employed. This approach applies to all in-situ washing methods, as these require the ore to be pre-concentrated. However, the level and quantity of concentrated ore vary depending on the washing technique.

One variant of this method involves adding mercury to the ore before a third milling stage, following the drying process. This approach necessitates a substantial volume of mercury due to the larger quantity of concentrated ore involved.

Similar practices have been documented at other gold-mining sites in Burkina Faso. For instance, Sawadogo (2011) describes mercury usage at the Fafora site. Here, miners process two concentrations of waste rock, which are washed at the edges of pits. The first step involves separating out larger elements, such as wood fragments and stones. The resulting concentrate is dried and then mixed with rejects from amalgamated ore and additional mercury. Once crushed, this mixture is further concentrated by beating to recover the gold-mercury amalgam.

In the Sanmatenga region, miners mix waste rock from panning and ore from sinking with mercury before crushing. This method is used to improve their chances of recovering more gold (Zongo, 2020).

The changes are not limited to the use of mercury as a chemical agent. Cyanide has also become a key component of these transformations, with its dosage increasing in proportion to the concentration of gold powder measured in grams[18]. For ore with a sufficient gold content, the cyanidation process typically uses 1 kilogram of cyanide per basin, with each basin holding the equivalent of two tricycle loads of ore. For ore with minimal or no detectable gold content, the cyanide dose increases to 3 kilograms per basin. However, on other sites, only 1 kilogram of cyanide is needed to process three full tricycles of ore (Kouadio, 2016; Roamba, 2014).

In addition to increased cyanide use, some pit managers now opt to repeat the cyanidation process—a departure from earlier practices when a single cyanidation was the standard. The scarcity of

[18] This is the ore that has undergone the various processing phases (crushing, grinding, washing, amalgamation).

gold has necessitated this second cyanidation phase to recover any remaining gold particles that may have escaped during the first treatment. Consequently, the amount of cyanide used in the first phase is doubled for the second cyanidation.

Not all miners on the site proceed to the cyanidation stage; some limit their efforts to mercury recovery. However, the trend at the Tangonie site shows that most miners are now shifting toward completing the entire cyanidation process, as it represents the final recovery phase. This shift is aimed at minimizing potential gold losses, given the scarcity of gold at the site.

Finally, one of the most significant transformations concerns the role of women on the mining site. In addition to men, women also play an active and substantial role in gold panning activities. Women constitute 40% to 50% of the workforce on these sites (Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development [IGF], 2017). Their involvement extends beyond their traditional roles as housewives (Leclerc-Olive et al., 2023)[19], Women are heavily involved in both alluvial and lode gold mining. Their contributions are particularly notable in the maintenance and management of gold ore washing sheds, where men come to wash their ore. This significant role has been highlighted by several authors (Mégret, 2009; Ouédraogo, 2020; Sawadogo, 2011; Sawadogo, 2021; Sawadogo & Da†, 2021; Zongo, 2020). However, Ouédraogo (2020) also documented the emergence of competition between men and women over control of the washing sheds. This rivalry stems from disputes over the ownership of residues and sludge produced during ore washing.

At the Tangonie site, women no longer fulfill this role, as men have chosen to manage their own washing sheds within the yaar compound. Gold miners interviewed explained that this shift is driven by the scarcity of gold at the site and a desire to minimize potential losses. As one gold panner, Mme Zoun Aminata, remarked: *"The men no longer wash the gold here. If there is gold, the mud is for the women; if there is no gold, it's difficult for the mud to return to the women"*[20] (A. Zoun, personal communication, March 18, 2020). Kouama Bouba also testifies that: *"There's not much gold left. Often, crushing and washing can be done without the initial investment. We need to get to cyanide so that it responds well and makes a profit"* (K. Bougma, personal communication, February 18, 2020). This explains why so few women own ore washing sheds; on the Tangonie site, only two women are reported to have such ownership.

This shift has driven women to become more directly involved in lode gold mining. They now visit mining sites to purchase ore clandestinely, which they trade with team leaders. This practice is facilitated by two factors. First, women collaborate with team leaders in the absence of the hole leaders. Second, they also buy ore directly from the hole leaders. The latter are often willing to sell ore due to a lack of financial and human resources to effectively manage their operations. However, the ore sold to women is often considered by men to be of lower gold content. Long before the extraction of gold-rich ore, portions of it are mixed with earthy gangue. It is this mixed ore that is typically sold to women.

In their study conducted in Noumbiel province, Dah and Somda (2023) observed women who own wells and collaborate with other men to manage them. Additionally, some women have taken

[19] There are gold miners living with their families on the Tangonia yaar.
[20] Mrs. Zoun Aminata, gold digger managing an ore washing shed,.

ownership of mills and grinders. The same is true in Sanmatenga[21], where some women take on most of the expenses of a well, but prefer to leave the management to their partner (husband). In this way, women participate discreetly (Zongo, 2020). These cases were not reported during the field surveys, although it is important to note that this role is intentionally concealed by the women themselves.

Some possible explanations for the changes brought to the region by gold prospectors

Explaining the transformations carried out by miners is an arduous and complex task. This is due to the lack of data to corroborate their statements. Nevertheless, we have tried to find plausible reasons for these changes. The reasons for the evolution of changes or variations in gold processing methods were also the subject of our study. To this end, we needed to determine whether the transformations were linked to the extraction methods used by artisanal miners or whether they were related to the physical characteristics of the gold (nugget, inclusion, lode, or fine gold). Additional information was sought from ANEEMAS and the Burkina Faso Bureau of Mines and Geology (BUMIGEB), given the scarcity of data.

The primary objective of miners—and even industrialists—is to make maximum profit with minimum investment. They will take all appropriate measures to ensure a substantial return on investment. Gold miners carry out processing without any prior field study. They are either former industrial mine workers, friends of geologists or BUMIGEB agents, or have observed processing methods at other sites. This justifies their immersion in the business of clandestine gold processing and marketing. In the same vein, Zongo (2020, p. 444) mentions that: *"The movement of people from one gold panning site to another is accompanied by a strong mobility of mining and processing techniques, and a transfer of know-how"*. In the same vein, Traoré (2023, p. 8) states: *"In the course of their travels, gold miners come into contact and work with other miners from different regions or nationalities, from whom they gain experience. This has always been a feature of gold panning in West Africa.*

The goldsmith may find that other goldsmiths on a particular gold panning site are processing the ore in a special way and decide to imitate it on his own site without expertise. It is this latter reason that drives gold miners to use other gold extraction methods in addition to those that existed according to the state of the art of ore processing methods.

Thus, with the new processing methods certainly observed on the sites, these changes are also observed on the Tangonie site. They can be seen in the variations in gold processing methods. The scarcity of this mineral resource may explain the changing role of women on gold panning sites. These women, lacking customers, are obliged to go to different extraction sites and buy the raw ore to mine it themselves.

[21] Sanmatenga is one of Burkina Faso's provinces in the Centre-Nord region.

CONCLUSIONS

Artisanal gold mining is becoming increasingly widespread in Burkina Faso against a backdrop of dwindling natural resources. The situation is much the same in other countries of the sub-region. Gold is mined in two (02) ways: lode mining and alluvial mining. Lode mining rigorously follows a multi-phase mining scheme (prospecting, sinking, crushing, grinding, washing, and recovery with mercury and cyanide). In response to the increasing scarcity of gold, certain transformations are taking place in the gold panning industry. These changes are reflected in the quantity and use of mercury and cyanide by gold miners. They are also accompanied by changes in the role of women on all gold panning sites.

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Modern Geográfia
Vol. 20, Issue 2, 2025: 97–123
DOI: 10.15170/MG.2025.20.02.06

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Comparing RUSLE LS Calculation Methods Across Varying DEM Resolutions

ABSTRACT

Soil erosion reduces land productivity and causes environmental degradation. Soil erosion models, such as the Revised Universal Soil Loss Equation (RUSLE), are used to estimate the severity and distribution of erosion. The topographic factor (LS), which combines slope length and angle, is an important part of RUSLE. Two methods for calculating L, the grid cumulation (GC) and the contributing area (CA) methods, and two methods for calculating S, the neighborhood (NBR) and maximum downhill slope (MDS) methods, were compared using digital elevation models (DEMs) with resolutions of 1, 5, 10, and 30 m.

Keywords: soil erosion, RUSLE, slope, DEM, resolution

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INTRODUCTION

Soil erosion and related degradation are a global problem (Telles et al., 2011; Segura et al., 2014; Di Stefano & Ferro, 2016; Kassai et al, 2022). From persistent agricultural pressures to expanding infrastructures for growing populations, any activity that disturbs the Earth's surface increases soil vulnerability to detachment (Telles et al., 2011; Laflen & Flanagan, 2013; Segura et al., 2014; Di Stefano & Ferro, 2016). Soil erosion models help land managers make informed decisions to mitigate soil erosion issues by identifying the severity and location of soil erosion (Renard et al., 1997). One commonly used model to aid in managing and mitigating the effects of soil erosion is the Revised Universal Soil Loss Equation (RUSLE) (Renard et al., 1997).

Two major and often contentious components are the L and S factors that represent the slope length and steepness of the site. Traditionally, they were estimated or calculated from field measurements which can be used for local conservation planning, but this is only feasible at a small scale as using actual field measurements is labor-intensive, time consuming, and costly (Hickey et al., 1994; Van Remortel et al., 2001; Van Remortel et al., 2004; Liu et al., 2011; Yang, 2015). Within the past 20 years or so, various methods have been developed to calculate the L and S factors. However, the comparison of these is lacking consistent testing and analysis of the differences across multiple study sites and digital elevation model (DEM) resolutions. This research tests the quantitative and spatial differences of various GIS methods and algorithms for calculating the L and S factors. These differences are analyzed across varying resolutions using DEMs of 1, 5, 10, and 30 m.

Two of the most common and widely studied methods of calculating the L factor from a DEM are the grid cumulation (GC) and the contributing area (CA) methods (Winchell et al., 2008; Liu et al., 2011; Yang, 2015; Zhang et al., 2017). The GC method calculates slope length along the flow path using a D8 flow-routing algorithm which closely resembles the original USLE and RUSLE manual calculation methods (Hickey, 2000; Van Remortel et al., 2001; Van Remortel et al., 2004). The GC method can also include a slope cutoff factor that helps identify breaks in slope and areas of deposition (Hickey, 2000; Van Remortel et al., 2001; Van Remortel et al., 2004). This method will be used with and without the incorporation of this slope cutoff factor to determine how much this variable influences L factor values. The CA method substitutes the linear estimate of slope length in the L factor with the upslope contributing area for a particular point (Moore and Burch, 1986; Desmet & Govers, 1996a, Winchell et al., 2008). For this method, two different flow-routing algorithms are used in the calculation of a cell's upslope contributing area which determine the distribution of flow from a cell to its downslope neighbors (Desmet & Govers, 1996b, Wilson et al., 2007; Winchell et al., 2008; Liu et al., 2011).

Two different algorithms for calculating slope in the S factor are also compared. The neighborhood (NBR) method is the standard used by the Environmental Systems Research Institute's (ESRI) ArcMap and ArcGIS Pro programs and calculates a cell's slope using that cell's eight neighbors (ESRI, 2018c). The maximum downhill slope (MDS) method considers a cell's elevation in relation to its eight surrounding neighbors to calculate the maximum value of the downhill slope for that cell (Dunn & Hickey, 1998; Ashraf et al., 2012).

The original research plan was to compare LS output against measured erosion. However, collecting said data was outside the scope of the project, and we couldn't find any existing erosion data at an appropriate scale. Attempts were then made to find the original data used to derive the USLE, but the plots and data were no longer available. Thus, this project was left with comparing model outputs over different DEM resolutions in different landscapes. Future research on this topic should be focused on collecting real world erosion data that can be used to further compare and refine these algorithms. This paper provides details about a single site – however, see Moody (2019) for a similar analysis across multiple locations and terrains.

This research will provide a foundation for understanding the differences between these L and S calculation methods and how they affect erosion estimates. If real world erosion data becomes available this will help to verify the most appropriate methods and if different methods should be used with changing landscape conditions. The objectives of this research are to:

- compare and analyze the L and S factor outputs using the grid cumulation method and the contributing area method for L,
- compare the neighborhood method and the maximum downhill slope method to calculate slope angle for S,
- and to quantify the effects of DEM resolution on L and S factor calculations.

METHODS

Erosion modeling

The Universal Soil Loss Equation (USLE) family of models estimate overland soil erosion by water from the major factors that influence this process such as climate, topography, vegetation, and land use (Wischmeier & Smith, 1978; Renard et al., 1997; Gilley & Flanagan, 2007; Suhua et al., 2013; Ganasri & Ramesh, 2016). Karydas et al. (2014), Bezak et al. (2021), and Borrelli et al. (2021) found that the USLE family (and RUSLE in particular) were the most widely used empirical models. The RUSLE, especially when combined with a geographic information system (GIS), is a cost-effective management tool that can be used to determine the pattern, intensity, and cost of soil erosion on sensitive landscapes (Renard et al., 1997; Van Remortel et al., 2004; Liu et al., 2011; Telles et al., 2011; Zhang et al., 2013; Zhang et al., 2017; Karydas et al., 2014; Segura et al., 2014; Ganasri & Ramesh, 2016; Raj et al., 2018). Empirical models are more frequently used than stochastic models for two primary reasons: data availability and historic precedent. Data is almost always available for a relatively simple model like the RUSLE, however, the more complex the model, the greater the data requirements and assumptions. Further, the USLE and its derivatives (like the RUSLE) have been used for a very long time and are generally considered acceptable.

The RUSLE contains six factors to estimate the average annual soil loss for a specified area from rill and interrill erosion processes. These factors are rainfall and runoff (R), soil erodibility (K), slope length (L), slope steepness (S), cover management (C), and support practices (P). They are combined

into the equation A = RKLSCP, where A is the long-term soil loss for the site, usually presented in tons/acre/year.

The R factor, usually presented as MJ mm ha^{-1} h^{-1} per year, is the erosion that results from raindrop impact and associated storm runoff (Wischmeier & Smith, 1978; Renard et al., 1997; Nearing et al., 2017). The K factor is the susceptibility of the surface soil to detachment and the transportability of that soil material to overland flow in a storm event under reference plot conditions (Wischmeier & Smith, 1978; Renard et al., 1997; Ganasri & Ramesh, 2016). The L factor and S factor are commonly evaluated and referred together as the topographic slope factor in most related literature (Renard et al., 1997; Winchell et al., 2008; Zhang et al., 2013; Zhang et al., 2017; Ganasri & Ramesh, 2016). This product of LS is the ratio of soil loss from a specified slope to a reference slope that has a length of 22.13m (72.6 feet) and a steepness of 9 percent, holding all other conditions equal (Wischmeier & Smith, 1978; Renard et al., 1997). The slope length is defined by Wischmeier and Smith (1978) as "the horizontal distance from the origin of overland flow to the point where either the slope gradient decreases enough that deposition begins, or runoff becomes concentrated in a defined channel." The C factor represents the effect that cropping and management practices have on erosion rates in relation to the reference plot conditions of a continuously tilled fallow site (Wischmeier & Smith, 1978; Renard et al., 1997; Laflen & Moldenhauer, 2003). Finally, the P factor is a ratio of the soil loss with the sites conservation support practices to the reference plot of straight row up and down tillage; values closer to zero represent good use of supporting practices (Wischmeier & Smith, 1978; Renard et al., 1997; Laflen & Moldenhauer, 2003; Ganasri & Ramesh, 2016).

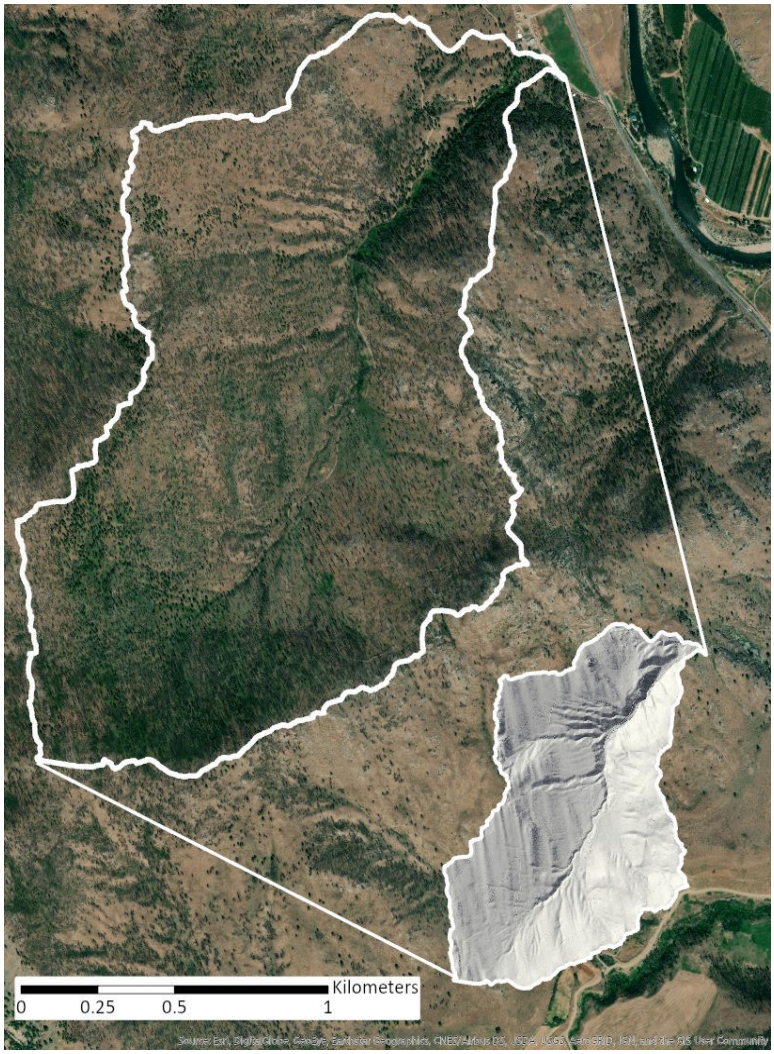
Study area

This article presents a subset of the work done as part of a MS thesis (Moody, 2019). In that thesis, there were four different study sites in Washington State in the northwestern United States that test varying terrain conditions (Moody, 2019). They were selected based on the availability of high point density LiDAR (Light Detection And Ranging) data, catchment areas of at least 1 km^2, no paved roads, and avoiding irrigated sites to best conform to conditions under which the RUSLE model is most applicable. The results from all 4 sites were similar. This paper presents only the results at a single study site (Figure 1).

The study site is the McCall Basin in Okanogan County, Washington, ~ 8 km northwest of Methow along the south side of State Route 153 and ~ 21 km south of Twisp. It is 2.6 km^2 with elevation ranging from 385 m to 920 m and slopes varying from 0 degrees to 84 degrees with a mean of 19 degrees. There are mostly east and west facing slopes with the main drainage channel moving south to north in the center of the catchment (Figure 2). This environment is largely open arid rangeland with ponderosa pine (*Pinus ponderosa*) dominated forests and woodlands. Precipitation occurs predominantly in winter and spring as rain, averaging 12.7 inches per year, and snow, averaging 43.3 inches per year (Western Regional Climate Center, 2021).

Figure 1. Study site location in Washington State, United States.

Figure 2. Study site boundary south of Twisp, Washington, United States.



Building DEMs

LiDAR data of the study site was used to create 1, 5, 10, and 30 m DEMs using the ArcGIS Pro 2.4 LAS Dataset to Raster tool. The interpolation type was set to binning interpolation (output cell uses those points that fall within its extent) with the cell assignment method set to average and the void fill method set to linear (ESRI, 2018d). These are the default settings for this tool. The binning approach is also supported by the idea that DEM cells can be interpreted as an average elevation over the area that that cell represents, and so the average of that cell can be the average of LiDAR points that fall within the cell (Zhang et al., 1999).

Calculating S factors

The S factor involves two equations depending on the slope gradient:

$$S = 10.8\sin\theta+0.03 \text{ for slopes} < 9 \text{ percent}$$
$$S = 16.8\sin\theta-0.50 \text{ for slopes} \geq 9 \text{ percent},$$

where θ is the slope angle in degrees. Research has found that the S factor has the greater influence on RUSLE estimates, so the method of calculating the slope angle is crucial (Wang et al., 2002; Warren et al., 2004; Ashraf et al., 2012).

Neighborhood method

The NBR method of slope angle calculation, which is used by the Environmental Systems Research Institute (ESRI) in their GIS programs, is an averaging method where a 3x3 window moves over the DEM and calculates the center cell's slope by averaging the rate of change in elevation of the surrounding eight neighbors. Geographic Resources Analysis Support System (GRASS) and Quantum GIS (QGIS) also use similar averaging methods for their slope calculations (GDAL, 2020; GRASS, 2020). The equation used for the NBR method (in degrees) is (ESRI, 2018b):

$$\theta = \tan^{-1}\left(\sqrt{\left(\frac{dz}{dx}\right)^2 + \left(\frac{dz}{dy}\right)^2}\right)$$

where $\frac{dz}{dx}$ is the east to west slope and $\frac{dz}{dy}$ is the north to south slope. This method leads to inaccuracies where lower slope estimates are calculated in steep terrain and higher estimates are calculated in flat terrain (Dunn & Hickey, 1998; Hickey, 2000; Ashraf et al., 2012; ESRI, 2018c). This calculation is also inconsistent with flow direction, which follows the steepest downslope direction, making its use inconsistent and problematic for models that rely on flow direction (Dunn & Hickey, 1998).

Maximum downhill slope method

The maximum downhill slope method is able to retain local variability and small scale features as it does not use an average for calculating slope (Dunn & Hickey, 1998; Hickey, 2000). This method

also uses a 3x3 window, but considers the center cell's elevation and its difference between one of the eight neighbors that gives the maximum downhill slope (Dunn & Hickey, 1998; Hickey, 2000). The consideration of only downhill neighbors for maximum value ensures that slope calculations are neither over- or underestimated (Dunn and Hickey, 1998; Hickey, 2000). The equation is as follows:

$$\theta = \tan^{-1}(\max \frac{(z_9 - z_i)}{L_e})$$

where L_e is the distance between the midpoints of the center and neighboring cell (if neighboring cell diagonally adjacent then multiply by $\sqrt{2}$, z_9 is the center cell, and z_i is neighboring cell 1–8. The advantage of this method being able to retain small scale features can also result in the disadvantage of being sensitive to local errors in DEMs (Hickey, 2000; Ashraf et al., 2012). However, this method more accurately represents true landscape variability, especially in combination with high quality fine resolution DEMs, producing greater variance in values of slope steepness and the S factor (Dunn & Hickey, 1998; Hickey, 2000). This method is consistent with flow direction (flow direction is the direction of maximum downhill slope angle), making it the better method to use for models that require flow direction (such as RUSLE).

Calculating L factors

The grid cumulation method

This method uses the length calculated along flow path as slope length (λ) in the L factor calculation. It is the summation of the non-cumulative slope length (NCSL) following flow direction, using a D8 flow routing algorithm, from high points in the landscape. This calculation conforms to RUSLE requirements where the measurements are in (x,y) space rather than (x,y,z) space.

High points are first identified as they represent the start of all flow paths. They are cells that have an out-flow direction but no in-flow, such as ridgelines and peaks, and so flow length is assumed to only occur in that half of the cell that is downhill from the center (Van Remortel et al., 2001). Then, the NCSL is calculated for every cell following the rules below:

- If the cell is a high point and:
  - Flow direction is cardinal = 0.5 (cell resolution)
  - Flow direction is diagonal = 0.5 (1.4142) (cell resolution)
- If the cell is not a high point and:
  - Flow direction is cardinal = (cell resolution)
  - Flow direction is diagonal = 1.4142 (cell resolution)

NCSL values are then added together for the cumulative slope length along flow direction starting at high points. The cumulative slope length is terminated either when two flow paths meet and the shorter path ends, a stream channel is reached, or the slope angle decreases enough that deposition occurs (Hickey, 2000; Van Remortel et al., 2001; Van Remortel et al., 2004). The slope cutoff factor incorporates the occurrence of slope angles decreasing enough to initiate deposition. It assumes that

at least a 50 percent slope angle decrease from one cell to the next describes areas of deposition rather than erosion (Hickey et al., 1994; Hickey, 2000). It is recommended that this value be assigned by an expert of the study area, but as this is not always feasible, a default value of 0.5 can be used (Hickey, 2000). A value of 1 means that the slope length never resets; a value of 0 means slope length resets anytime the slope angle decreases.

In this research, the MDS method is used to calculate slope angle for the L factor calculations (used in the rill to interrill ratio exponent). The slope raster produced is searched for flat pixels (0 degrees slope) which are re-assigned a 0.1 degree slope angle; this allows for minimal erosion within that flat area without altering flow paths (Van Remortel et al., 2001).

Another update is the incorporation of a channel initiation threshold variable to account for areas where rill to interrill erosion is no longer the dominant erosion process, such as stream channels (Wischmeier & Smith, 1978; Renard et al., 1997; Zhang et al., 2013). This is another user input value that sets the percentage of maximum cell area required to define a channel. The default value is set to 1 percent of the maximum flow accumulation value, meaning if a cell's flow accumulation is greater than 1 percent of the raster's maximum flow accumulation value it will be considered part of a defined channel and the L factor values will be set to no data (ESRI, 2018a). After the cumulative slope length is calculated for the entire site, the L factor equation can be applied using the calculated cumulative slope length for each cell as λ. The equation for the L factor in the RUSLE model is:

$$L = (\lambda/72.6)^m,$$

where λ is the linear measurement of slope length, 72.6 is the model reference plot length in feet, and m is a variable slope length exponent related to the ratio of rill to interill erosion (Foster & Wischmeier, 1974; Renard et al., 1997).

The procedure for calculating the L factor using the GC method is shown in Figure 3. The inputs to the tool include a DEM larger than site boundary, a slope cutoff factor, and an optional channel initiation threshold value. The tool was run twice for each DEM with slope cutoff values at 0.5 and then at 1.0; the channel initiation threshold value was always set to 1.0.

In order to maintain the single L algorithm as previously discussed for this study, it is assumed that slope lengths are longer than 15 ft, since the RUSLE includes alternative L algorithms for slopes less than 15 ft (Renard et al., 1997; Van Remortel et al., 2001). It is possible to include these alternate algorithms for slopes less than 15 feet for the 1 m DEMs but not for the 5, 10, or 30 m DEM. To allow for proper comparison of L factor calculation methods across all DEM scales, these alternate algorithms have not been incorporated.

The contributing area method

A separate script was created to simplify and automate the creation of the L Factor with the CA method (Figure 4). This script was run with two different flow-routing algorithms, D8 and D, to calculate the unit contributing area. The channel initiation threshold stayed at 1.0, just as it was with the GC method. The D8 algorithm follows flow direction and directs all flow to the one steepest down slope neighbor; the D algorithm accounts for dispersion and splits flow between one or two

downslope neighbors (Desmet & Govers, 1996b, McCool et al., 1989; Quinn et al., 1991; Wilson et al., 2007; Liu et al., 2011; Raj et al., 2018).

The CA method substitutes slope length with upslope contributing area. This is based off the concept that overland flow and erosion does not depend on the distance of flow from a point of origin, but rather on the flow convergence and divergence over the area per unit contour length contributing flow to a specific point in the landscape (Desmet & Govers, 1996a). This method of calculating the L factor in a GIS using the upslope contributing area is:

$$L_{i,j} = \frac{(A_{i,j-in} + D^2)^{m+1} - A_{i,j-in}^{m+1}}{D^{m+2}(x_{i,j}^{m})22.13^{m}}$$

where $L_{i,j}$ is the L factor for the grid cell at coordinates (i, j), $A_{i,j\text{-}in}$ is the contributing area at the inlet of that grid cell, D is the grid cell size (meters), and $x_{i,j} = \sin(a_{i,j}) + \cos(a_{i,j})$ where $a_{i,j}$ is the aspect direction.

Figure 3. Process of calculating the RUSLE L factor using the GC method.

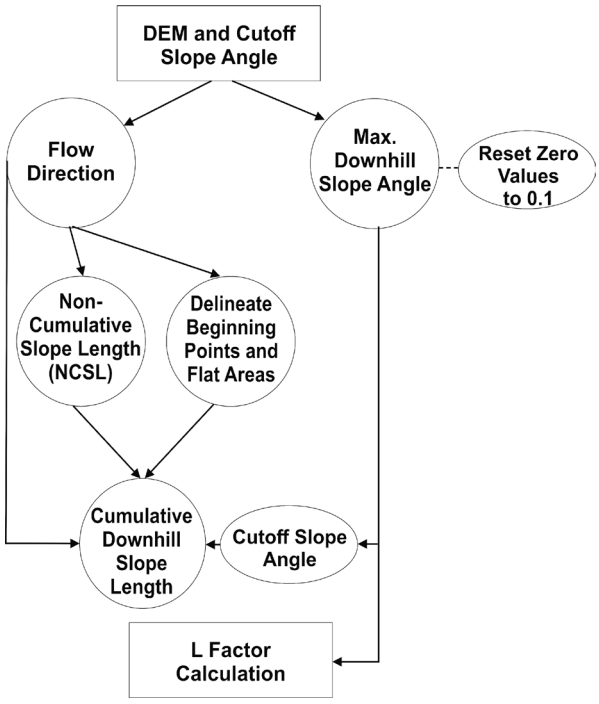
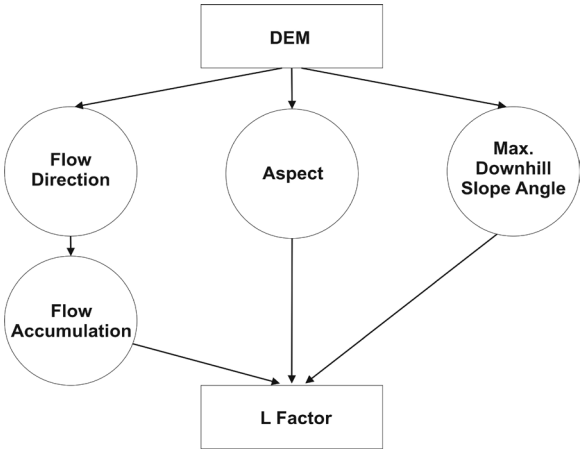


Figure 4. Process of calculating the RUSLE L factor using the CA method.



RESULTS

S factor

Overall, the MDS method appears to be less sensitive to changing DEM resolutions than the NBR method (Tables A1–4, Appendix). As resolution becomes coarser the mean, median, and maximum values for both methods decrease. The mean and median values for the MDS method are more resilient to coarser DEM resolutions and typically exhibit a smaller degree of change in comparison to the changes the NBR method mean and median values experience. The most significant change that occurs is the increase in minimum values for both methods using a resolution of 30 m. Minimum values can increase by more than ten times the value at 1 m with the MDS having the largest increase.

Overall mean and median values from each method produce similar results, especially at finer resolutions, but are strongly influenced by changing DEM resolutions. As resolution decreases, the methods begin to produce outputs that are no longer statistically different at the 1% significance level using a Kolmogorov-Smirnov test. The null hypothesis is that the NBR and MDS method produce results that come from the same data distribution. This was rejected at the 1, 5, and 10 m resolution. The null hypothesis was not rejected at the 30 m resolution. The S factor is vulnerable to losing small scale features to landscape smoothing at this resolution and differences between the MDS and NBR methods decrease since the larger cell sizes homogenize the landscape.

S outputs using the MDS method reflect the landscape more accurately and are more detailed for resolutions coarser than 1 m. Features such as roads and trails are still identifiable at the 5 m resolution using the MDS method, while they are lost in the NBR method.

The smoothing effect of decreasing resolution is most noticeable on those slope categories that are most scarce in the landscape. If the landscape is predominately a gentle flat terrain, then the minority of area that exhibits steep slopes is going to be minimized further or even lost. The MDS method is the best method to retain variability of slope steepness in the landscape, retaining small scale features. Coarse resolution DEMs smooth the landscape and using the NBR method on those DEMs further smooths landscapes and dramatically reduces local variability. This can be seen from the loss of detecting roads in the 1 m resolution to the 5 m resolution using the NBR method. Features such as roads are important influences on water flow and erosion. Being able to detect these features and their influences is important in obtaining representative outputs of the landscape.

The MDS method produces higher maximum values which confirms existing understanding that the NBR method underestimates steep slopes. At coarse resolutions, the MDS method is more likely to produce higher maximum values than the NBR method. However, the MDS does not always produce lower minimum values. Minimum values stay relatively similar until 30 m resolutions where the MDS method produces significantly larger minimum values. At coarse resolutions the landscape is smoothed, meaning that local depressions that could have been picked up with the MDS method are lost. This significantly raises the minimum values calculated by the MDS method.

L factor

The L factor was compared across 1, 5, 10, and 30 m resolutions. At each resolution the L factor was calculated as follows:

- using the GC method that utilizes a SFD algorithm (D8 algorithm) and a slope cutoff factor (Figures 5 and 6),
- using the CA method utilizing both SFD (D8 algorithm) and MFD (D∞ algorithm) algorithms (Figures 7 and 8).

This allows for understanding where change occurs within each individual method across DEM scales. Nodata areas (shown in red) are those locations identified as sites where the channel initiation threshold was >1. The CA method produces higher mean, median, and maximum values of L than the GC method in all landscapes, since accumulating cell area yields higher values than accumulating cell length and values are combined when flow paths converge (Tables A5–7, Appendix). It is also sensitive to areas along prominent drainage channels where the greatest area accumulates and produces extremely high L values.

GC method

L factor mean and median values produced by the GC method with slope reset varied little from those produced without slope reset, however a difference raster of the GC without slope reset minus the GC with slope reset shows significant spatial variability (Figure 9). Maximum values varied the most at 1 m, where the resolution can capture landscape features that reset slope length. In the figures below, as DEM resolution becomes coarser, spatial differences decrease to being less than 2. The GC method without slope cutoff produces higher maximum values and longer slope lengths.

In simple terrains and/or small catchments, the areas that change the most with the slope cutoff variable appear to be long smooth hill sides without any defined channels where flow continues predominately in one direction. For this landscape type, flow paths continue to accumulate with the only condition of breaking slope length to be a change in slope steepness. At coarse resolutions of 10 m or more, this landscape loses the micro features that alter flow and becomes smoothed, so differences from using the slope cutoff are lost. More complex landscapes and/or larger catchments, such as the study site, have proportionally smaller differences in maximum values between using or not using the slope cutoff variable, but the longest flow paths are still greater than those in the simpler or smaller landscapes and differences remain detectable even at coarser resolutions of 10 m or greater. For most landscapes, the incorporation of the slope cutoff variable at high resolution 1 m DEMs accounts for fine scale variability. Sudden changes in steepness that occur from barriers or micro features that interrupt flow and break slope length are detected. However, the problem still remains that visually interpreting erosion estimates for these areas at 1 m is noisy, and it is difficult to identify patterns or locate problem areas. For example, using aerial photography in combination with visual on-site verification for this project, micro features that are captured at 1 m and not 5 m, such as cattle paths that create small bench features, increases the chance of meeting the slope cutoff variable to break slope length. However, 5 m resolutions are still able to capture the influence of other small-scale features such as dirt roads.

Figure 5. L factor with the GC method with slope cutoff set to 0.5 at 1 m (top left), 5 m (top right), 10 m (bottom left), and 30 m (bottom right).

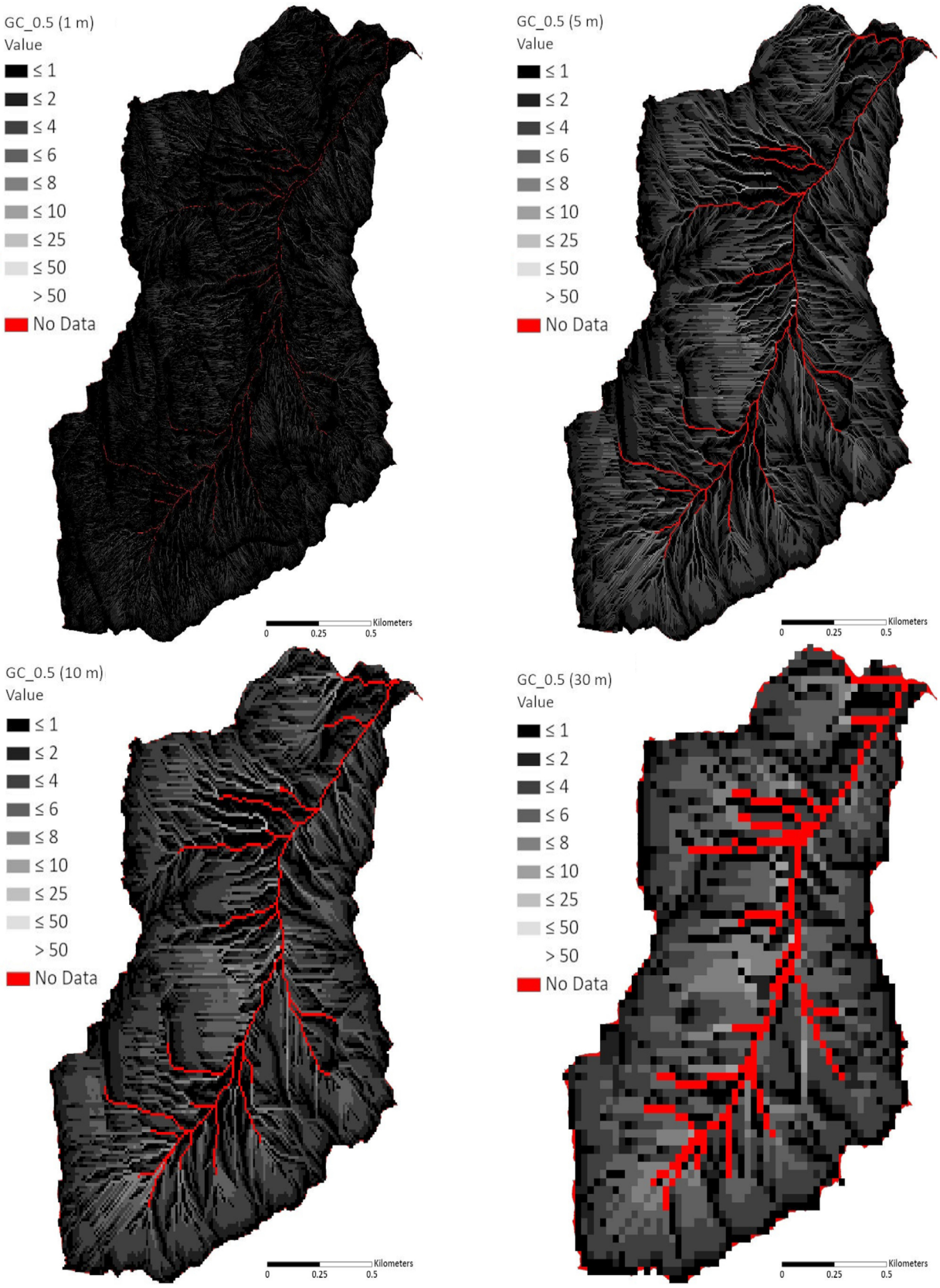


Figure 6. L factor with the GC Method with slope cutoff set to 1.0 at 1 m (top left), 5 m (top right), 10 m (bottom left), and 30 m (bottom right).

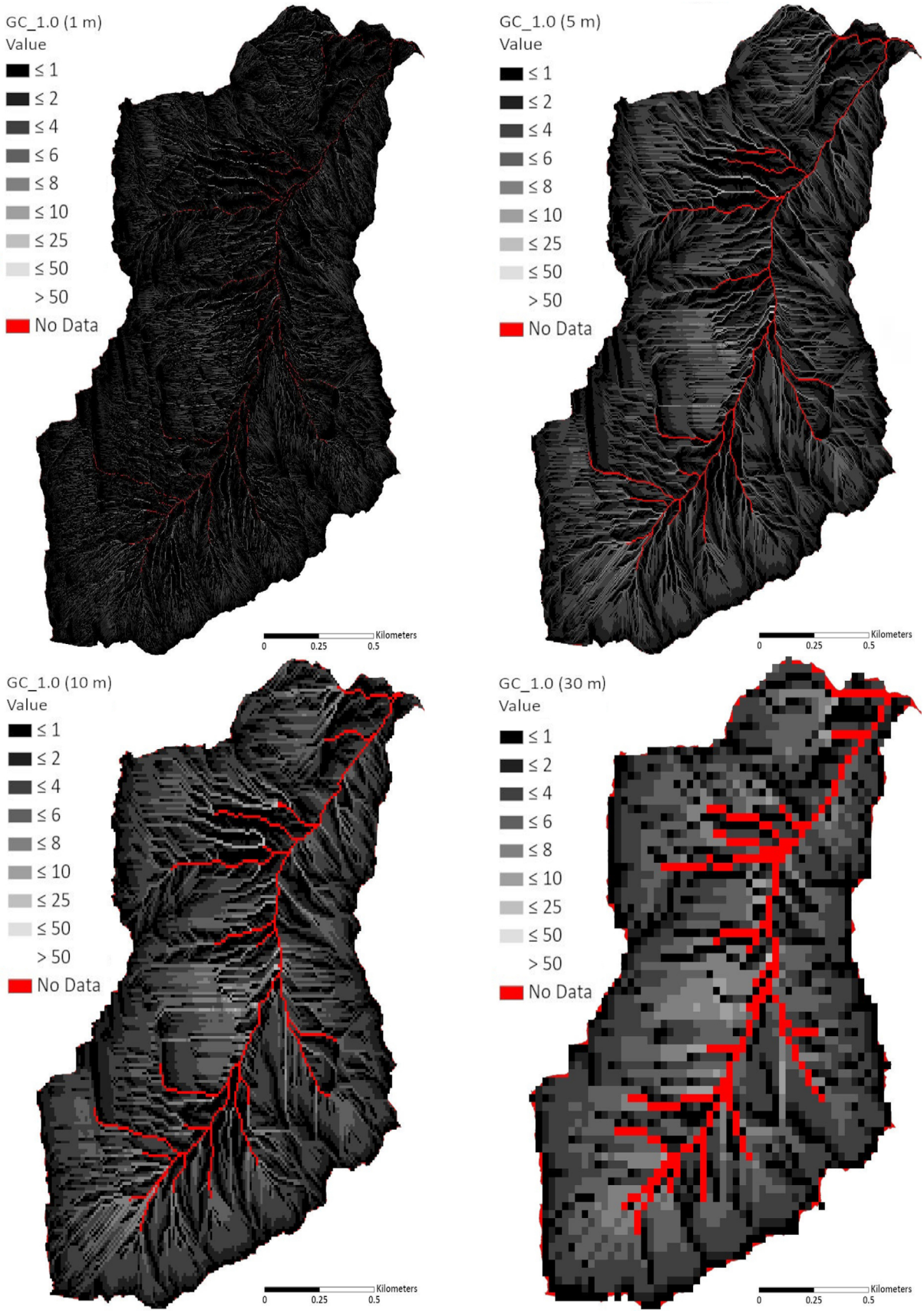


Figure 7. L factor with the CA method with a SFD algorithm at 1 m (top left), 5 m (top right), 10 m (bottom left), and 30 m (bottom right).

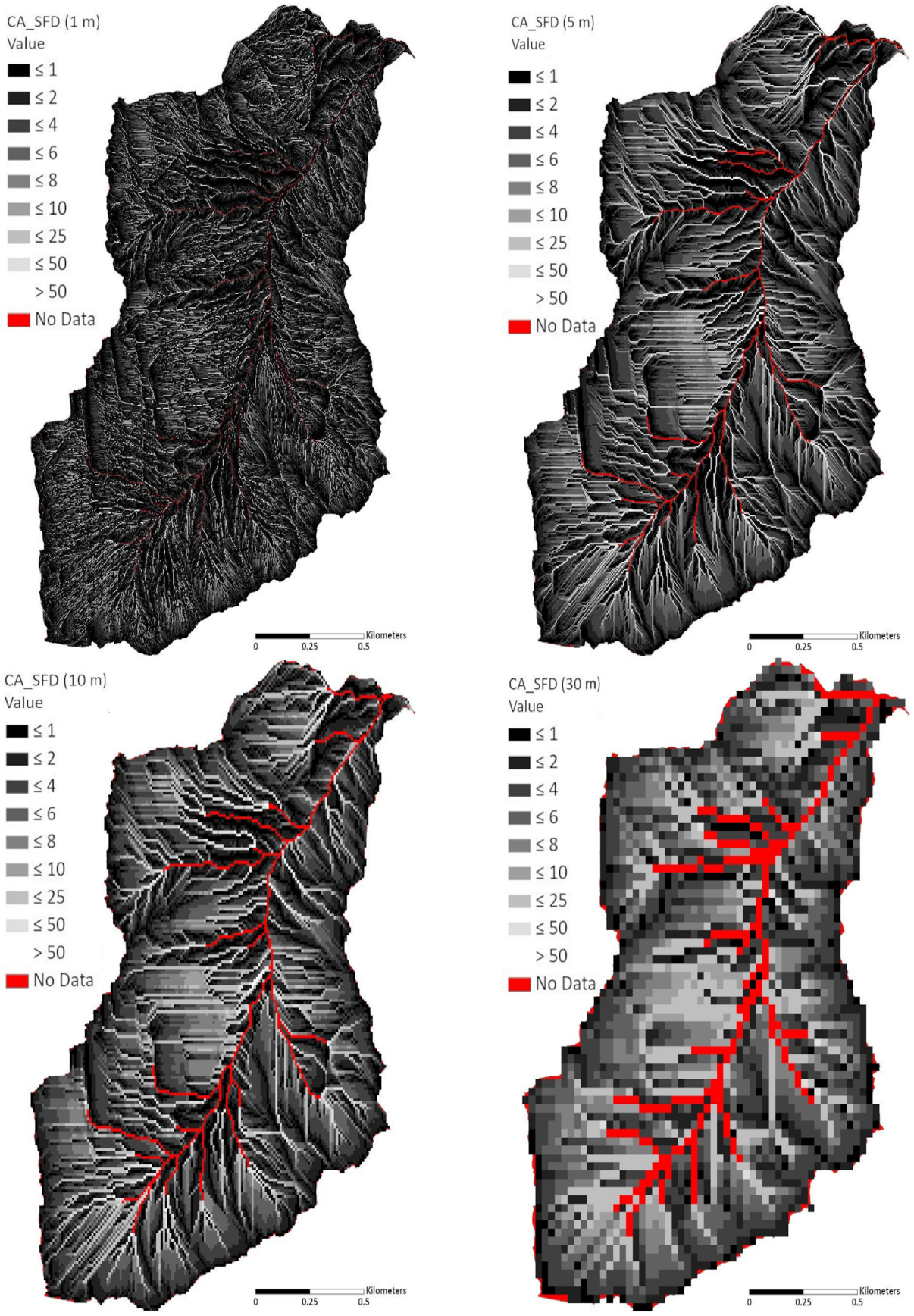


Figure 8. L factor with the CA method with a MFD algorithm at 1 m (top left), 5 m (top right), 10 m (bottom left), and 30 m (bottom right).

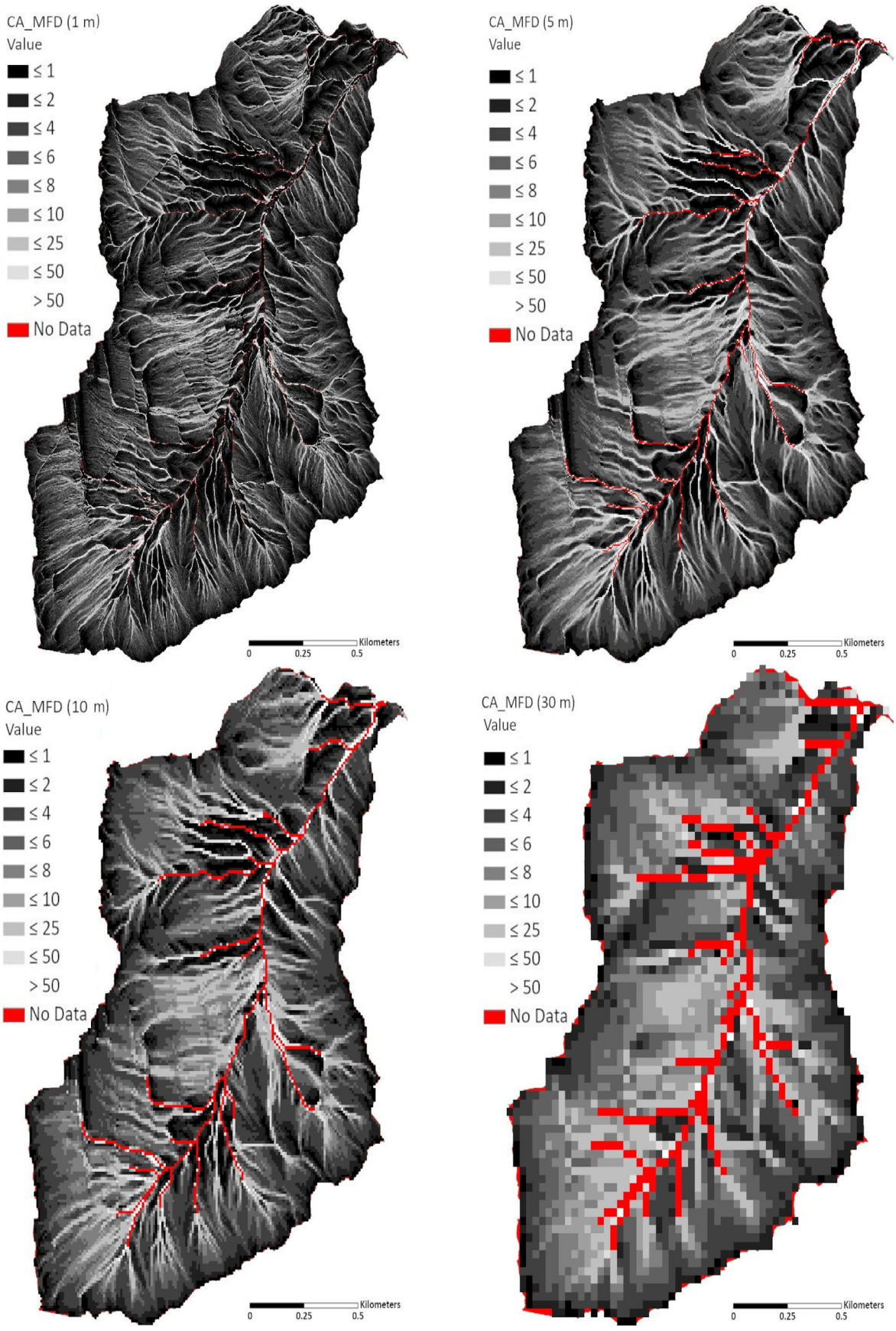
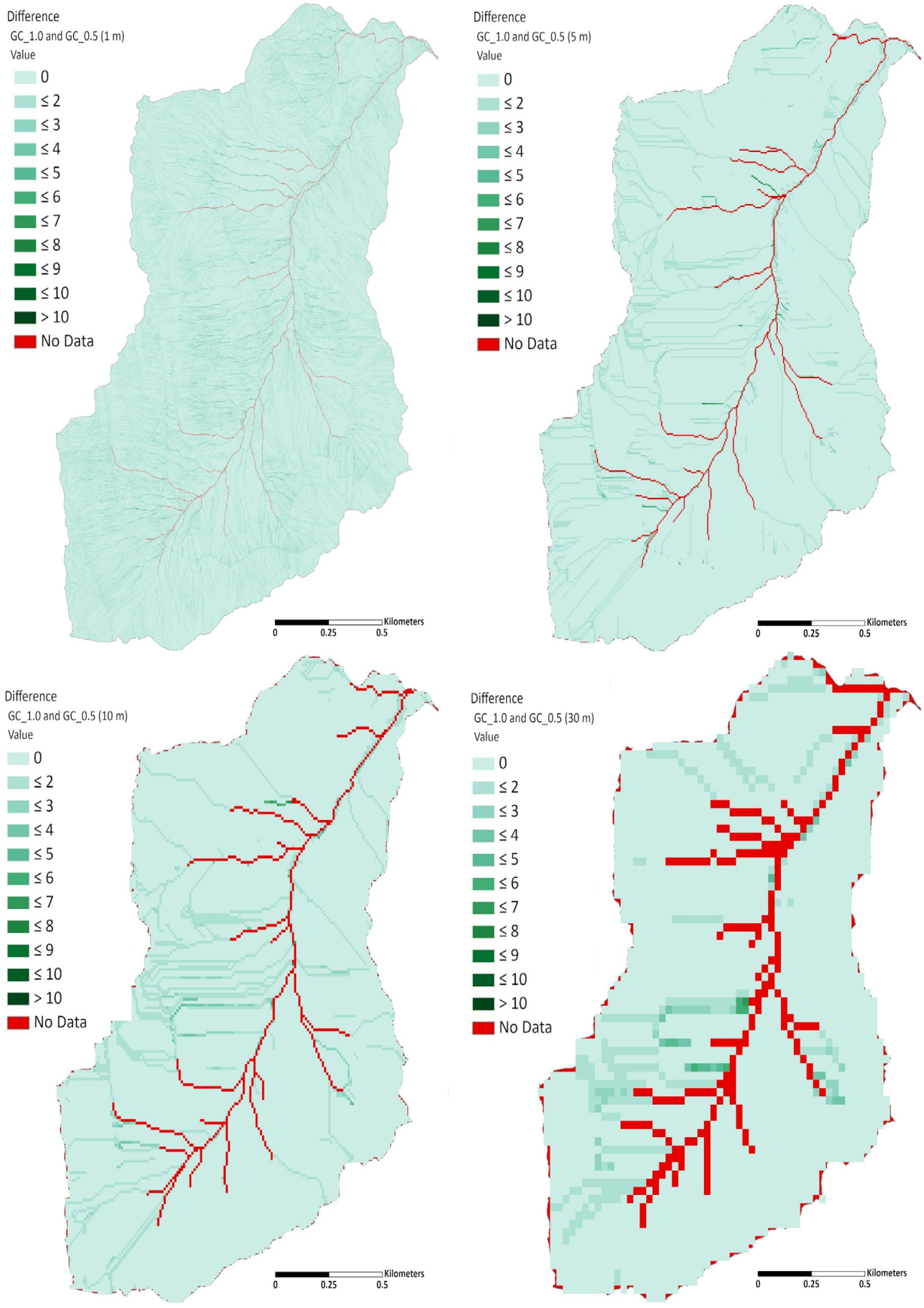


Figure 9. Difference raster of the GC method with slope cutoff (GC_0.5) subtracted from the GC method without slope cutoff (GC_1.0) at 1 m (top left), 5 m (top right), 10 m (bottom left), and 30 m (bottom right).



The 1 m resolution can be difficult to visually interpret, especially for more complex landscapes, but may produce more meaningful estimates of total erosion occurring in the site if looking at a sum total of RUSLE estimates. The 5 m resolution visually highlights patterns and specific areas within the study site that have the highest erosion related to slope length. This provides a valuable resource for useful qualitative visual analyses. Resolutions coarser than 5 m smooth landscapes and lose small scale features, producing less detailed outputs.

Lower resolutions mean that the minimum slope lengths for every pixel are increased with the greater pixel size and increase L mean and median values. The mean and median increase also due to the decrease in the number of starting point pixels of flow paths (low L values) that occur at the top of slopes.

The GC method without slope cutoff generates longer slopes and produce higher L factor values in the above-mentioned areas. Using the slope cutoff variable better refines the spatial distribution of erosion estimates across slopes and identifies areas in a slope where slope change can be initiating deposition instead of continuing to accumulate slope length for greater erosion.

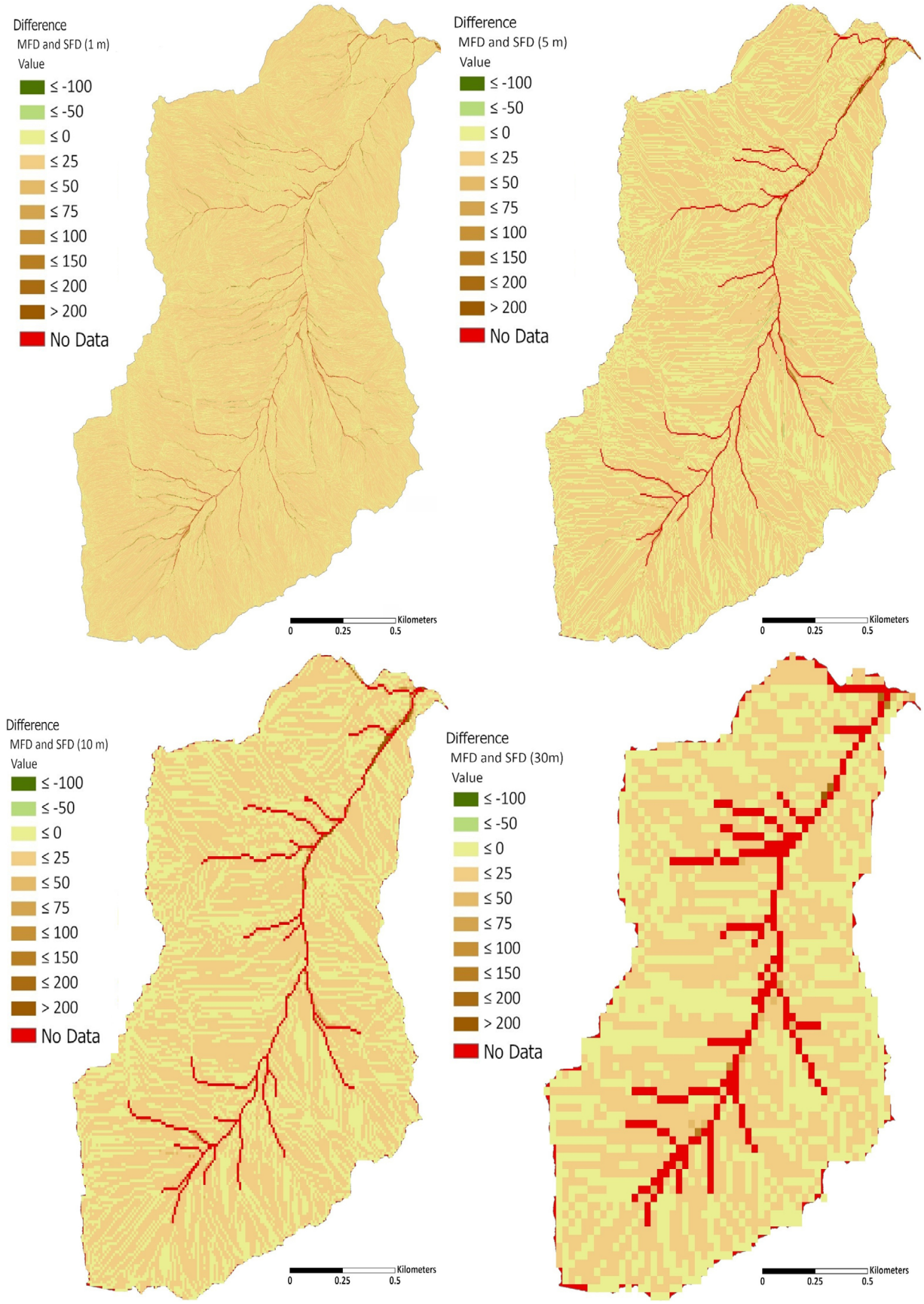
CA method

The CA method produces extremely high L factor values that skew the distribution and create higher mean values. Thus, the median value is more representative of the central values. This method will produce increasingly higher L values with increasing catchment area, greater elevation change, and decreased number of main drainage channels. These factors control available area to distribute flow down the slopes and the amount of area draining down around any one defined channel.

Difference rasters of the CA method with the MFD and then the SFD algorithm are shown below (Figure 10). The MFD diffuses the contributing area, while the SFD concentrates that area into a single flow to produce easily identifiable drainage patterns. The MFD algorithm splits and distributes area to more downslope neighbors so there are more cells with overall higher L values, leading to a higher mean, median, and maximum values. Most of the smaller differences between the SFD and MFD algorithms appear to occur in open gentle slopes where topography does not naturally aggregate flow into drainage channels.

The CA method overall is sensitive where flow begins to concentrate near a defined channel, producing exceptionally high values as almost all upslope area is combined. For the SFD algorithm, these high values are concentrated in easily identifiable drainage patterns while the MFD algorithm disperses area in a fan like pattern before converging and reaching the defined channels. These areas are in a zone that is no longer applicable to the RUSLE model, where flow concentrates enough that the dominant erosional process is greater than rill and interill erosion becoming either gullies or stream channels (Wischmeier & Smith, 1978; Renard et al., 1997; Zhang et al., 2013). The defined channel threshold is meant to minimize the effect of this occurrence and is best set by an expert of the study site and drainage network. A detailed stream network file, built from topographical data of at least the same resolution and timeframe of the site's DEM, could also be used if available.

Figure 10. Difference raster of the CA method using a SFD algorithm (SFD) subtracted from the CA method using a MFD algorithm (MFD) at 1 m (top left), 5 m (top right), 10 m (bottom left), and 30 m (bottom right).



Coarse resolutions increase the pixel size and minimum area to disperse downslope which increases L mean and median values from 1 to 30 m resolutions. However maximum value decreases as the landscape is smoothed and simplified and there are fewer cells to disperse downslope area to before reaching defined drainage channels or catchment boundaries.

GC and CA methods

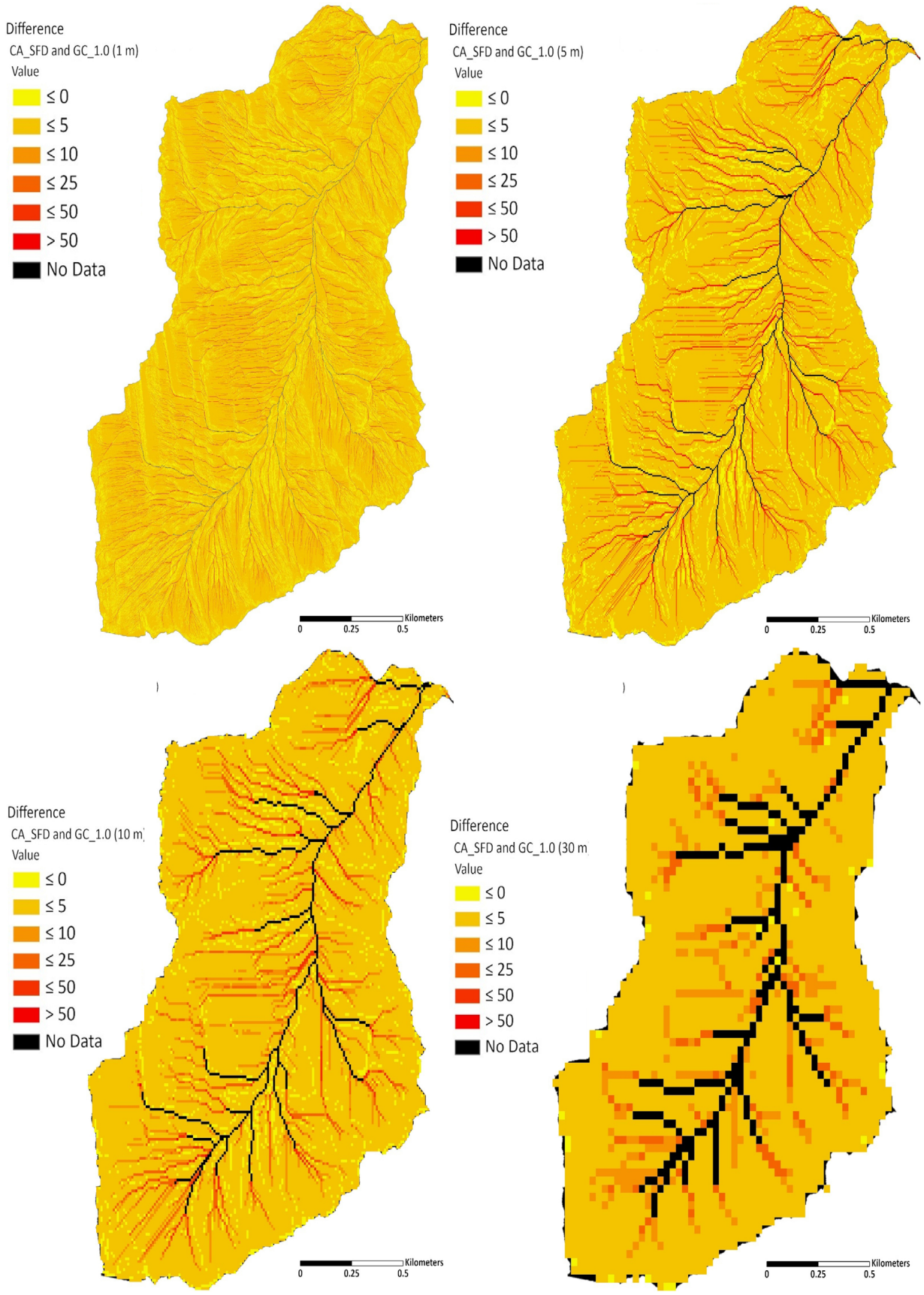
To compare the two methods, the CA method using the SFD algorithm and the GC method without slope cutoff are used for difference rasters. This is done since these are most similar, the CA with the MFD algorithm producing higher mean, median, and max will have even greater differences to the GC method with a slope cutoff of 0.5. The differences identified with CA using the SFD and GC without slope cutoff will be increased with other combinations such as CA using a MFD and GC with slope cutoff. Differences between the methods grow larger as flow becomes concentrated moving downslope, especially along drainage channels (Figure 11). This corresponds to how each method treats convergence in the landscape. The CA method combines accumulated area where two or more paths converge, allowing for all area in the site to influence values downslope. The GC method only continues the longest flow path; the flow paths that are ended no longer influence values downslope.

The largest differences in all outputs occur between the choice of SFD and MFD algorithms for the CA method as well as between the GC and the CA methods. Differences between the outputs of these methods decrease as resolution of the DEM becomes coarser. For the CA method, the choice of flow routing algorithm has the least impact on L values in comparison to the effects of degrading DEM resolution and in comparison to the GC method, which was also noted by Liu et al. (2011). However, within the choice of flow-routing algorithms for only the CA method, SFD algorithms produce lower mean contributing area and L factor values than MFD algorithms which has also been shown in Desmet and Govers (1996b), Wilson et al. (2007), and Liu et al. (2011). The CA method has no equivalent for the slope cutoff that is incorporated in the GC method. This means the greater values of area accumulating in the CA method will continue to accumulate while the GC method has the opportunity to reset slope length values. The CA method creates overall higher L values than using slope length which alters the weight of the L factor in the RUSLE model, potentially overestimating erosion.

To determine the statistical significance of the differences between these methods, a two-sided hypothesis test with a null hypothesis that two independent methods at the same resolution were drawn from the same distribution was conducted. For each method pairing, at each resolution, the null hypothesis is that the distribution values for both methods are the same. It was found that the GC methods were statistically different from the CA methods at the 1% significance level for all resolutions. The CA method using the SFD algorithm (CA_SFD) is also statistically different to the CA method using the MFD algorithm (CA_MFD) at the 1% significance level for all resolutions.

The GC method using slope cutoff (GC_0.5) remained statistically significant at the 1% level compared to the GC method without slope cutoff (GC_1.0) for the 1, 5, and 10 m resolutions. This provides support to the assertion that as resolution degrades, differences between using these methods are lost to landscape smoothing.

Figure 11. Difference raster of the GC method without slope cutoff (GC_1.0) subtracted from the CA method using a SFD algorithm (CA_SFD) at 1 m (top left), 5 m (top right), 10 m (bottom left), and 30 m (bottom right).



CONCLUSIONS

Soil erosion models aid land managers and policy makers in the use, management, and conservation of soil resources. Using the CA method for the L factor cannot be recommended without extensive research comparing L values to real world erosion rates, as its calculation fundamentals are outside the construction of the RUSLE model. Using this on large sites and sites with great elevation change increases the area available and produces much higher L values than what is seen in relatively small sites with minimal elevation change. Since RUSLE is concerned with the erosion of soil across the land surface and is not applicable to other erosional processes, the CA method could be overestimating the L factor's influence on erosion estimates by using area and allowing convergence to dominate the output rather than slope length. Differences between using the GC and the CA method grow as the size of the study area enlarges, landscape complexity increases, and the number of drainage channels increase.

The slope cutoff variable should be used with the GC method, especially at resolutions less than or equal to 5 m. While the range in values are similar, the spatial distribution and occurrence of lower values around slope steepness changes is statistically different at these fine resolutions. Once the landscape loses its microfeatures at resolutions of 10 m or greater, there is a low chance that outputs incorporating slope cutoff will be statistically different at the 1% significance level.

The MDS method is recommended for slope calculations, particularly at fine resolutions. This method retains landscape variability and creates more realistic estimates related to slope steepness. Small scale features such as roads and cattle trails were still detectable at a 5 m resolution, while many were lost using the NBR method. The NBR method underestimates slope at ridges and produces lower S factor values while overestimating slope in flatter regions. If possible, its recommended to use resolutions finer than 30 m due to the dramatic effect that this coarse resolution has on slope values.

Overall, very fine resolution does not necessarily produce the best outputs. A resolution of 5 m is recommended for most uses since it is still able to detect fine scale features that alter flow in the landscape while using the MDS method for the S factor and the GC method with slope cutoff for the L factor. This resolution allows for meaningful interpretation of the spatial distribution of erosion without showing an overwhelming amount of variation in the values across the site that can make visual interpretation difficult.

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APPENDIX

Table A1. Mean value of S factor.

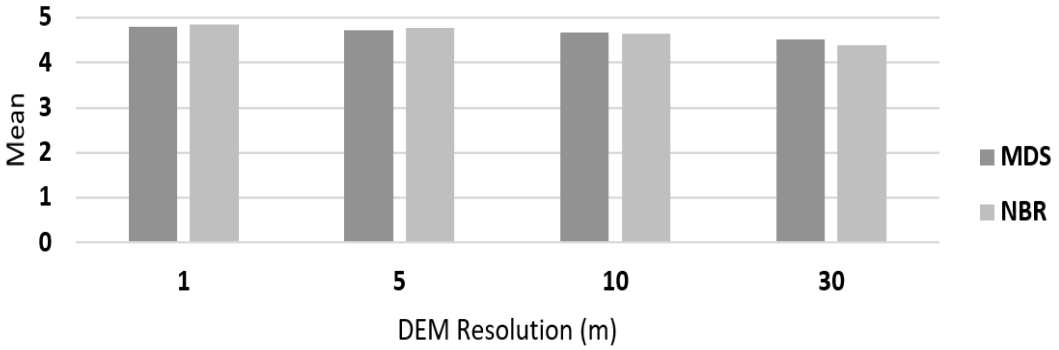


Table A2. Median value of S factor.

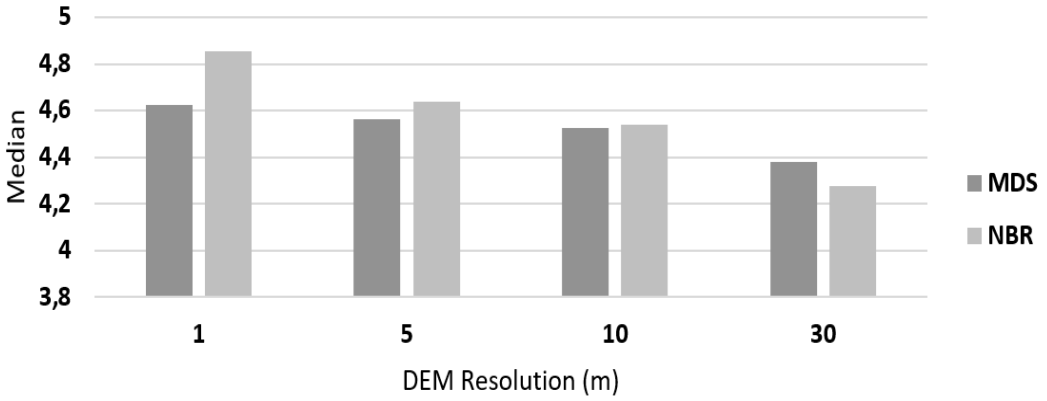


Table A3. Maximum value of S factor.

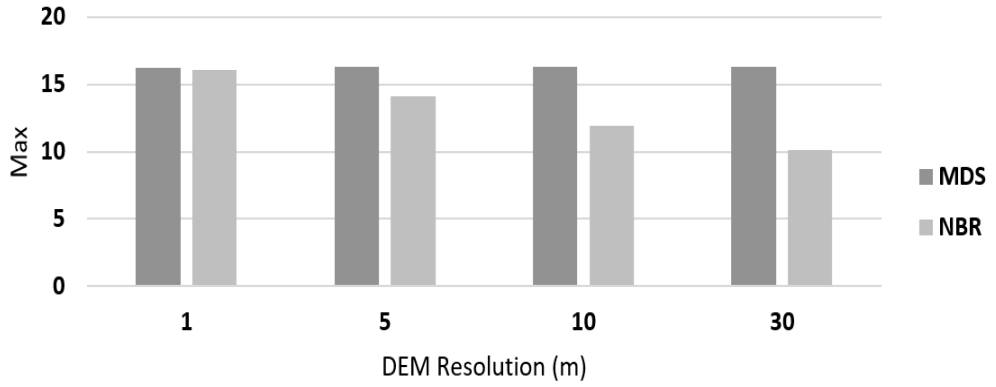


Table A4. Minimum value of S factor.

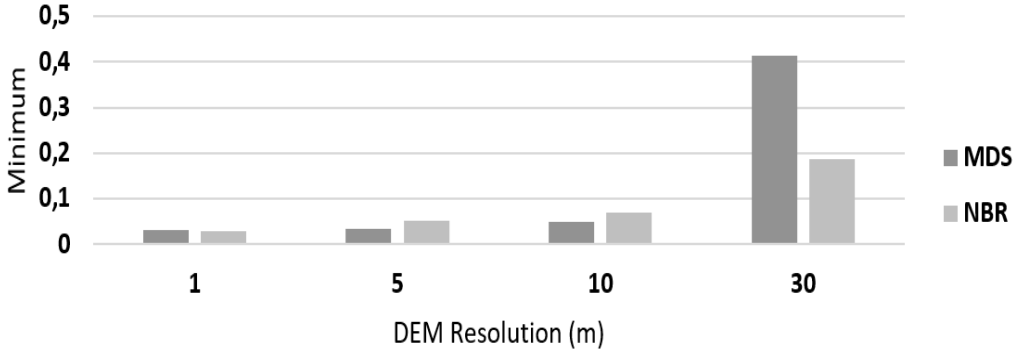


Table A5. Mean value of L factor where GC_0.5 is the GC method with slope cutoff set to 0.5, GC_1.0 is the GC method without slope cutoff, CA_SFD is the CA method using a SFD algorithm, and CA_MFD is the CA method using a MFD algorithm.

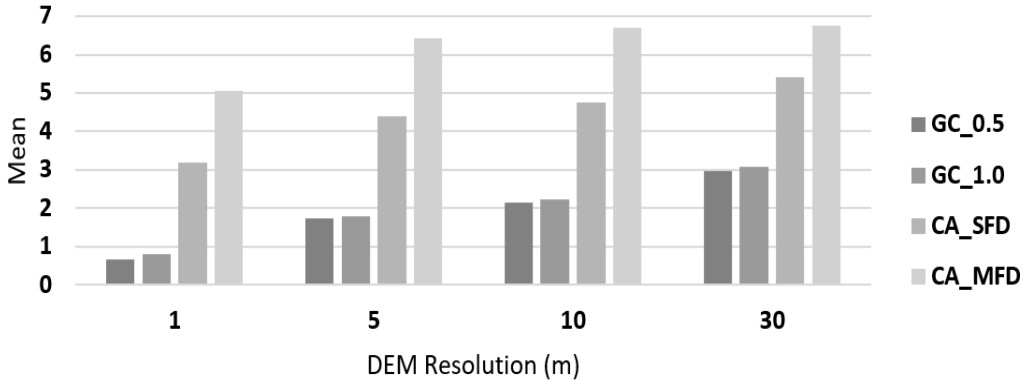


Table A6. Median value of L factor where GC_0.5 is the GC method with slope cutoff set to 0.5, GC_1.0 is the GC method without slope cutoff, CA_SFD is the CA method using a SFD algorithm, and CA_MFD is the CA method using a MFD algorithm.

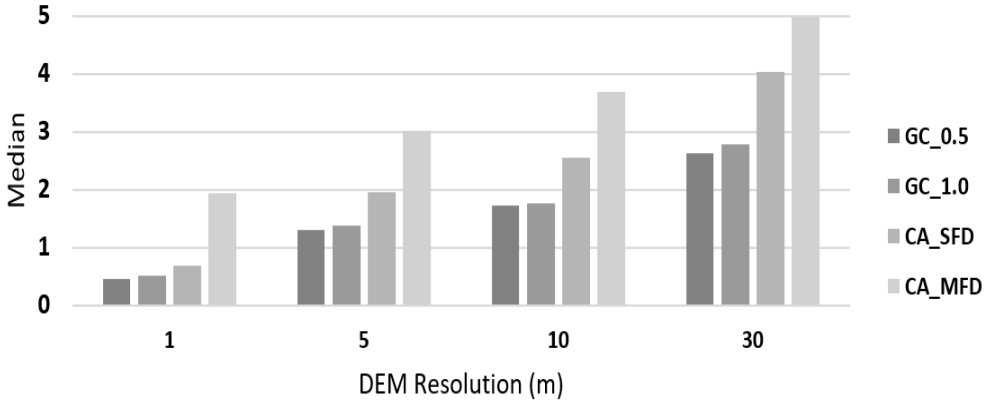
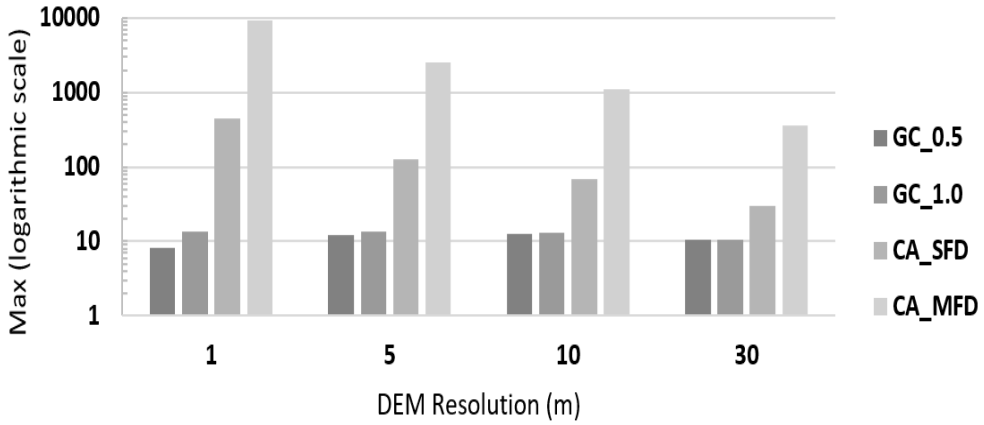


Table A7. Max value of L factor where GC_0.5 is the GC method with slope cutoff set to 0.5, GC_1.0 is the GC method without slope cutoff, CA_SFD is the CA method using a SFD algorithm, and CA_MFD is the CA method using a MFD algorithm.



Modern Geográfia
Vol. 20, Issue 2, 2025: 125–140
DOI: 10.15170/MG.2025.20.02.07

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Sustainabilities in Brazil: Institutional Modernization, Strategic Public Policies and Political Geography in the Brazilian Environmental Agenda

ABSTRACT

Since the early 1970s, the discourse on sustainability has been employed in development projects based on the use, appropriation, and management of resources. Since then, socio-spatial contexts have introduced development rhetoric at various scales (from global to local) to civil society, making the socio-spatial consequences of ecological and environmental exploitation more or less intelligible. Such rhetoric informs policy changes implemented by territorial managers and social actors who directly experience environmental conditions in their regions. As a result, environmental management strategies in Brazil have adapted to varying degrees of public participation, depending on the level of democracy in public policies across different levels of government. In the context of sustainability in Brazil, the role of political levels within federalism fosters the greatest plurality of ideas, responding to the eco-environmental demands of Brazilian society—both from the cultural perspectives of traditional communities and the requirements of national economic projects. To address this complex political and institutional challenge, multi-scale public management must prioritize the understanding that nature and society co-produce environments shaped by both harmonious and conflicting forces, ultimately promoting quality of life and social justice.

Keywords: environment. federalism. scales, public policy, Brazil

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Funding by CNPq and FAPERJ.

INTRODUCTION

Mentioning the early days of institutional discussions on ecology and the environment in Brazil means revisiting the developmental rationale behind military government projects between 1965 and 1985. The first approaches to regulating nature and its spatial relationship with public authorities carried a strong geopolitical burden, tied to the State's control over national territorial resources. As identified by Bertha Becker (1993, 2007) in her extensive research on the Brazilian Amazon since the 1980s, Brazil's public management of these issues until that decade strongly resonated with the military's decisions and interests, which were shaped by conservative nationalism. This ideology prioritized border protection, particularly in the northern and western regions—territories where state-driven agricultural frontier expansion and infrastructure projects for transportation and energy remained underdeveloped. Consequently, Brazil's initial environmental management emerged as a bureaucratic geopolitical strategy rooted in national development, which, in turn, was primarily focused on the internal control of resources and closely linked to the prevailing economic growth model of the time.

By the 1970s, discussions on ecology and the environment had gained prominence on the international stage through forums and conferences that disseminated new ideas and perspectives. These gradually influenced territorial management strategies and the incorporation of ecological and environmental considerations into public policy modernization and institutional planning[2]. In this context, the decentralization of ecological and environmental public policies in Brazil occurred primarily in the northern and midwestern regions, which had been strategically prioritized by the state for the administration of the national strategic vision, *Amazônia Legal*. With the gradual return to decentralized federal management in Brazil, the strengthening of state governments—alongside the rise of multiple political parties through direct elections—created momentum for ecological and environmental discussions. This, in turn, reinforced the management of these issues across different levels of political and institutional representation.

With the enactment of the 1988 Constitution, the restoration of bureaucratic and public governance in Brazilian states was reinforced by expanding the power of local governments (municipalities). Magrini (2001) consolidates this fact within an *integrative standpoint*—a characteristic of the 1990s—highlighting environmentalism as the theoretical foundation for contemporary political actions on ecological and environmental matters in the country. In this framework, the federal, state, and municipal governments began to collaborate on ecological and environmental projects within their respective territories, following a hierarchical authority structure (Wright, 1988—see page 12, tables 3 and 4) in which municipalities play a key role. Today, they remain the third level of decision-making power regarding strategies for the use and appropriation of natural resources.

According to Magrini (2001), the evolution of environmental policy in Brazil can be understood in relation to global milestones that shaped ecological and environmental policies after the mid-20th century. Before reaching its current *integrative* approach—now considered ideal—environmental

[2] Articles examining the integration of sustainability into development strategies have also been published relatively early in the pages of *Modern Geográfia* (Baranyai, 2007; Darányi & Gálosi-Kovács, 2011; Glied & Barkóczi, 2013; Kovács, 2013).

policies, as Magrini notes, initially followed a *correctional* perspective (predominant in the late 1960s and throughout the 1970s), later shifting to a *preventive* stance (mainly in the 1980s).

Under this integrative standpoint, Théry (2005) emphasizes that the revival of the Brazilian rule of law elevates the discussion and appropriation of *Amazônia Legal* to a new level of national significance. According to the same author, the governments of Fernando Henrique Cardoso, through the federal programs *Brasil em Ação* (1996) and *Avança Brasil* (2000), promoted economic and structural integration projects in the Amazon at both national and continental levels. These initiatives strengthened the region, establishing it as a key milestone in the interconnectedness of Brazil's productive and structural networks across South America. The Amazon's production chains became central to Brazil's continental integration, and the substantial technological and infrastructural investments in the region prompted both Brazilian and international societies to organize forums aimed at developing public policies to mitigate the severe ecological and environmental challenges emerging in the Amazon.

These social and environmental transformations had a ripple effect on how both the State and Brazilian society perceived ecological and environmental issues. Following the Rio-92 Summit (among numerous other conferences held throughout the final decade of the 20th century) in Rio de Janeiro, such topics were firmly incorporated into national public policy at multiple levels of governance.

Since the beginning of the Workers' Party governments in 2003, Brazil has undergone a decade of significant decentralization in national environmental management projects—despite the persisting contradictions in legislation, which remains highly centralized and hierarchical. This reality underscores the critical role of geography in understanding what we refer to as *sustainability* within Brazilian territory as a reflection of political space. How can sustainability be effectively promoted in a country with such ecologically diverse and politically complex territories? How does the State conceptualize ecological and environmental management, and how can it be structured to foster social justice through cooperative governance among federative units?

In this context, this article encourages readers and researchers to critically engage with and apply management tools that can expand the possibilities for utilizing ecological and environmental resources, with a primary focus on reducing social inequalities for collective benefit. It also highlights the need to structure public management dynamics in a geographically diverse country, contributing to a broader understanding of how geography can inform territorial policies in both Brazil and the world.

METHODS

Environmental research in Brazil has undergone significant transformations since the 1990s. These changes reflect both scientific advancements and the socio-environmental needs of a country that revalidated its data collection agencies and redefined the roles of federated units and municipalities,

which gained greater autonomy under the Federal Constitution of 1988, still in effect. This section presents the methodology employed by the author for the ongoing discussion.

In the twenty-first century, environmental research has become increasingly integrated with broader access to high-resolution remote sensing technologies. Computational modeling has allowed researchers to simulate future scenarios and assess the impacts of climate change and land use, among other pressing challenges. Additionally, there has been a growing emphasis on citizen science, wherein local populations contribute to data collection, expanding the scale and reach of research efforts. Despite persistent challenges—such as environmental governance issues and political conflicts that hinder the implementation of evidence-based policies—the literature in this field is highly developed. It provides researchers with multiple avenues for investigation and diverse analytical perspectives.

The integration of large volumes of environmental knowledge has guided the author of this article in selecting secondary data from various research efforts, following three main methodological paths:

1. A broad survey of public reports (mostly available online) on legal changes and the establishment of public authorities concerning ecology, the environment, and environmental management in Brazil, dating back to the 1960s (a period marked by the military coup that abolished the rule of law at the time);
2. Consultation of scientific works related to transitional historical periods, where the degree of interdisciplinarity and the scalar diversity of environmental events and their public managers can be assessed; and
3. Methodological approaches (with reference literature) based on participatory strategies and citizen science. These include books, reports, and videos that illustrate how the integration of local communities into environmental research projects contributes to public engagement in data collection, thereby broadening research scope and fostering environmental awareness.

Thus, from advancements in remote sensing to the expansion of citizen science, the qualitative-quantitative foundation of this article enables a more efficient, collaborative, and sustainable approach to understanding the environment—its management structures, challenges, and possibilities.

RESULTS

Phases of the eco-environmental policy transformation in Brazil: General aspects of a late federative problematization

Eco-environmental policies in the country developed late compared to other sector-based policies and emerged primarily in response to international environmental movement demands, starting with the German ‚Grünen' (Greens) in the mid-1960s (Leis, 2004). This delay is directly related to the limited academic culture of that period in the country, as the conservative urban-industrial elite adhered to the classical model of national wealth, based on Rostovian or Marxian logics.

As an ancillary aspect of development, or a 'necessary evil,' pollution and environmental degradation increasingly affected the country's population, worsening with metropolitanization in

the global periphery. Issues related to the distribution and conservation of urban water bodies, the preservation of springs, green slopes, and air quality in cities, as well as various other changes in natural elements to maintain ecological balance, expanded the discussion on the State's capacity to mitigate the impacts of development (Rodrigues et al., 2022). Consequently, large urban centers became fields of observation for researchers attuned to the environmental challenges of Brazilian cities. Although the pollution and environmental impact of uncontrolled urban growth were evident, they were often justified by the benefits brought by progress; in other words, eco-environmental issues were expected to be accepted with resignation (Goldemberg & Barbosa, 2004).

However, times were changing. Considering the power of U.S. public authority—the first country to recognize the need and urgency of governmental intervention in eco-environmental issues in the 1960s, with the formalization of the Environmental Impact Assessment (AIA) at the federal level in 1969 (Goldemberg & Barbosa, 2004)—it was in Cold War-era West Germany that environmental policy representation took shape. Over the following decades, Germany developed a strong environmental education culture (Grün, 2007), forming numerous individuals active in legislative spheres with well-structured agendas to serve German and European society.

In Brazil's case, despite eco-environmental policies being introduced during military governments in the 1970s, their emergence was largely due to international pressure concerning the Amazon and its preservation. Even though the Stockholm Conference (1972) is considered the most significant environmental summit in the contemporary world—one that helped shape future institutional summits addressing major eco-environmental issues—it was conceived in Brazil as a geopolitical strategy of the Cold War. It represented a Western appropriation of environmental causes, seen more as a "necessary evil" than a genuine development concern, something that could potentially hinder development itself.

This discussion was suppressed in Brazil for two reasons: (1) Debates about national sovereignty over areas rich in natural resources (Amazônia Legal) and continental borders. (2) The prevailing belief that nature should fuel Brazil's rise as the "great country of the future", a nation yet to be fully industrialized, maintaining high agricultural production and vast reserves of minerals and potable water. As a future global power, Brazil was expected to play a key role in sustaining the international system of power relations concerning resources for development.

Despite the significance of these issues, specific environmental policies—similar to those implemented in countries like West Germany—were not developed by Brazilian public authorities. Instead, environmental matters were handled through sectoral regulations, including the Water Code (1934), the Forest Code (1965), and Fishing and Hunting regulations (1967) (Bredariol, 2001). There was no coordinated government action or any central agency overseeing environmental concerns (notably, the periods referenced by the author correspond to times of dictatorship in Brazil—both under Vargas and the military government post-1964). Additionally, no structured environmental governance existed at other levels of the federation.

Nevertheless, with the modernization of peripheral economies (including Brazil), pollution became a growing concern in some social and economic sectors (e.g., industrial activities, water pollution,

and urban mobility), leading to increasing environmental demands (Meadows et al., 1972). Despite minimal regulations and interventions, the state could no longer avoid legislative changes addressing water and air pollution.

Having been extensively studied, post-1970 development projects adapted the ‚Limits to Growth' report formulated by MIT. This report presented models linking economic and demographic growth to pollution and natural resource depletion, highlighting the technical aspects of contamination due to rapid industrialization and urbanization (Meadows et al., 1972). The document aimed to provide a broader understanding of the limitations and quantitative and qualitative constraints related to population growth and the expansion of human activities (production, consumption, and waste generation), identifying key factors influencing global systems and their interactions. The academic and managerial intelligentsia referred to a "certain world crisis".

At that point, political concerns regarding eco-environmental management began to take shape, and global ecology conferences—primarily organized by the UN—encouraged societies to push for governmental actions providing technical and financial assistance to mitigate growing environmental damage. Several national entities were tasked with planning, managing, and controlling environmental resources within their territories. However, the dictatorship at the time and the military government's geopolitical vision of transforming Brazil into the "power of the future" reinforced the notion that economic growth should not be sacrificed for a cleaner environment. This perspective was officially defended by Brazil's central government at international summits, such as the Stockholm Conference in 1972 (Ferreira, 1998).

Brazil's international participation was primarily aimed at shifting the responsibility for the environmental costs of economic growth onto central nations. Brazilian leaders invoked the principle of sovereignty (i.e., natural resources within national territory belong to Brazilians) to prevent the country's subjugation to international eco-environmental protection decisions imposed by foreign countries and organizations.

With the establishment of the National Bureau of Environment (SEMA) in 1973, public authorities began internally addressing eco-environmental issues generated by economic growth, although decision-making remained centralized within the military dictatorship. Despite this, there were notable legislative advances concerning the production of biodegradable detergents, vehicle emissions control, the designation of critical pollution areas, and the creation of national conservation units. However, at that time, policy measures mainly focused on industrial and rural pollution, while neglecting significant contributors to environmental degradation, such as inadequate investments in public housing and basic sanitation in major Brazilian cities. Additionally, environmental education projects and professional training programs for agricultural producers were largely ignored, allowing polluting practices (such as deforestation through burning) to persist, causing severe harm to biodiversity and soil quality in rural areas.

The lack of control over real estate speculation, coupled with insufficient regulation of fertilizers and pesticides used by large landowners, led to escalating ecosystem destruction and environmental degradation throughout the 1970s.

During the political re-democratization process, SEMA laid the groundwork for the creation of the National Environment System (SISNAMA) in August 1981. Federal Law 6.938 introduced a more comprehensive framework, and the National Environmental Council (CONAMA) was established as a consultative and deliberative body within the environmental governance structure. CONAMA included representatives from ministries and federal agencies directly involved with environmental issues, as well as state, municipal, and Federal District environmental bodies, industry representatives, and non-governmental organizations.

From 1981 onward, eco-environmental concerns were no longer treated merely as isolated sectoral issues but became part of a broader collaborative framework involving both institutional and non-institutional actors in environmental debates. Within this context, redefining responsibilities in sectoral environmental management became a strategic federal issue, triggering intense disputes within the public administration due to differing perspectives on how eco-environmental policies should be implemented across multiple levels of government.

The complexity of eco-environmental issues and the diversity of stakeholders involved in their management, as established by the 1980s legal framework, contributed to defining objectives, principles, guidelines, tools, responsibilities, and institutions within the National Environmental Policy. According to Bredariol (2001, p. 18), this framework reinforced the understanding that environmental preservation is "favorable to life and aims to ensure the conditions for the socio-economic development of the country, national security interests, and the protection of human dignity." The regulatory instruments were further reinforced and enshrined in the 1988 Federal Constitution. However, even before this constitutional transformation, Brazil's environmental policy underwent a significant redefinition during José Sarney's government (1985–1989).

> (…) through restructuring of public agencies in charge of the environmental issue. Through the program *Nossa Natureza* (Our Nature), Sudepe (fishing), Sudhevea (rubber), IBDF (forest development) and Sema (environment) were unified around only one federal agency: the Brazilian Institute for the Environment and Natural Resources (IBAMA, in Portuguese). (Sousa, 2007, p. 5).

After the adoption of the new Federal Constitution, the decentralization of political decision-making also influenced the way eco-environmental responsibilities were managed nationwide. Under a "more preventive than corrective" approach and within the framework of decentralized federalism—where roles and responsibilities in state administrative management were restructured—the implementation, development, expansion, and operation of activities that generated pollution became subject to prior licensing by a state agency within SISNAMA, in accordance with Decree 99.274 of 1990. The preventive system's mandate to address situations that could jeopardize quality of life (specifically, human health at that time) extended the technical and political competencies of state authorities. This included establishing basic criteria for Environmental Impact Studies and the Environmental Impact Report (EIA/RIMA, in Portuguese), which became mandatory in such cases (Sousa, 2007).

In this context, the advancement and dissemination of technology in the post-Cold War era, along with the recognition of the need for more qualified professionals to address the causes and consequences

of environmental issues in Brazil, led to an increase in the training of eco-environmental leaders and professionals in specialized fields. These experts were tasked with monitoring and assessing the quality of environmental management at the local level. Once again, the emergence of a technical-scientific body helped drive legislative discussions across different levels of Brazilian federalism, aiming to modify and/or expand regulations, controls, and permitted uses in a country marked by vast socio-ecological disparities. This shift undeniably brought eco-environmental discussions, specific policies, and key stakeholders into the political arena. Consequently, the environmental agenda at both municipal and state levels began to be adapted to respect local specificities and demands.

The eco-environmental debate primarily focused on the adverse impacts of socio-spatial development, which, based on Western economic growth models (whether capitalist or socialist), raised a crucial new question: What were the prospects for development in degraded environments? Who was responsible for protecting the environment to ensure the availability of natural resources for future generations across diverse environments and scales? The concept of "Sustainable Development", introduced by the Brundtland Report of 1987—better known as *Our Common Future* by the United Nations Environment Programme (PNUMA, in Portuguese)—became deeply embedded in political-institutional discourse, political parties, social movements, and all levels of education, from basic to technical and academic.

The report's integrative perspective—which emphasized the responsibilities of various actors, agents, and stakeholders at multiple levels—reinforced the idea that society needed to diversify its networks, structures, and operational levels (including the political-institutional sphere) in order to bring about meaningful change in eco-environmental issues. This opened the door to new agreements, responsibilities, competencies, and forums for discussion. In Brazil, this issue became particularly evident with the redistribution of federative responsibilities, prompting discussions and institutional reforms regarding the nature and application of sustainability. Sectoral forums facilitated discussions on global environmental issues, with active participation from national and international non-governmental organizations (NGOs), guided by the principle: "Think globally, act locally". As a result, federative units and municipalities increasingly played a role in decision-making on environmental matters in Brazil.

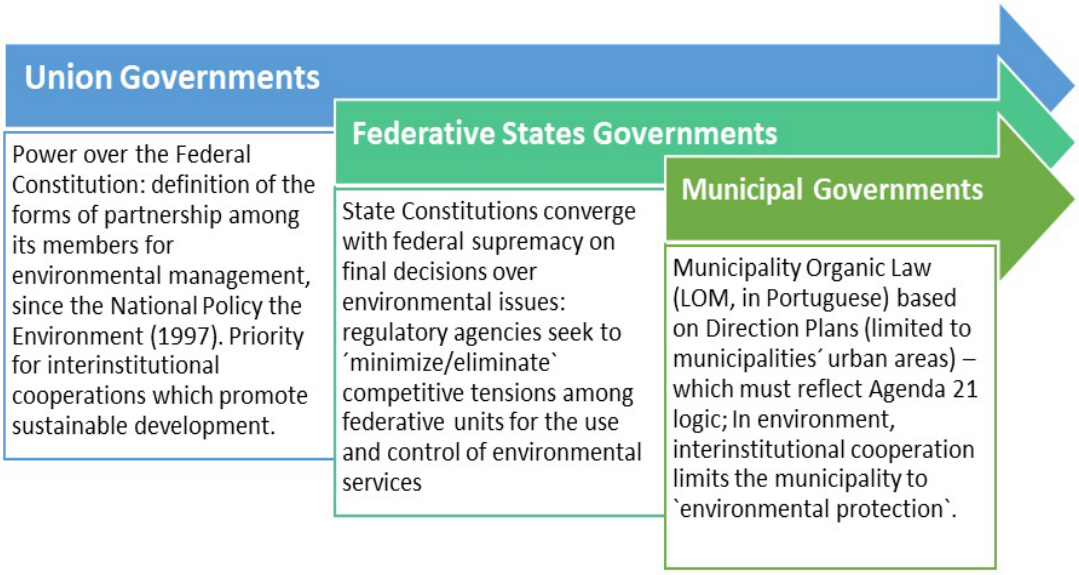
With the full implementation of the 1988 Constitution, local environmental responsibilities were clearly defined, and the decentralization of environmental actions and decision-making became a key aspect of governance. However, even 20 years after the Constitution came into effect, the *Basic Guide for Municipal Management*, distributed by the Central Government since 2008, still places states and municipalities hierarchically below the federal government in environmental management. This suggests that the national government continues to assume primary responsibility for eco-environmental policies in the country, as illustrated in Figure 1.

New themes for environmental policy have been redefined. Additionally, the need for broader competencies within political-institutional spheres, alongside social movements, led to the creation of a new international conference: the United Nations Conference on Environment and Development (UNCED-92), commonly known as RIO-92, held in Rio de Janeiro, Brazil, in 1992. This event

signified Brazil's commitment to addressing the environmental crisis while simultaneously resuming development, strengthening federative democracy, and ensuring economic stability. The issue of development was finally framed within a socially sustainable environmental perspective and democratic decentralization. As a result of the discussions at the conference, industrial pollution control and urban environmental management were prioritized as essential components of local governance, particularly for municipal governments, the credit market, and technological advancements.

> The water we drink, the air we breathe, the contamination of the food we consume, the garbage and waste we produce, the recreational, leisure and green areas or the silence we enjoy have become problems of market and of citizenship, to be provided by local governments (Bredariol, 2001, p. 20).

Figure 1. Federative entities and interests in Brazil (Constitution of 1988).



Source: Basic Guide for Management of Municipalities, 2008. Compiled by the author.

However, from the perspective of this article, the most significant outcome of the conference was the establishment of *Agenda 21*. As the summit's main document, *Agenda 21* outlined a series of programs considered fundamental instruments for the development of public policies at all levels, benefiting local initiatives (Guimarães, 1997). It redefined environmental policy options and the role of the Brazilian state across its multiple levels of governance. Despite increased institutionalized decentralization concerning environmental and ecological sustainability issues, the formal establishment of a ministry *stricto sensu*—which, in a republican and federative sense, serves as the most significant representation of the sector to be supported by public policies—only materialized in 1999, during the second administration of Fernando Henrique Cardoso, reflecting the growing complexity of environmental management today (Figure 2).

Figure 2. Changes in the conceptions on environment and institutional competences in Brazil after 1970.

Source: http://www.mma.gov.br. Access on January 3, 2014. Edited by author.

Human complexities in the political networks of territories

In this regard, it was only at the beginning of the 21st century, with the creation of the Ministry of the Environment (MMA, in Portuguese), that environmental issues began to be treated as a distinct sector in public policy decisions. The introduction of environmental variables became relevant criteria in political-economic decision-making and project financing by official development agencies. The federal government, states, and municipalities adopted a policy of responsibility and partnership through dialogue, persuasion, and public awareness to achieve optimized natural resource management (Sousa, 2007). The Ministry of the Environment (Ministério do Meio Ambiente, MMA) transferred, either wholly or partially, the planning and execution of environmental policies to states, municipalities, NGOs, and other public and private entities. These policies are implemented by public authorities and multilateral agencies.

In 2002, the Rio+10 Environmental Conference took place in Johannesburg, South Africa, followed by the Rio+20 Conference in 2012, where countries reconvened in Rio de Janeiro. During both conferences, opinions varied regarding the 'advances' brought about by international guidelines in the creation of public policies. While these policies aimed to address ecological and environmental challenges worldwide, they also raised concerns about the persistence of poverty, resource scarcity, and environmental destruction. The problems, discussions, and analyses generated a vast body of literature, research, conferences, and agreements that can be studied by those interested in assessing the impact of these conferences on both global and Brazilian society, as well as the expectations and obstacles they encountered.

For example, in 2022, the State of Rio de Janeiro implemented initiatives to promote sustainability, such as Rio2030 and the "Inclusive and Sustainable Rio" project. That year, the Government of the State of Rio de Janeiro launched the Official Rio2030 Events Calendar with an opening ceremony on World Water Day and signed a partnership with UN-Habitat to assist all 92 municipalities in the state in becoming more sustainable. The "Inclusive and Sustainable Rio" project aims to advance the Sustainable Development Goals (SDGs) through three key action paths: Informed Rio, Resilient and Sustainable Rio, and Inclusive Rio. These initiatives include the creation of an SDG Observatory and the training of municipal and state managers and technicians.

However, institutional discussions on environmental policies have grown increasingly complex over the past decade (2011–2021), particularly as ecology and environmental concerns have become integral to transformative political projects affecting local development structures and interdependent federative agreements on "development sustainability". Sustainability can only be achieved through collaboration among management agents and organized social networks, each operating within its legitimate framework. In this context, it is essential to consider the role of territorial policy and the intersection of legislation enacted by both public authorities and private entities.

Possibilities and obstacles for sustainability in Brazil today

Ideal ecological and socio-environmental policies should encompass the multiple dimensions of human life in society—social, environmental, political, and economic. Territorial planning and governance should be guided by the principle of sustainability, understood here as the foundation for development models that safeguard the quality of life in all aspects. Thus, eco-environmental considerations should be integrated into the socio-spatial development policies of states, as implementing this dimension requires recognizing that all growth and sectoral adjustments are shaped by local, national, and global biophysical, cultural, and territorial contexts. For this reason, environmental concerns should align with broader societal perspectives, incorporating commitments to human rights, collective and individual autonomy, and the cultural identities of affected populations.

The 1988 Brazilian Constitution guarantees that an ecologically balanced environment is a common asset of the Brazilian people, making it the duty of both society and public authorities to protect and preserve it for future generations—though the interpretation of this mandate is often contradictory and misleading. In an effort to institutionalize this responsibility, large and mid-sized Brazilian municipalities have been working to establish environmental departments, agencies, and advisory councils to address public concerns and gradually assume responsibilities previously managed by federal and state entities. Moreover, these local governments play a crucial role in promoting sustainability by structuring territorial governance that reflects the capacities, limitations, and aspirations of their respective populations (Silva, 2013b).

Despite the so-called political-territorial democracy currently in place—one that has gradually shifted the national intelligentsia's perspective on prioritizing eco-environmental issues—numerous obstacles remain to adopting these practices in a politically integrative manner. Key sectors such

as health, education, industrial policy, agriculture, urban expansion, and tourism can only achieve sustainability if ecological and socio-environmental balance is maintained. Therefore, I highlight several aspects related to Brazil's bureaucratic and federal structures that must be addressed to ensure that sustainability is effectively integrated across all levels of society:

- Strengthening the institutional framework of the federal government regarding conceptions and standards for "quality of life" within Brazil's socio-cultural diversity.
- Expanding discussions on what constitutes "traditional populations", while more clearly defining and characterizing indigenous, quilombo, and extractivist communities.
- Recognizing the historical land rights of social groups and assigning public authorities the responsibility for regulating and consolidating the political achievements of these communities in recent decades.
- Reducing the constraints on public spaces for political policymaking by adopting a geographically informed approach to legislation that considers the distinct needs of different groups.
- Reassessing the territorial architecture (e.g., river basins, zoning, regional and eco-economic structures) to challenge Brazil's traditional federalism, which prioritizes legal territorial demarcations over the actual scale of spatial events (Silva, 2012, 2013a, 2016, 2020, 2023).
- Addressing territorial inequalities and institutionally recognizing committees, districts, consortia, regions, and zones that actively engage in solving ecological challenges related to environmental services (Morais & Silva, 2021)..
- Reforming the power dynamics among the entities that constitute Brazil's political-institutional system (federal government, states, and municipalities), which currently function in a hierarchical manner (Figure 3) rather than through an interdependent and collaborative framework (Figure 4), as suggested by Wright (1988).
- Rethinking the complexity of national governance to ensure the effective implementation of eco-environmental policies. Only through such reforms can policy decisions be clear, sustainable, and socially accepted at all levels.
- Allocating substantial resources to mass environmental education programs capable of reshaping ideological perspectives and fostering more ethical socio-spatial development projects beyond local boundaries (Grün, 1996).
- Recognizing that societal transformations are specific, interconnected, and shaped by diverse processes. While contradictions and unresolved issues will always exist, they must be addressed at the management level to prevent social, political, and institutional stagnation. Society is complex—ordinary yet unique, global yet local—offering an array of possibilities where progress depends on a deeper understanding of contradictions.

Figure 3. Hierarchical Authority (Adapted from Wright, 1988)

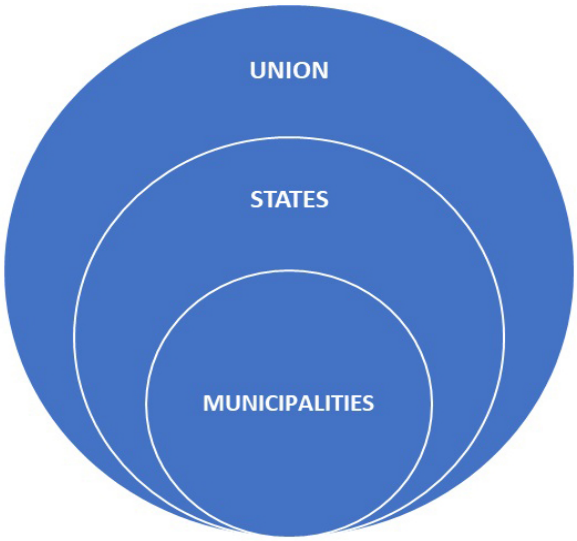
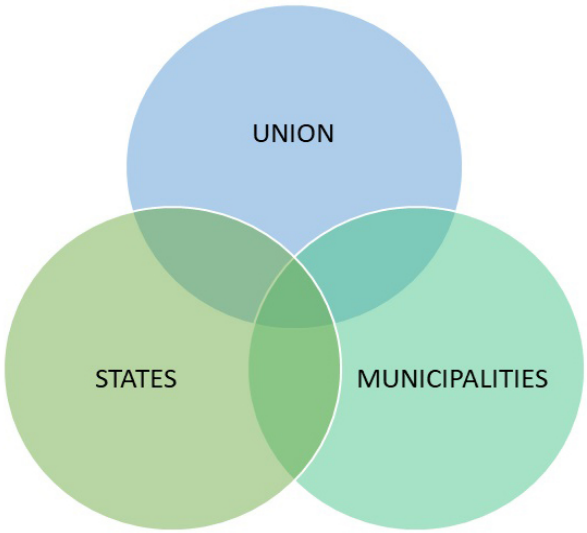


Figure 4. Interdependent Authority (Adapted from Wright, 1988)



CONCLUSIONS

Environmental policies that gained momentum in Brazil after RIO-92 have reached a stage where they can no longer be considered secondary within the institutional policies of the federative Union. The commitment of the Union, states, municipalities, the market, and civil society to embracing new challenges in social practices requires continuous evaluation by researchers to analyze both their origins and consequences. Political geography seeks to guide reflection and adjustment of the progress made thus far, aiming to expand the political arena (Castro, 2009, 2013). Given the ambiguities and contradictions between development and sustainability, these concepts reveal their polysemic nature. Their meanings remain contested, undergoing constant construction and deconstruction, with unpredictable outcomes characteristic of ongoing democratic processes worldwide.

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