

Jänicke, Clemens; Müller, Daniel

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Revealing agricultural land ownership concentration with cadastral and company network data

Clemens Jänicke^{1,2,3} · Daniel Müller^{1,2,3}

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Abstract

In many high-income countries, agricultural land is highly concentrated in a few hands, but detailed knowledge of ownership structures is limited. We examined land ownership structures and agricultural land concentration for the entire state of Brandenburg, Germany (1.3 million ha), using cadastral and company network data. Our aim was to characterise all landowners, analyse the degree of ownership concentration, and examine the role of the largest landowners in more detail. We found a high fragmentation of ownership among 185,000 different owners. Most of the land was owned by individuals not active in agriculture and only a third of the land was owned by farmers and other agricultural actors. Absentee ownership covered a quarter of the land. Ownership concentration was low to moderate in most regions and reached high levels in only a few areas. The largest owners were public institutions, private investors and nature protection institutions. Areas where public institutions owned a lot of land showed high concentrations, but also some areas where private landowners owned a lot of land. In summary, our analysis provides rare information on the concentration of agricultural land ownership in a large region. Such analysis facilitates better justification and design of policies that regulate agricultural land markets.

Keywords Farmland · Land concentration · Financialization · Investments in land · Land tenure

Introduction

The competition for land has increased due to the rise of flex crops and the biofuel sector, an increasing need for productive land due to a growing world population, rising incomes that go hand in hand with more land-intensive livestock products in diets, and more land being set aside for nature conservation (Genoud 2018; Johansson & Azar 2007; Smith et al. 2010). Furthermore, land investments became a profitable and secure

investment opportunity, particularly during the period of low interest rates since the financial crisis in 2008 and the food crises in 2007/08 and 2010/11 (Borras et al. 2016; Deininger et al. 2011). This has stimulated investments of capital-rich individuals, companies, and state actors (Braun & Meinzen-Dick 2009; Deininger et al. 2011), often from outside the agricultural sector. The growing interest in land investments has been reported worldwide. Large-scale land investments became pronounced in the Global South (Deininger et al. 2011), but were also reported in transition countries with large and fertile land reserves, such as Russia and Ukraine (Visser & Spoor 2011). Land investments from non-agricultural actors contributed to a higher concentration of land ownership in OECD countries, such as Canada (Desmarais et al. 2015, 2017) and Europe (Gonda 2019; Rasva & Jürgenson 2022; Stacherzak et al. 2019; van der Ploeg et al. 2015), where the agricultural sector experienced increased financialisation (Fairbairn 2014).

Land concentration and consolidation can have advantages, such as more efficient farm management, improved economies of scale, and enhanced labour efficiency (King & Burton 1982; van Dijk 2003), but they can increase competition over land because fewer but larger farms raise land

✉ Clemens Jänicke
jaenicke@iamo.de

Daniel Müller
mueller@iamo.de

¹ Leibniz Institute of Agricultural Development in Transitions Economies (IAMO), Theodor-Lieser Str. 2, 06120 Halle (Saale), Germany

² Geography Department, Humboldt-Universität Zu Berlin, Unter Den Linden 6, 10099 Berlin, Germany

³ Integrative Research Institute On Transformations of Human-Environment Systems (IRI THESys), Humboldt Universität Zu Berlin, Unter Den Linden 6, 10099 Berlin, Germany

market concentration, arguably to the detriment of small-scale family farms, with potentially harmful consequences for the environment, the economy, and society (Mehrabi 2023). Some authors refer to Goldschmidt's hypothesis (e.g. Bailey et al. 2021; Besser et al. 2017; Constance et al. 2014), which states that increasing farm sizes and declining farm numbers adversely affect the quality of life of rural communities. However, the evidence for Goldschmidt's hypothesis is ambiguous; some studies found evidence that more industrialised farming systems are less beneficial for rural communities (Lobao & Stofferahn 2008), while other studies failed to support the hypothesis (Barnes & Blevins 1992; Park & Deller 2021). Furthermore, the concentration trends have also raised concerns about an increase in ecologically unsustainable land use, such as more homogeneous landscapes due to larger farms, increased energy crop cultivation, and highly input-intensive management practices (Kay et al. 2015; Sosa Varrotti & Gras 2021; van der Ploeg et al. 2015). Owners often live far away, so-called absentee owners, who identify less with the local population and the land. Additionally, capital flows outside rural regions in the form of rents. These externalities can contribute to a deterioration in the quality of life in rural areas.

Additionally, land fulfils various functions for people who live on and from the land (Bunkus & Theesfeld 2018). Land not only provides resources and food but also has symbolic value for people who often build personal connections with it, contributing to the identity of the local population. Various studies have shown that economic interests drive land management decisions, preserve traditional agricultural ways of life, and fulfil the desire to maintain a connection to the land (Preissel et al. 2017). Additionally, dispersed land ownership can contribute to people's self-empowerment (Mishra & Sam 2016), while high concentration can lead to deterioration in community cohesion (Desmarais et al. 2015; Magnan et al. 2022). Economically, the critical concerns of high concentration are that family farms or new entrants into farming are not able to access land due to the high prices for land that exceed the production potential of the land (Magnan et al. 2022) or due to the market power of capital-rich investors (Haggerty et al. 2022).

Market power occurs when one or a few market players control large market shares with the ability to control prices or the availability of goods and services. Institutional economists regard shares of over 40% of a market held by the largest four players as a loose oligopolistic market (Gwin 2001). This approach has been taken to investigate the shares of the four largest firms in various sectors, such as the US poultry and hog industry (Constance et al. 2014). It was found that the shares of the largest firms increased steadily over time in these agricultural sectors. In another approach to identifying market concentration, the European Commission uses a threshold of the Herfindahl–Hirschman index in

its Horizontal Merger Guidelines (European Commission 2004). The German law against Restraints of Competition (*“Gesetz gegen Wettbewerbsbeschränkungen”*) states that a company has a dominant position in a market if its market share is higher than 40% (§ 18) (GWB 2013). Market concentration can also occur vertically along value chains. For example, Ashwood et al. (2022a, b) analysed market network power by considering relationships between companies via corporate structures and flows of financial capital. They presumed that actors with many connections in a network have high power, which they leverage to their benefit.

However, transferring such approaches to the land market requires accounting for the specific characteristics of land markets (Balmann et al. 2021). Land is a limited and immobile production input, and land quality can vary considerably over space. In addition, farmers prefer land close to their farms, making land a spatially differentiated production factor and stimulating local land concentration. Spatial differentiation can generate rent and lead to market power. This raises the question of how to define local land markets, i.e., the spatial level of analysis. One approach is to approximate the spatial extent within which farms actively participate in the land market. For example, the extent could be determined by the typical distance in which land transactions of farmers occur, as has been done for Brandenburg (Plogmann et al. 2022) and the Netherlands (Cotteleer et al. 2008).

Unfortunately, ownership data often does not exist in digital formats, and access to existing ownership data is restricted. As a result, ownership structures and concentration remain elusive for larger areas. Existing insights on ownership concentration in agriculture originate from qualitative case studies and databases based on news reports on land acquisition, such as the Land Matrix (Braun & Meinzen-Dick 2009). Valuable as they are, these databases only represent snapshots, do not provide complete coverage, lack representativeness, and are not rigorously tested for plausibility and validity (Goetz 2015; Yang & He 2021). Only a few studies can rely on official data for larger areas, such as Desmarais et al. (2017), who investigated all cadastral data from Saskatchewan, Canada. They found that investor ownership increased strongly between 2002 and 2014. Pritchard et al. (2023) analysed all land parcel data from a region in New South Wales, Australia. They identified seven companies that used pooled capital from mutual and pension funds to acquire agricultural land. Lastly, Bailey et al. (2021) used property tax records of all rural counties in Alabama to test correlations between ownership concentration and life quality. Despite these examples, ownership structures and concentration remain elusive for most regions or countries.

However, even official ownership records from the cadastre fail to reveal the actual concentration of ownership because only individual entities are listed in the cadastre. Larger investors or corporate structures remain hidden if

a parent company owns the listed land-owning company. This is the case for so-called agroholdings (Graubner et al. 2021) and “multi-layered subsidiary forms” (Ashwood et al. 2022a, b). The former are large agricultural enterprises that often own horizontally integrated subsidiaries, which are individually responsible for operational tasks, e.g. one focuses on livestock production and another on crop farming. In multi-layered subsidiary forms, parent companies hold the majority shares in subsidiaries and operate as management companies but are legally disconnected. This multi-layered form hides the actual owners of the subsidiaries; in case creditors claim debts from subsidiaries, they act as a ‘liability firewall’ to the parent company’s assets, protecting them from any claims (Prechel et al. 1999). Large company networks can also arise when capital-rich investors, such as private equity funds, foundations, corporations, or institutional investors, acquire shares in other, possibly land-owning companies. Therefore, accounting for such company networks is a prerequisite to revealing the actual concentration of land ownership.

In this study, we aim to reveal ownership structures and concentration for all agricultural land (more than 1.3 million ha) of the federal state of Brandenburg in former East Germany. We calculate ownership concentration using complete ownership records from the official cadastre and combine these with a database that uncovers ownership networks. We present a largely automated, coded method to analyse concentrations at the local level. Finally, we highlight the largest private landowners and their influence on the local land market.

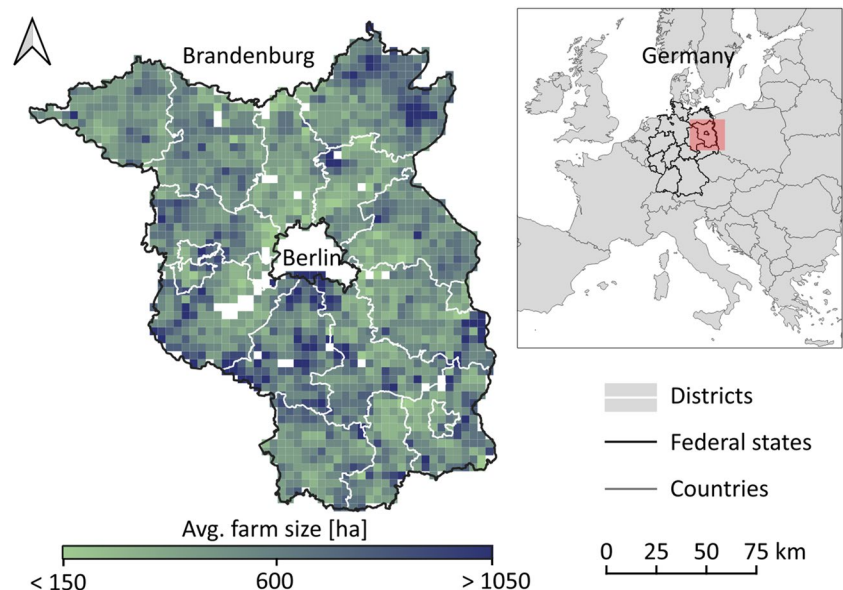
Our analysis of ownership structures and ownership concentration answers three research questions. First, who are the landowners in Brandenburg? To reveal ownership

categories, we quantify how much land is in private hands and how much is owned by the state, companies, or civil society actors. We also assess where the owners are registered to identify absentee ownership. Second, how concentrated is the ownership of agricultural land, and are there spatial patterns of ownership concentration? To answer this, we compute absolute and relative concentration measures at different spatial scales to reveal the concentration of ownership. Third, who are the largest private landowners in Brandenburg, and what impact do they have on ownership concentration? Using the trade register and information from media reports, we research the 15 largest landowners that we characterise according to their professional background and likely motivations to enter the agricultural land market. With this, we aim to provide insights into the influence of the largest actors on the concentration of land.

The agricultural land market in Brandenburg

The federal state of Brandenburg is in north-eastern Germany and surrounds Berlin (Fig. 1). It covers an area of 29,500 km² and has a population of 2.5 million. Current agricultural structures are shaped by historical developments during the German Democratic Republic (GDR) and the reunification period (Wilson & Wilson 2001; Wolz et al. 2010). In the early years of the GDR, the Allied powers were concerned about the large landed estates in Germany, which had strong ties to the old political order. As a result, the GDR government carried out a land reform, during which all landholdings of over 100 ha were expropriated. A total of 3.3 million ha of agricultural and forest land was expropriated and placed in a land fund, of which 2.1 million ha were

Fig. 1 The federal state of Brandenburg with average farm sizes [ha] in 4×4km grid cells



distributed to landless agricultural workers, who received an average of 8 ha (Wilson & Wilson 2001, pp. 113–114). Another 450,000 ha of land were handed to newly established state-run farms. The redistribution of land to farmers led to a marked increase in the number of farms. Even though the newly established farms received monetary state support for living and production buildings, the productivity of newly established farms was low in the following years due to shortages of production inputs and the lack of an efficient marketing and distribution system (Hohmann 1984; Löwenthal & Fitzgerald 1950 cited in Wilson & Wilson, p. 114). As a result, a collectivisation policy was introduced, in which land was collectivised and placed under the control of agricultural production cooperatives (APCs) to exploit economies of scale. Formally, landowners continued to hold land titles but did not have the right to dispose of them. At the same time, the state farms increased to 700,000 ha because farmers accused of political crimes were expropriated. In 1989, state farms controlled 7.6% of the agricultural land and the APCs 82.2% (Beckmann 2000, p. 389).

After German reunification, collectivised agricultural land was privatised and returned to the original landowners. Many recipients of the restituted land received only the small plots (usually between 5 and 7 ha), which they had owned before collectivisation. The expropriated land was treated differently. Landowners who had been expropriated during the GDR era could reclaim their land. However, land expropriated right after World War II was placed under the administration of a state agency, which later became the Land Utilisation and Administration Company (*Bodenverwertungs- und -verwaltungs GmbH*, BVVG). The BVVG aims to privatise the land, first by leasing, then by subsidised sales, and finally by open market sales. The cadastral data show that the BVVG retains large areas and is the largest landholder in Brandenburg. Its role in the land market is controversial, as it has auctioned land at substantially higher prices than was achieved in private negotiations (Hüttel et al. 2016).

In the years following reunification, the large APCs were dissolved, and APC members, i.e., farmers whose properties, livestock, machinery, and buildings were formerly controlled by the APC but also farm workers and other citizens, could decide whether to set up successor farms under a different legal form. To do this, two-thirds of the APC members and most landowners had to agree to the restructuring. By 1991, 40% of APCs had been dissolved, but most were restructured into agricultural cooperatives or limited liability companies. At the same time, the number of farms increased as some restituted landowners entered farming. This was supported by leading West German politicians favouring smaller family farms because many larger successor companies to the APCs were expected to collapse once they had to compete in an open market. However, the successor farms to the APCs

proved to be competitive. At the same time, many restituted landowners regarded their lands as too small for farming and lacked the capital and agricultural training to start a farming business (Kallfass 1991). Additionally, in East Germany, there was a general inexperience, scepticism, and lack of tradition regarding family farms (Wilson & Wilson 2001, p. 142). As a result, most of their land was leased or sold to larger successor farms. These developments led to a high fragmentation of land ownership while the concentration of land use increased, similar to the situation in other Eastern European countries (Hartvigsen 2014; Sklenicka et al. 2014). The structural changes in ownership and land use after 1989 also resulted in a decline in employment in agriculture from 800,000 people to 135,000 in 2020 in the former states of the GDR (Statistisches Bundesamt 2021; Wilson & Wilson 2001). In 2022, Brandenburg had 37,600 employees on 5,440 farms with an average size of 237 ha (compared to 48 ha in West Germany) (Statistisches Bundesamt 2022).

Land prices have tripled between 2001 and 2018 in East Germany (Kirschke et al. 2021). Judging by media reports and evidence from case studies, land concentration appears to be a growing concern (Bunkus & Theesfeld 2018; Tietz et al. 2021; van der Ploeg et al. 2015). Purchases of large shares of farms up to 90%, known as share deals, have further fuelled the debate because these purchases allow to gain control over large tracts of farmland while circumventing the payment of land transfer taxes and existing land market regulations (Tietz 2017; Tietz et al. 2013). A prominent example is the case of KTG Agrar, a large agricultural company that owned more than 45,000 ha in East Germany, accumulated mainly through share deals. In 2016, KTG Agrar became insolvent, and its land was sold to the Munich Re insurance company and a subsidiary of the Zech Group, a construction and investment company (Zinke 2021). Another example became known in March 2023 when the property company Quarterback Immobilien outbid a farmer and acquired one of the largest farms in Brandenburg (van Bebber 2023). Recently, the state government of Brandenburg drafted a law to regulate agricultural structures. The law aims to dampen the rise in land prices and limit ownership concentration (MLUK Brandenburg 2023). All this underscores that the examination of land ownership structures and the role of investors constitutes a significant problem in the land markets in the region.

Data

We use the official cadastral registry (*Amtliches Liegenschaftskadaster*, ALKIS) that contains information about all legal landowners of agricultural parcels in Brandenburg (Landesvermessung und Geobasisinformation

Brandenburg 2020). The data represent the situation at the cut-off date of November 9, 2020. ALKIS stores the names, addresses, and, for private persons, the birth dates of the owners of all agricultural parcels. On the cut-off date, there were 1.4 million parcels designated as agricultural land in Brandenburg, covering 1,818,764 ha. The original data contained 348,796 different ownership entries but contained duplicates due to typos, for example, due to different spellings of names and abbreviations, and because some parcels are owned by multiple owners.

The agricultural areas reported in the ALKIS data differ from Brandenburg's official agricultural land statistics, which report 1,437,113 ha. To quantify agricultural land use, we use the Integrated Administration and Control System (IACS), which includes all agricultural fields for which subsidies from the European Union (EU) are claimed. For 2020, official statistics suggest that IACS data covered 93% of the agricultural area, and no subsidy claims were submitted for the remaining 7%. This was because fields smaller than 0.3 ha were not eligible for subsidies, or farmers did not apply for subsidies to circumvent the administrative effort. The intersection of the data on land ownership (from the ALKIS cadastre) and land use (from the IACS) data results in 1,315,182 ha.

To extract information on companies active on the land market in Brandenburg, we used the company database DAFNE (*‘Die Analyse von Finanzdaten nun erleichtert’*) (Bureau van Dijk, n.d.). DAFNE provides information on the managing directors, shareholders, board members, authorised signatories, and subsidiaries of the companies, as well as a classification of the company's activities. It provides detailed information on all companies registered in Germany; for foreign owners of companies, only the name is reported. DAFNE was used to identify company networks and their global ultimate owners (for more details, see next Section).

To separate agricultural from non-agricultural private owners and companies, we used the list of recipients of farm subsidies from the EU for the years 2019 and 2020 (<https://farmsubsidy.org/>) and the list of all feed producers in Germany (Bundesamt für Verbraucherschutz und Lebensmittelsicherheit 2020).

Methods

Pre-processing and data analysis were primarily done in Python. All scripts and a detailed workflow description can be found on GitHub (https://github.com/clejae/brandenburg_ownership_analysis).

Data cleaning, identification of company networks, and characterisation of landowners

The pre-processing of all data included the following steps:

- 1) We cleaned and standardised the names of landowners from the ALKIS data. Some landowners have died, or institutions no longer exist but remain listed in the cadastre. The data also contain multiple addresses and different spellings of names and abbreviations for the same landowner. Our cleaning algorithms automatically corrected most errors, but they could not fix all of them. However, this mainly affects the smallest owners.
- 2) We merged families through family names and addresses.
- 3) We categorised owners into private persons, companies, public institutions, and religious institutions; we grouped other institutions, such as foundations, associations, and other non-profit organisations, into an additional entry.
- 4) We use DAFNE to identify directors, shareholders, board members, authorised signatories, and subsidiaries of all companies and other institutions we identified in ALKIS.
- 5) We combined DAFNE with ALKIS records by names and addresses.
- 6) We identified company networks and their global ultimate owner (GUO), assuming that a single person or company holds the majority share ($\geq 50\%$) in another company, it is the beneficial owner and, therefore, exercises control over the company. If companies were beneficial owners (also known as the parent company), we identified their beneficial owners until we identified the last beneficial owner in the network, which we assumed to be the GUO. A network also included all managing directors and board members of each company. We also added companies to the network with the same managers and board members as other companies.

We acknowledge that DAFNE only includes information on shares held in limited liability companies. In the cases of public limited companies, usually, only the majority shareholder was listed. This did not allow us to identify shareholders who possibly held shares less than 50 % of multiple public limited companies. These types of shareholders are suspected to be institutional investors whose scattered ownership between companies increases market concentration (Azar et al. 2018), which we cannot identify with the available DAFNE data. Furthermore, for registered cooperatives, the shareholders were not listed in DAFNE, as cooperatives are not obliged to reveal this information publicly in Germany. By including acting manag-

ers or board members in company networks, we also identified the majority shareholders of cooperatives. A company network generally encompasses companies linked through their parent companies and subsidiaries, managing directors, board members, and majority shareholders. In the following, the term 'network member' refers to any company or person that is part of a company network. All areas belonging to the network members are aggregated, as we assume that the network members are not likely to be competitors on the land market but act as a unit to benefit their network. We also assume that the GUO, which has the largest share of all companies, is likely to steer the strategic orientation of the entire network.

7) We categorised owners into agricultural and non-agricultural owners. We assume that a single person or a company is agriculturally active if they receive agricultural subsidies, are feed producers, or are classified as agricultural companies. This information was derived from the lists of subsidy recipients, the list of feed producers, and the DAFNE classification. We were likely unable to identify all agricultural persons and enterprises due to errors in the names of the landowners. IACS data suggest over 6,000 farms in Brandenburg, but we could only identify 5,000 agricultural landowners. We assume that a company network is active in agriculture if one of the network members is active in agriculture. This assumption is based on the fact that agroholdings may split their agricultural activities, such as crop production, livestock rearing, bioenergy production, transport services, or management, into different companies.

However, when a non-agricultural investor buys the majority share of a farm, a company network might form where the newly acquired farm is agriculturally active, yet the new investor is not. Differentiating between these cases cannot be automated and requires a qualitative analysis, which we have done only for the 15 largest landowners. Distinguishing these cases for all Brandenburg networks is beyond the scope of this study. Haggerty et al. (2022) and Hüttel et al. (2016) also emphasised the difficulty in identifying non-agricultural investors due to their diverse business strategies and motivations.

- 8) We geolocated owners using OpenStreetMap (OSM) vector data, the geocoding Nominatim tool from OSM, and the geocoding API from Google. This allowed us to calculate the average distance from each owner's place of registration to their parcels. For private persons, we used the home address; for companies and institutions, we used the distance to the company's headquarters.
- 9) We categorised owners and owner networks into nine categories of owners using the categories from Step 3 (Table 1).
- 10) We examined the 15 largest landowners in more detail using newspaper articles and official documents from the trade registry. This allowed us to conjecture their histories and possible motivations for owning land in Brandenburg.

Ownership concentration

Farmers who want to expand their farm or start a new farm need to be active in the land market and are, therefore,

Table 1 Descriptions of ownership categories

Ownership category	Description
Private agricultural persons	All persons, family associations, and partnerships engaged in agriculture are counted as one unit; families are counted as one unit
Non-agricultural private persons	Like private agricultural persons, but not involved in agriculture
Agricultural single companies	All companies and associated persons (managers, majority shareholders, directors) for which no affiliation with another company was identified; either the company or one of the associated persons must be active in agriculture
Non-agricultural single companies	Like single agricultural companies, but not active in agriculture
Agricultural company networks	Owner networks with at least two companies; at least one of the network members must be active in agriculture
Non-agricultural company networks	Like agricultural company networks but not active in agriculture
Public institutions	All owners identified as a public entity, such as federal, state, and local government agencies or companies owned by them, owner networks where the GUO is a public entity. It also includes all unknown owners, which, according to applicable law, fall under the jurisdiction of the respective municipality (Tietz et al. 2021)
Other institutions	All owners identified as foundations, associations, and other non-profit organisations
Religious institutions	All owners identified as religious institutions, and all owner networks in which the GUO is a religious institution

potentially most affected by excessive market concentration. As farmers mainly operate on the local land market, we compute the degree of ownership concentration for the spatial extent that we considered representing the local land market. We defined this extent based on Plogmann et al. (2022), who found that 90% of all farm transactions were made in a 12 km radius around the farm centre in Brandenburg. We calculated the radiuses between the farm centres and the furthest fields to corroborate this. We found that the fields of 87% of all farms fall into the 12 km radius (Appendix 1); therefore, the 12 km radius likely captures the relevant extent of the land market for most farms. We superimposed a 4-km square grid over the study region (Fig. 2, left side) and calculated the concentration measures for a radius of 12-km around the centroid of each cell (Fig. 2, right side).

We calculated relative and absolute measures of ownership concentration and used standard concentration thresholds from other markets as benchmarks. However, we acknowledge that thresholds from other markets may not resemble those on land markets (Balmann et al. 2021). The concentration measures were (formulas in Appendix 2):

- Concentration ratios CR1 and CR4: These measure the share of land owned by the largest and the four largest landowners in each area. CR1 is used in the German law against competition restraints to assess dominant market positions by single players (GWB 2013). We use CR4 because it is a standard measure for identifying oligopo-

listic markets (Gwin 2001). A threshold of 40% for CR1 is used to identify a dominant market position. For the CR4, a threshold of 40% identifies a loose oligopoly, and a threshold of 60% identifies a tight oligopoly.

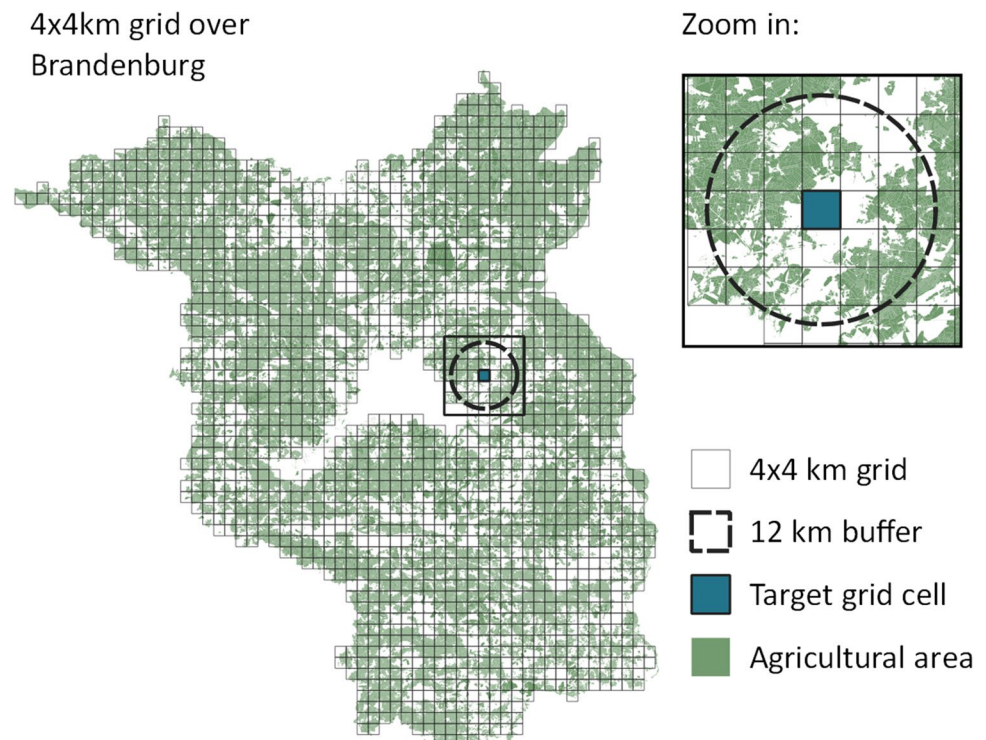
- The Herfindahl–Hirschman index (HHI) measures market concentration and has, among others, been used by the European Commission (EC) in the assessment of horizontal mergers (European Commission 2004). The HHI can vary between 0 and 10,000; the EC uses 1,000 as a threshold for markets that need closer examination.
- The Gini coefficient (Gini) is a standard measure of income inequality that has been used to measure land ownership inequality (e.g., Benra and Nahuelhual 2019). It varies between 0 and 1, with 1 being the complete inequality. It has also been applied to land markets because, unlike CR and HHI, it is a relative measure and less dependent on the total agricultural area within a radius of 12 km.

Results

Land distribution and landowner characteristics

In total, we identified 185,284 unique owners. Most owners are private persons (178,640), of which we identified 3,774 engaged in agriculture. We found 689 non-agricultural company networks, 443 agricultural company networks, 765 non-agricultural single companies, and 294 agricultural

Fig. 2 Schematic representation of the 4 x 4 km grid (left). On the right is an example of the 12 km buffer used to calculate the concentration measures for each target grid cell



single companies. The rest are public and religious entities, non-profit groups, associations, and foundations. Non-agricultural persons own 52% of the land, followed by agricultural company networks (18%), private agricultural persons (12%) and public entities (8%) (Fig. 3a). All other ownership categories each own less than 5%. In general, only one-third of the land is owned by agriculture owners, indicating high rental rates for farmers. Non-agricultural landowners and public, religious, and other institutions own the remaining land. The agricultural company networks hold the largest average area (521 ha), followed by individual agricultural companies (230 ha), other institutions (66 ha), and private agricultural persons (40 ha) (Fig. 3b).

About half of the land is owned by owners registered less than 10 km away from their parcels (Fig. 3c), and 25% of the land is owned by owners located at least 50 km away from their parcels, which we interpret as absentee owners.

Agricultural ownership categories (private agricultural persons, agricultural company networks and single companies) are closer to their properties than non-agricultural counterparts (private non-agricultural persons, company networks, and single companies) (Fig. 3d). However, 20% of the land held by agricultural company networks is at least 50 km away from the location of the headquarter, while only 10% of the agricultural land owned by private persons and 5% of the land of single companies are further than 50 km away (Fig. 3d).

Company networks

We identified 1,132 company networks that encompass 1,967 different owners in the ALKIS data (from any ownership category), which together have 245,000 ha. Before identifying the company networks, each of these individual

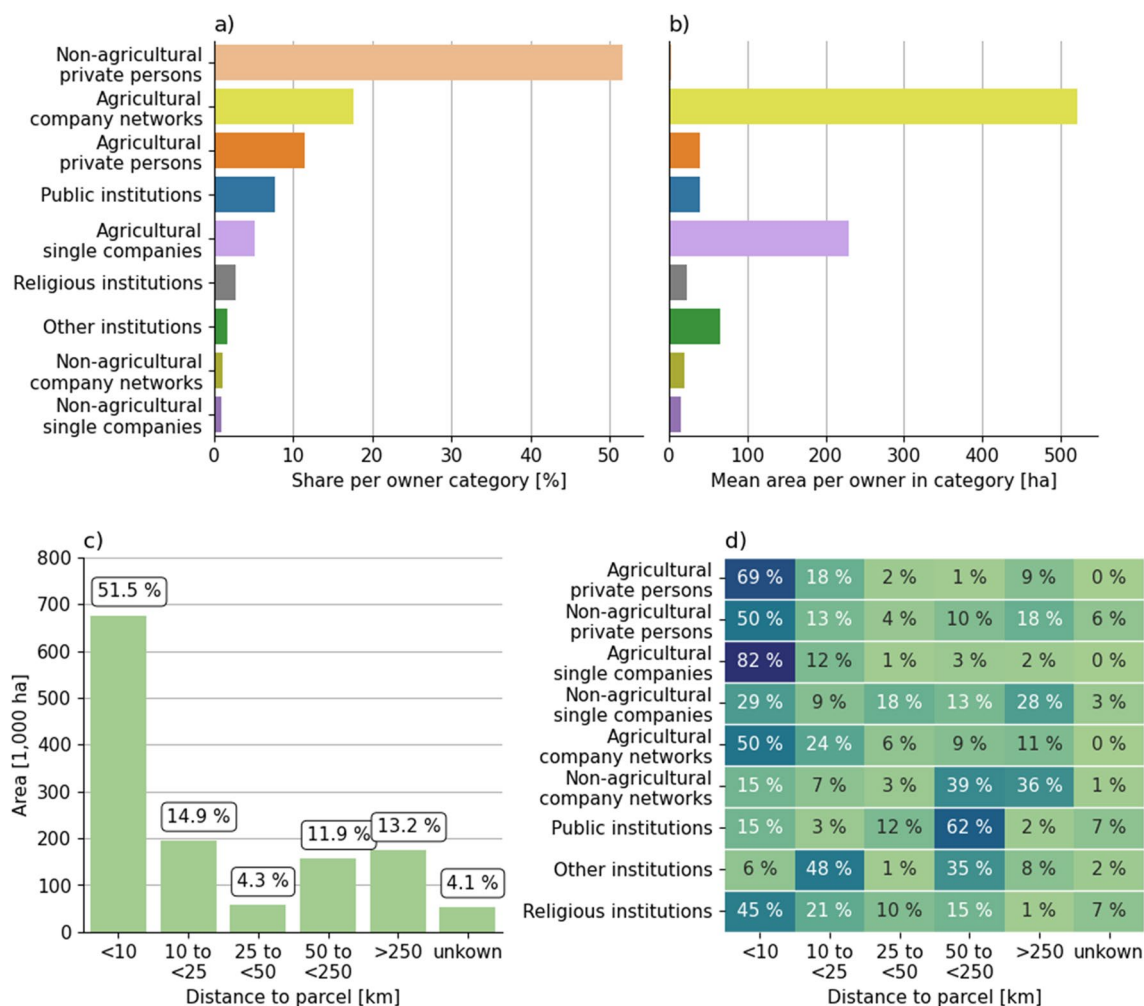


Fig. 3 Characteristics of landowners in Brandenburg: **a)** proportion of land per ownership category; **b)** mean area per owner in each ownership category; **c)** total area [ha] and proportion of land owned by

distance to parcels; and **d)** proportion of land owned by owners who reside within a certain distance of their land parcels per ownership category

owners owned an average of 127 ha; after network identification, each network owned 216 ha. The smallest company networks comprise two companies, while the largest contains 320 companies and private persons. Company networks with many members, as identified with DAFNE, are not synonymous with many landowners or large areas. For example, the network with the third largest number of members comprises 145 companies, but only two of them own land, which sums up to 50 ha. The largest company network in terms of area owned 10,000 ha, distributed over 31 companies and nine private persons. Of the 40 members, 19 own land within Brandenburg. On average, the mean distance from the place of registration of each owner to his parcels increased by 56 km with network identification; therefore, the GUOs of the company networks lived farther away than their landholding subsidiaries. Before the aggregation of the company network, 87% of all land was owned by owners located 25 km or less away; afterwards, it was only 71%. This reveals that absentee ownership increases when accounting for the location of the parent companies, similar to the findings of Ashwood et al. (2022a, b).

Ownership concentration

At the local level, i.e., within the 12 km buffers, the average CR1 was 7%, CR4 18%, HHI 146, and Gini was 0.83 (Fig. 4). However, all concentration measures exhibit local spatial variability. We found small spatial clusters with a high concentration of CR1, CR4, and HHI, especially south of Berlin and in a few areas in northern Brandenburg (Fig. 4a-c). The higher concentrations are generally in regions with less agricultural land (e.g. regions bordering Berlin, other federal states, or where other land uses dominate; Fig. 4e and Appendix 3). CR4 and HHI exceeded 40% and 1000 on the southern border with Berlin, indicating an oligopolistic market structure. In this region, a public institution owns a large part of the land (see next Section). CR1 does not exceed the 40% threshold anywhere, suggesting that no single market player dominates the Land Market in Brandenburg. The Gini is above 0.83 in many regions, but especially in northeast Brandenburg, where it reached 0.9 (Fig. 4d). Agricultural land is more abundant, and there are fewer landowners in these regions than in the south of Brandenburg (Fig. 4e and f). The most prominent landowners in the northeast own similar shares but more land, whereas the other landowners are more numerous than in the south, thus increasing the Gini.

The largest landowners

In most regions, the largest landowner is either an agricultural company network, a public institution, or an

agricultural single company (Fig. 5a). In areas with the highest CR1, the largest landowners are often public institutions or agricultural company networks, sometimes other institutions, such as national parks (Fig. 5b).

The 15 largest landowners in Brandenburg are in various ownership categories (Table 2): Five are public institutions, eight are agricultural company networks, and two are other institutions. Public institutions include the BVVG, which still manages 31,000 ha in Brandenburg, a company, which operates agricultural areas owned by the city of Berlin, a company owned by the state of Brandenburg that manages old military areas, the state forest administration and the agricultural ministry of Brandenburg. The other two private institutions are a national park and a nature conservation organisation.

The private persons and company networks, which own the most extensive land holdings, have widely varying characteristics. The largest private landowner is a company network owned by a stock corporation from a western German state with a history in the transport business but with early connections to agriculture. It acquired control of 11 different land-holding companies between 2008 and 2014. It likely seized the opportunity of low interest rates after the financial crisis of 2007 and the expectation of rising prices for agricultural land. The second largest private owner is a network of successor companies of former APCs in which a few people from Brandenburg became managers, major shareholders, or board members of 23 land-owning companies between 1991 and 2023. It is likely an example of a successor farm that has proved very competitive in the market economy. The third largest private landowner is a company network comprising two subnetworks. One of the subnetworks consists of organic farms, which an individual acquired major shares in 2006. The other subnetwork purchased land to rent out to farmers with long-term contracts and lower prices on the condition that the land is organically farmed. It was founded in 2009 as a response to growing land scarcity and increasing land prices. Both subnetworks are connected through a board member and a manager who started working together in 2020. The fourth largest private landowner consists of two investors from the finance sector that began to acquire majority shares in three landholding companies in 2001, 2006, and 2020. The fifth largest landowner is a company network of a couple from western Germany who were active in the trading business and started to become shareholders of successor farms between 1992 and 2015. In recent years, the next generation has slowly taken over management in the company, and the home address has changed from Western Germany to Brandenburg over time, indicating that some formerly absentee owners can become local owners. The chronicle of the acquisitions in examples four and five suggest that investments in agricultural companies already

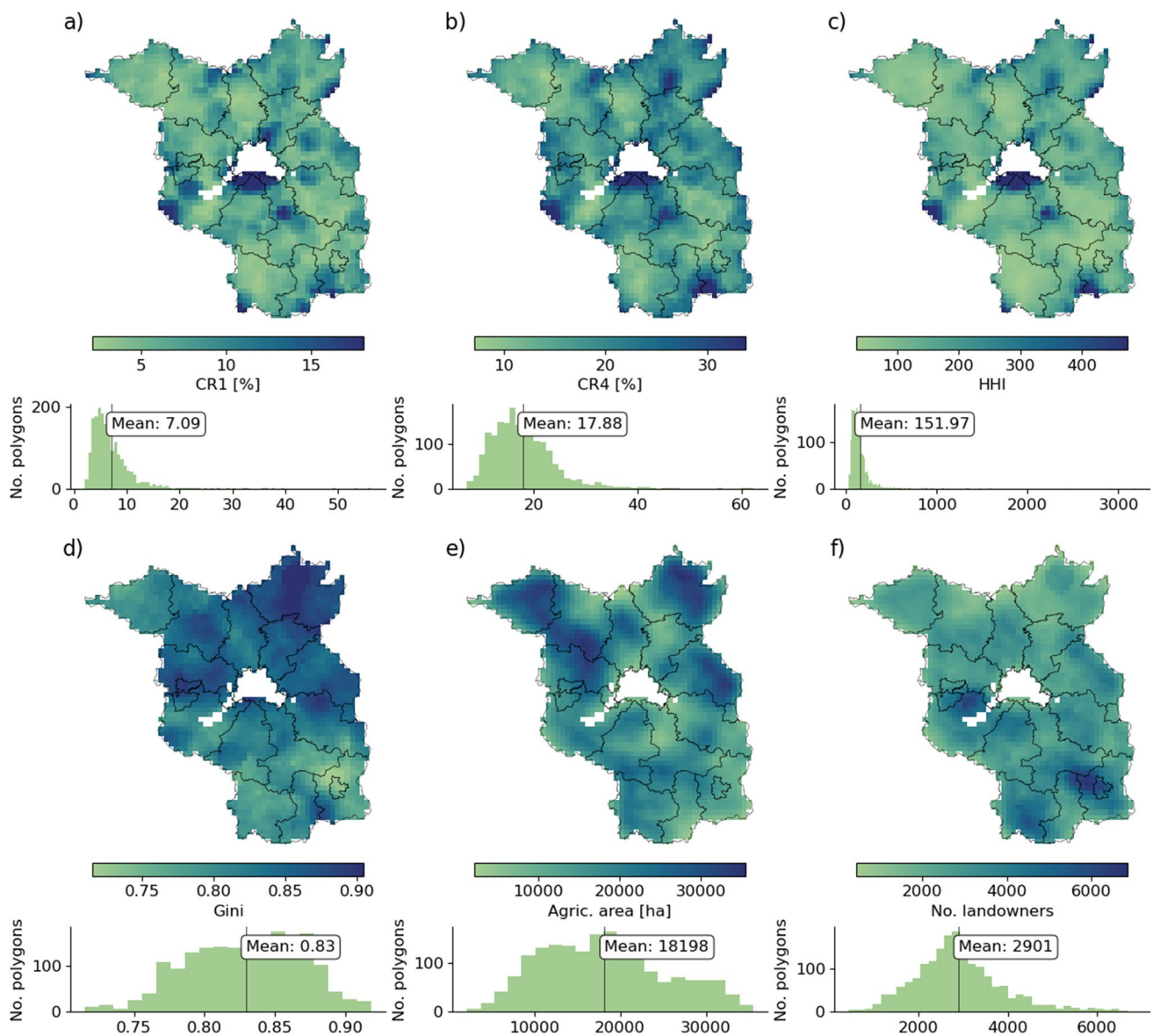


Fig. 4 Spatial patterns and histograms of the concentration of land ownership for local land markets (calculated with 12 km buffers around the centroids of the grid cells). **a)** CR1; **b)** CR4; **c)** Herfind-

ahl–Hirschman index (HHI); **d)** Gini coefficient; **e)** agricultural area; **f)** number of landowners

occurred before the financial crisis, probably because many could not compete on the open market in the early years after reunification. The other three cases of company networks were also built on former APCs; individuals from Brandenburg played a pivotal role as the majority shareholder, managers, or board members. In one of these cases, two individuals from Brandenburg formed a network of successor companies between 1991 and 2007 and now own more than 2,700 ha. In 2018, a large farmer from West Germany became influential in this network by acquiring major shares and becoming a co-manager and board member of the companies.

Of the 15 largest landowners, 13 were also the largest landowners at various local land markets, i.e. they owned the most land within a circle of 12 km (Table 2). In most cases, their shares were higher than the average CR1 of 7%, the usual share of the largest landowner in the 12 km circles. (Fig. 4d). Only a public institution and the nature conservation organisation are not the largest landowner in any grid cell because their parcels are scattered across Brandenburg. Interestingly, it is a public institution that exceeds a CR1 of 40%. The CR1s of the largest private landowners are between 7 and 27%. This would suggest that landownership in Brandenburg does not violate the German Law Against Restraints of Competition

Fig. 5 a) Ownership category of the largest landowner per 4×4 km grid cell; b) Proportions of owner categories per CR1 range, indicating high or low concentrations

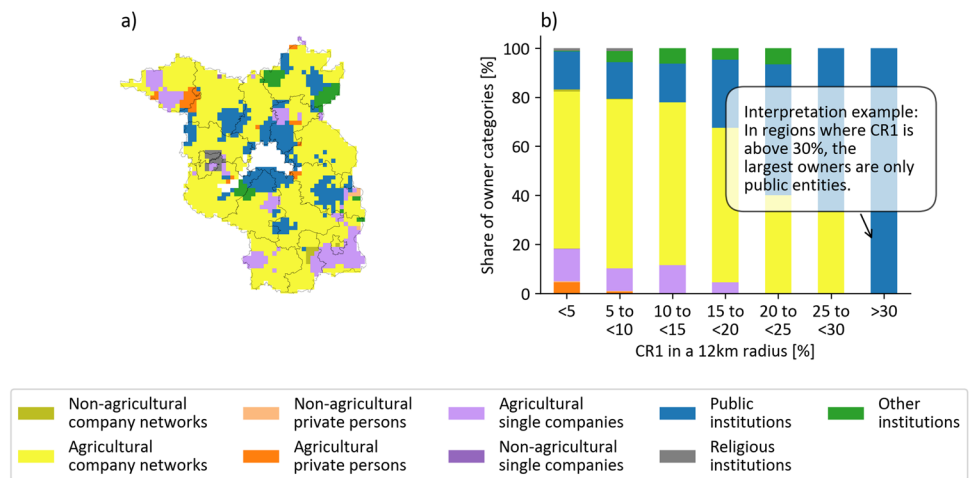


Table 2 The 15 largest landowners in Brandenburg with ownership category, owned area, average distance between the place of registration and their parcels, and CR1 and CR4 in the local land market.

Empty cells indicate that the owners are not the largest landowners in the local market. To ensure anonymity in accordance with the data privacy regulation of the cadastral data, we do not report names

Rank	Ownership category	Owned area [ha]	Average distance between the place of registration and their parcels [km]	Maximum CR1 in areas where they are the largest landowner	Maximum CR4 in areas where they are the largest landowner
1	Public institution	30,900	92 km	12%	28%
2	Public institution	11,200	30 km	69%	77%
3	Public institution	10,300	96 km	-	-
4	Agricultural company network	10,100	309 km	27%	41%
5	Agricultural company network	8,100	38 km	12%	28%
6	Public institution	4,500	96 km	9%	25%
7	Agricultural company network	3,900	477 km	11%	33%
8	Public institution	3,600	86 km	11%	28%
9	Agricultural company network	3,500	263 km	18%	34%
10	Other institution	3,300	14 km	20%	37%
11	Agricultural company network	3,200	10 km	7%	22%
12	Agricultural company network	3,000	51 km	17%	29%
13	Agricultural company network	2,700	87 km	16%	25%
14	Other institution	2,700	90 km	-	-
15	Agricultural company network	2,600	15 km	9%	23%

because no single owner has a dominant market position. However, in some areas, the CR4 exceeds 40% because two to four landowners own a large share of the land, which may indicate oligopolistic market structures and potential market power of these actors. According to our definition, three of the eight largest private landowners are absentee landowners who reside more than 50 km from their properties.

Discussion

Landowner characteristics, land ownership fragmentation, and absentee ownership

Our analysis reveals that Brandenburg's landownership is distributed over many owners, resulting in high ownership

fragmentation, similar to other post-socialist countries (Sklenicka et al. 2014; Swinnen et al. 2006). Such a high fragmentation of ownership often exacerbates land use consolidation, as for most owners, the parcels are usually too small to be suitable for agriculture and, therefore, rented to larger farms (Sklenicka et al. (2014). Additionally, around 94% of the landowners in Brandenburg are not active in agriculture and rent land to active farmers. In general, only one-third of agricultural land is owned by those who use it, and two-thirds are rented. Due to the large share of rented land and the high fragmentation of ownership, many farms have high transaction costs for managing the rental contracts, which can add up to several hundred Euros for larger farms. New farmers have difficulty acquiring suitable plots of land to start a farming business because most parcels owned by individuals are small, and many landowners need to be willing to sell or rent their land.

However, rental payments provide stable income for landowners. Furthermore, if landowners reside close to their land, the contractual connection between owners and farmers can strengthen communities, preserve traditional agricultural ways of life, and contribute to the empowerment of people (Bunkus & Theesfeld 2018; Desmarais et al. 2015; Magnan et al. 2022; Preissel et al. 2017). We found that 71% of the land is owned by local owners who live at most 50 km away. However, approximately 25% of the land was owned by owners that are registered more than 50 km from the land (the cadastre did not provide an address for the remaining 4%). This absentee ownership likely resulted from the land reforms after German reunification because many former owners had moved to other places. In Brandenburg, rural emigration has been ongoing since reunification; absentee ownership might still increase (Landesamt für Bauen und Verkehr 2021). Additionally, the GUOs of company networks tend to reside further away than single companies, suggesting that an accumulation of land in the hands of larger companies increases absentee ownership, as has also been shown for the US (Ashwood et al. (2022a, b).

Impacts of ownership concentrations

The Gini coefficient, which accounts for all landowners, had a mean of 0.82, suggesting a high concentration on the agricultural land market. However, this must be evaluated against the characteristics of the Brandenburg land market, where we found more than 180,000 landowners but only approximately 6,000 farms in the IACS data for 2020 in Brandenburg. The fact that agriculturally active owners, i.e., farmers, own significantly more land on average than non-agriculturally active owners (Fig. 3b) contributes to the high Gini values on the agricultural land market.

Therefore, it is essential to consider the concentration at the top of the ownership structure. Here, the average CR1 is 7%, the average CR4 is 18%, and the average HHI is 146. This suggests that the overall concentration level among the leading players is low to moderate. The CR and HHI values only rise above thresholds that indicate a high concentration in a region close to Berlin, where a public institution is the largest landowner. This suggests that individual private landowners are not dominant in the local land market in Brandenburg.

However, the perception of local actors may be different for various reasons. First, farmers may only be active in areas smaller than a 12 km radius. A smaller radius would, in turn, increase the concentrations because the relative importance of a few landowners increases (for illustration, see Appendix 4). Second, the Brandenburg land market is very rigid, with few land sales, because the increase in land prices reduces land purchases. As mainly capital-rich actors can afford to acquire new land resources, this could reinforce that land is becoming more concentrated in the hands of a few. Finally, the perception also depends on how the ownership structures have changed over time, something that we cannot investigate with the data available, which only represents one point in time.

We compared the CRs and HHIs with thresholds from other markets because guidelines and specific thresholds for the land market have been largely lacking to date. We must note that these thresholds serve only as an orientation because the land market requires more detailed investigation (Balmann et al. (2021). An analysis of how concentration levels affect land prices could illuminate whether incomplete competition on the land market contributes to price-dominating behaviour, possibly with adverse consequences on new entrants or smaller landowners.

The role of the largest landowners

Our analysis has shown that the largest landowners in Brandenburg include a diverse mix of public, private, and non-profit actors. Although CR1 indicated only moderate concentration among the largest private landowners, CR4 revealed that an oligopolistic market structure could occur in some areas where the largest company network owned the most land. However, very high concentrations were observed more often for public owners, who were the largest landowners in general.

Private landowners can be divided into networks of successor companies of the APCs and networks of companies which new actors have joined. Most are networks of successor companies to APCs in which individual companies have expanded their activities over time and have taken over others. However, we also find four examples of new investors

entering at different times. One bought shares in a company in Brandenburg in the early 1990s, the second in the early 2000s, the third after the financial crisis in 2008, and the last in 2018. This testifies that actors invested in agricultural land before the financial crisis in Brandenburg. All four of these investors were registered in West Germany, suggesting that absentee ownership tends to increase with the entry of new investors. This results in cash flows outside the regions, as taxes that large agricultural companies have to pay do not go to the state of Brandenburg; they are paid at the companies' headquarters. This is the case, for example, for the largest private landowner that we identified, as well as for the recent acquisition of a farm by the real estate company Quaterback Immobilien GmbH that resides in another federal state. However, absentee ownership need not be permanent, as the heirs of one investor we identified have moved to the Brandenburg region two decades after the acquisition. The motivations of the investors are very diverse. An investor had a background in the financial sector, suggesting that farming helped diversify the investment portfolio. Others had previous connections to agriculture, suggesting they invested in land to expand their farming activities. Another company network was even founded to permanently protect land from financial investors so that it could be leased to organic farms on a long-term basis. These examples exemplify the broad diversity of landowner types.

The company networks examined revealed that several successor farms to the APCs, which had large tracts of land, were often incorporated into a single network. This highlights that large farms constitute an entry point for investors to take control of large areas quickly by taking over the successor farms. By integrating several farms into their networks, changes in the land ownership structures occur more rapidly than via single land purchases. A similar process has been observed in Australia, where large corporate and successful family farms eventually sold out to larger agricultural units or financialised agribusinesses, paving the way for significant structural changes and increasing ownership concentration (Pritchard et al. 2023).

In developed economies, the number of farms decreases while the size of farms increases. This structural change in agricultural land use is often accompanied by a growing concentration of land ownership in fewer hands. Similar trends to higher concentration occurred in the agri-food system (Hendrickson et al. 2017), such as in animal production (Ashwood et al. 2022a, b), seed production (Maisashvili et al. 2016), and in retailing and distribution (Hendrickson et al. 2017). Such consolidation trends reduce farmers' autonomy and incomes while redistributing costs and benefits across the food chain (Mooney 2017). Concerning agricultural production, large landowners have the potential to exert significant influence on agricultural practices as large ownership also means that decision structures about production practices and land use on these lands are concentrated in their

hands (Bunkus & Theesfeld 2018). The land provides them with decisive power about leasing contracts or, in case they farm themselves, production methods. This gives larger landowners additional advantages over smaller players in the agri-food system.

Implications of results

In response to rising land prices, decreasing availability of land due to conversion to non-agricultural uses, and increasing concerns about local concentration of land, the Brandenburg state government drafted an agricultural structure law (*Agrarstrukturgesetz*) in 2023, which aims to strengthen local farmers by making purchases of agricultural land or shares of agricultural companies more difficult for non-agricultural investors (MLUK Brandenburg 2023). The measures include a price cap on land sales and leases, a strengthened right of first refusal for farmers, and a limit of land ownership to 2,600 ha per landowner and their associated companies, including all land leased and owned by the corporate network. However, Brandenburg's ownership structures were only known for small areas, and the envisaged law was mainly based on information on land use (i.e., how much land a farming entity farmed). The unknown nature of actual ownership structures, owner types, and ownership concentration has drawn criticism that the draft needed to be revised (Appel et al. 2023). Our results show that not only non-agricultural investors accumulate large areas in Brandenburg but also successor farms of the APCs, which are typical for Brandenburg. Furthermore, the impact of the largest owners on the local concentration of ownership is moderate, and we found only very few cases where ownership structures were associated with a high local concentration. Although large landowners can increase concentrations locally, we do not see a necessary causality between more than 2,600 ha ownership and high concentrations. It, therefore, remains to be seen whether such a threshold value will fulfil the intended objective of strengthening local farmers by reducing the concentration of land throughout Brandenburg.

A concentration measure should address local ownership concentrations instead of the total area owned by individual owners. Furthermore, a clear definition of a local or regional land market should be established. We provided a possible solution, which could be adapted to allow for variations between different regions, e.g. by flexibly determining the average radius of activity of farmers for subregions. Furthermore, before setting a threshold that indicates excessive ownership concentration, a clear link should be established between a certain degree of concentration and possible disadvantages, such as limited land access or dominant players' price-determining behaviour. To make land more accessible, greater transparency about ownership and land purchases is needed. This will ease market entry for smaller farmers by identifying land parcels and thus increase competition

among sellers. Finally, large areas of publicly owned land could be leased to prioritised actors, such as sustainable farming operations, smaller farms, or young farmers.

Conclusion

We provide the first complete account and analysis of all landowners and ownership concentration in the entire state of Brandenburg (1,315,182 ha of agricultural land). The results form the basis for further research on the social, economic, and environmental implications of land ownership concentration. We revealed a high degree of land ownership fragmentation with more than 185,000 individual landowners, most of whom own only small parcels. Only a third of the land is owned by farmers, and absentee ownership accounts for a quarter of all agricultural land in Brandenburg. High fragmentation and a high proportion of leased land pose risks to Brandenburg farms in the form of high transaction costs. High levels of absentee ownership can be detrimental to rural regions because owners may have weak bonds with their land and because capital gains flow outside. The ownership concentration for the local land market in Brandenburg was low to moderate when evaluated with standard measures of market concentration, such as the concentration ratio 1 and 4 and the Herfindahl–Hirschman index. However, the Gini coefficient showed higher concentration rates, as the most prominent landowners own relatively more land than many smaller landowners.

We identified public institutions, agricultural company networks, and non-profit organisations among the largest owners. The company networks could be further classified into more extensive networks of successor companies of agricultural production cooperatives, company networks mainly taken over by West German farmers, and corporate networks where financial investors bought the major shares of agricultural enterprises.

Our findings help to reveal individual actors' behaviour on the land market. For example, our results show that large landowners are active across large areas and that significant land ownership only sometimes goes hand in hand with high local market concentration. This has implications for studies of market power about land market pricing, which often assume that large landowners can exert market power. Our results emphasise that it is essential to look beyond the size of landowners and that a closer look at local concentrations is necessary. In addition, our results show how historically evolved structures characterise today's land market and simultaneously create the conditions for new players in the land market. Both can be seen in the successor farms of the APCs, which are major players in the land market today but, at the same time, can represent a major entry point for new

investors. In this way, we contribute to the understanding of rural developments.

Our analysis provides rare information on large-scale agricultural land ownership concentration. We have shown how institutional legacy, economic development, and land market regulations shaped contemporary ownership patterns. The results further reveal how land ownership patterns can deviate from land use patterns, with the latter much more consolidated in our study region. The resulting ownership patterns allow for analysing the drivers, causes, and consequences of land ownership concentration and provide essential entry points for designing land market regulations that aim to achieve land ownership patterns that balance economic, social, and environmental goals.

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Clemens Jänicke is a doctoral student at the Land Systems Group of the Leibniz Institute of Agricultural Development in Transition Economies (IAMO) and the Humboldt-Universität zu Berlin. His research investigates agricultural land markets, their outcomes, and whether they fulfil envisaged societal functions. In his dissertation, Clemens places particular focus on the relationship between land ownership structures and land use.

Daniel Müller studies agricultural sciences and is a professor of geography at the Humboldt-Universität zu Berlin. He leads the Land Systems Group at the Leibniz Institute of Agricultural Development in Transition Economies (IAMO). His research aims to advance the understanding of land-system change, including its multiple repercussions on rural livelihoods, food production, carbon balance, and biodiversity. Daniel uses quantitative and qualitative methods that combine his expertise in resource economics and environmental sciences. Most of his work concentrates on the countries of the former Soviet Union, Western Balkans, and China