

1 **Desakota as Energy Potential Landscape:** 2 **Distributed Hydropower Potential in the Taipei–** 3 **Kaohsiung Mega Urban Region**

4
 5 *Asian urbanization has unsettled conventional urban/rural binaries, yet the*
 6 *infrastructural capacities of hybrid territories remain insufficiently examined.*
 7 *This paper reinterprets desakota as an energy landscape by assessing whether the*
 8 *Taipei–Kaohsiung Mega Urban Region offers favourable spatial preconditions for*
 9 *distributed low-head hydropower. Combining land-use co-presence, population*
 10 *density, hydrological networks, and electricity-grid data within a 5 × 5 km GIS*
 11 *framework, the study distinguishes desakota from predominantly urban and*
 12 *agricultural formations and compares their relative infrastructural characteristics.*
 13 *The findings show that desakota occupies approximately 29% of Taiwan’s*
 14 *inhabited land while accommodating about 42% of the national population. More*
 15 *significantly, it combines dense watercourse networks, comparatively strong*
 16 *electricity-network accessibility and carrying capacity, and a substantial*
 17 *dispersed demand base. These conditions differentiate desakota from compact*
 18 *urban cores, where water systems are often reduced or disconnected, and from*
 19 *lower-density agricultural areas, where grid capacity is weaker. The paper*
 20 *contributes to desakota studies by shifting attention from classification and*
 21 *transition to infrastructural potential, and to renewable-energy planning by*
 22 *demonstrating that feasibility is not only hydraulic or techno-economic but also*
 23 *territorial.*

24
 25 **Keywords:** *desakota; energy landscape; distributed hydropower; low-head*
 26 *hydropower; Taipei–Kaohsiung Mega-Urban Region.*

27 28 29 **Introduction**

30
 31 The World Urbanization Prospects has recently abandoned the dichotomy
 32 urban-rural to adopt a “degree of urbanization” perspective that treat landscapes as
 33 a continuum of urban, rural, and natural areas (UN, 2025). This is highly relevant in
 34 Asia, where rural and urban activities very often coexist, and reinforces the need to
 35 revisit hybrid categories, such as the *desakota*.

36 It is long that McGee introduced this concept to describe the densely populated
 37 Asian territories where wet agriculture, settlement, manufacturing, and circulation
 38 networks are all enmeshed within extended metropolitan processes (McGee, 1991;
 39 McGee, 2005). The concept emerged from research on urban geography categories
 40 such as the Extended Metropolitan Region, first, and the Mega Urban Region, later,
 41 and it has been influential in debates on Asian urbanization. Then, subsequent
 42 studies have progressively refined the concept as that of a mixed landscape
 43 characterized by the co-presence of wet-agriculture, structured water systems, high
 44 population densities, growing secondary activities, and high human connectivity
 45 (Wu and Sui, 2016).

46 However, today, two interpretations are still in tension within the literature. One
 47 sees *desakota* as a transitional condition ultimately to be replaced by more

1 conventional metropolitan forms, such as suburbanization. The other treats it as
 2 durable and thus distinctive spatial formation that needs ad-hoc planning. Relatively
 3 recent scholarship has strengthened this second view and argued that mixed agro-
 4 urban territories demand action-led, context-sensitive plans, rather than any
 5 imported blueprint planning (Chen et al., 2017).

6 However, the energy transition suggests a novel question that *desakota*
 7 literature did not address yet. This is whether the distributed morphology of
 8 *desakota* may be suitable to distributed renewable systems and, in particular, to
 9 hydropower-based ones, given the diffuse and structured water systems of *desakota*.
 10 In this respect, it is important to mention how reviews have long shown that ultra-
 11 low-head technologies have expanded the range of possible applications (Elbatran
 12 et al., 2015; Butera and Balestra, 2015; Zhou and Deng, 2017) but grid connection
 13 remains a variable and, thus, the relation of generation sites, network accessibility,
 14 and demand is crucial (Forouzabakhsh et al., 2007). In other words, only when
 15 hydrological networks, electricity networks, and end users demand are spatially
 16 interwoven—such as this appears to be in *desakota*—distributed hydropower energy
 17 systems may be plausible.

18 Consequently, the paper argues that *desakota* should be re-examined from this
 19 perspective. That is, rather than asking whether it is economically endogenous or
 20 morphologically transitional, it asks whether *desakota* is more favourable to
 21 distributed hydropower than adjacent territories. By this, the paper does not aim to
 22 claim the feasibility of any project but advances a morphological-comparative
 23 contribution to the literature.

24 25 26 **Literature review**

27
28 Existing scholarship on *desakota* may be grouped into three strands. The first
 29 one is conceptual. McGee’s original formulation described densely populated
 30 territories in which agriculture and non-agricultural employment coexisted to
 31 challenge the urban-rural binary inherited from Western theory (McGee, 1991).
 32 Later, he also renewed the argument by insisting that Asian peri-urban regions have
 33 peculiar development pathways and cannot be reduced to suburbanization (McGee,
 34 2005). Research on rural urbanization and planning for the Asian Mega-City
 35 emphasized similar logics (Qadeer, 2000; Yokohari et al., 2000) but recent studies
 36 have shown that, although the original concept is still valid, innovations had
 37 happened. Indeed, if some territories keep displaying stable *desakota* characteristics,
 38 others have undergone a restructuring that exceeds the original formulation of the
 39 concept (Hong and Kim, 2023).

40 Anyhow, recent scholarship uses it to question “city-centred” accounts of
 41 various processes. E.g., Ortega’s “*desakota 2.0*” has situated hybrid territories
 42 within postcolonial debate, insisting that these must be read through local histories
 43 and socio-spatial dynamics rather than any alterity to a supposed normal
 44 metropolitan fringe. Gillen, Bunnell, and Rigg’s “*rural-ization*” has displaced the
 45 assumption that urbanization proceeds through the disappearance of the rural,
 46 arguing that it is a balance with the urban to be at stake. Recent work on the “*peri-*

1 *urban turn*” and landscape-based planning reinforces this understanding by treating
2 the urban-rural interface as a complex socio-ecological *milieu*, rather than a
3 transitional arrangement (Ortega, 2020; Gillen et al., 2022; Rajendran et al., 2024;
4 Tan et al., 2024).

5 A second strand of research focuses on empirical-operational measurements.
6 In this framework, Shih and Chi (2012) showcased how *desakota* is best understood
7 not as a residual category between city and countryside but as an actively contested
8 space. Wu and Sui (2016) further clarified how the growth of *desakota* can be
9 related to globalization and, in particular, the expansion of foreign direct investment
10 and service economy. However, regardless such studies moved the discussion to
11 aspects of spatial form, they remain primarily concerned with classification.

12 A complementary empirical strand has translated *desakota* in terms of remote-
13 sensing and, from this, brought the concept in contact with associated studies. E.g.,
14 Sui and Zeng (2001) used landscape indexes and cellular automata to model
15 landscape dynamics in Shenzhen, and Xie et al. (2006; 2007) similarly examined
16 emergent *desakota* in Suzhou. Work on Ho Chi Minh and Jabodetabek extended the
17 approach to peri-urban population growth and the changing economic, social, and
18 ecological role of agriculture (Kontgis et al., 2014; Pribadi and Pauleit, 2015).
19 Recent work continues the trajectory: e.g., Ge et al. (2026) developed a population-
20 land-transport framework for urban-rural integration in Jiangsu based on *desakota*
21 metrics. If these studies expand the empirical vocabulary of *desakota*, at the same
22 time they reveal a methodological asymmetry. Land cover, density, accessibility,
23 and other administrative categories are often operationalized, but infrastructure,
24 including irrigation, drainage, and energy systems remain relatively untouched.

25 A third strand addresses governance. Long ago, Dick and Rimmer (1998)
26 already argued that the changing geography of Asian urbanization, here including
27 *desakota*, could no longer be explained by Third World city models. More recently,
28 Chen et al. (2017), has showed that conventional planning mismatches mixed
29 landscapes, such as the *desakota*, and, in particular, their spontaneous investment
30 patterns. Across such a literature, *desakota* tends to appear as a planning challenge
31 or a transitional formation. What remains less developed is a reading of *desakota* as
32 a spatial arrangement that helps or condition the development and later management
33 of infrastructure within.

34 Governance literature also connects to ecosystem services and resource
35 management discussions. E.g., Moench and Gyawali (2008) interpret *desakota* as
36 an interconnected rural and urban livelihood, rather than an administrative category
37 alone. Their seminal study shows that household strategies and environmental
38 pressures traverse the rural/urban divide, and that a singular territory may be
39 exposed to agricultural, industrial, residential, and infrastructural demands
40 simultaneously. From this point of view, *desakota* is difficult not only because
41 morphologically mixed. It is also because water, energy, and mobility systems
42 within are institutionally fragmented but materially interlinked, a condition that
43 strengthens the argument for reading *desakota* as an infrastructural landscape.

44 The underlining knowledge gap becomes more evident when it comes to
45 energy. If it is a decade since reviews have shown how technological development
46 widened the range of hydraulic conditions under which distributed generation can

1 be considered, including aspects of turbine types, civil works, and generator
 2 configurations, studies of irrigation networks have also shown that canals, drops,
 3 and hydraulic control structures may be treated as latent energy sites rather than just
 4 as water-conveyance devices (Carravetta et al., 2012; Williamson et al., 2014;
 5 Quaranta and Revelli, 2018). More recently, reviews have also extended this agenda
 6 by comparing costs and performance across the technologies (Klein and Fox, 2022;
 7 Duah et al., 2026; Chernobrova et al., 2026). Yet the literature remains very often
 8 site-technical or techno-economic. It rarely asks which forms of urbanization
 9 produce and maintain a spatial conjunction of hydraulic potential, electricity
 10 demand, and distribution infrastructure adequate for the diffuse adoption of
 11 hydropower, not to mention the relations with *desakota*.

12 In summary, the scholarship has examined *desakota* in terms of socio-
 13 economic transition, land-use change, governance, and environmental conflict, but
 14 far less attention has been given to the ways in which its irrigation networks,
 15 dispersed settlement, and electricity distribution infrastructures may constitute the
 16 possibility for a distinctive energy landscape. However, taken as a whole, the
 17 literature also suggests that *desakota* may be approached as a socio-eco-
 18 infrastructural formation, not only as a land-use mixture or planning anomaly.
 19 Indeed, some of its key features seem to create an opportunity field for distributed
 20 low-head hydropower that differs from the development potentials of any urban
 21 core or agricultural hinterland.

22 So, this paper aims to contribute to *desakota* studies by shifting the focus from
 23 classification to infrastructural capacity, and to renewable energy studies by
 24 addressing how systems feasibility may not only be techno-economic, but also
 25 territorial. Specifically, the paper asks whether *desakota* can provide spatial
 26 preconditions for distributed low-head hydropower that are more advantageous than
 27 those of urban cores or agricultural hinterlands within the same Mega Urban Region.
 28
 29

30 **Contribution and structure of the paper**

31
 32 In Taiwan, *deskota* has been examined in both metropolitan and county-scale
 33 studies (Liu and Tsai, 1991; Shih and Chi, 2012; Wu and Sui, 2016). So, the paper
 34 investigates the Taipei–Kaohsiung Mega Urban Region as a pertinent case through
 35 which to test the relation between urban form and distributed low-head hydropower
 36 potential. The research classifies this Mega Urban Region into various broad
 37 territorial formations—including *desakota*, predominantly agricultural areas, and
 38 more conventional urban areas—on the basis of land-use co-presence and
 39 population density. It then compares these formations in terms of watercourse
 40 density, electricity-network accessibility and carrying capacity, and spatial
 41 distribution of population. The aim is to determine whether *desakota* presents more
 42 favourable spatial preconditions for distributed generation than the other formations.
 43 The study is conceived as a regional screening and comparative analysis; as such, it
 44 does not replace hydrological modelling, ecological assessment, or plant-level
 45 techno-economic feasibility studies.

1 The paper is organized in five parts. After the introduction, Section 2 defines
2 the case study and the analytic model. Section 3 presents the results of the study,
3 first by identifying the distribution of different urban forms within the Taipei–
4 Kaohsiung Mega Urban Region and then comparing those forms in relation to
5 hydrological and electrical networks. Section 4 discusses the implications of the
6 findings in terms of *desakota* interpretation. Then, Section 5 outlines the limitations
7 of the study, and Section 6 concludes by summarizing the contribution and
8 indicating directions for future research.

11 **Materials and Methods**

13 *Case study.*

15 In the wider literature on Asian urbanization, Taiwan has often been treated as
16 an exemplary case of dispersed industrialization, intensive infrastructural
17 development, and persistence of agriculture amid metropolitan change (Liu and
18 Tsai, 1991; Williams, 1998; Wu and Sui, 2016), here including the seminal study
19 by McGee (1991). Also, the Taipei–Kaohsiung Mega Urban Region is relevant for
20 the discussion since, starting in 2019, the planning frameworks of Taiwan explicitly
21 recognize urban-rural development as a distinct field of spatial governance. This
22 does not in itself validate the study on *desakota*, but it adds practical relevance of
23 analyzing mixed territories within the context of the case study.

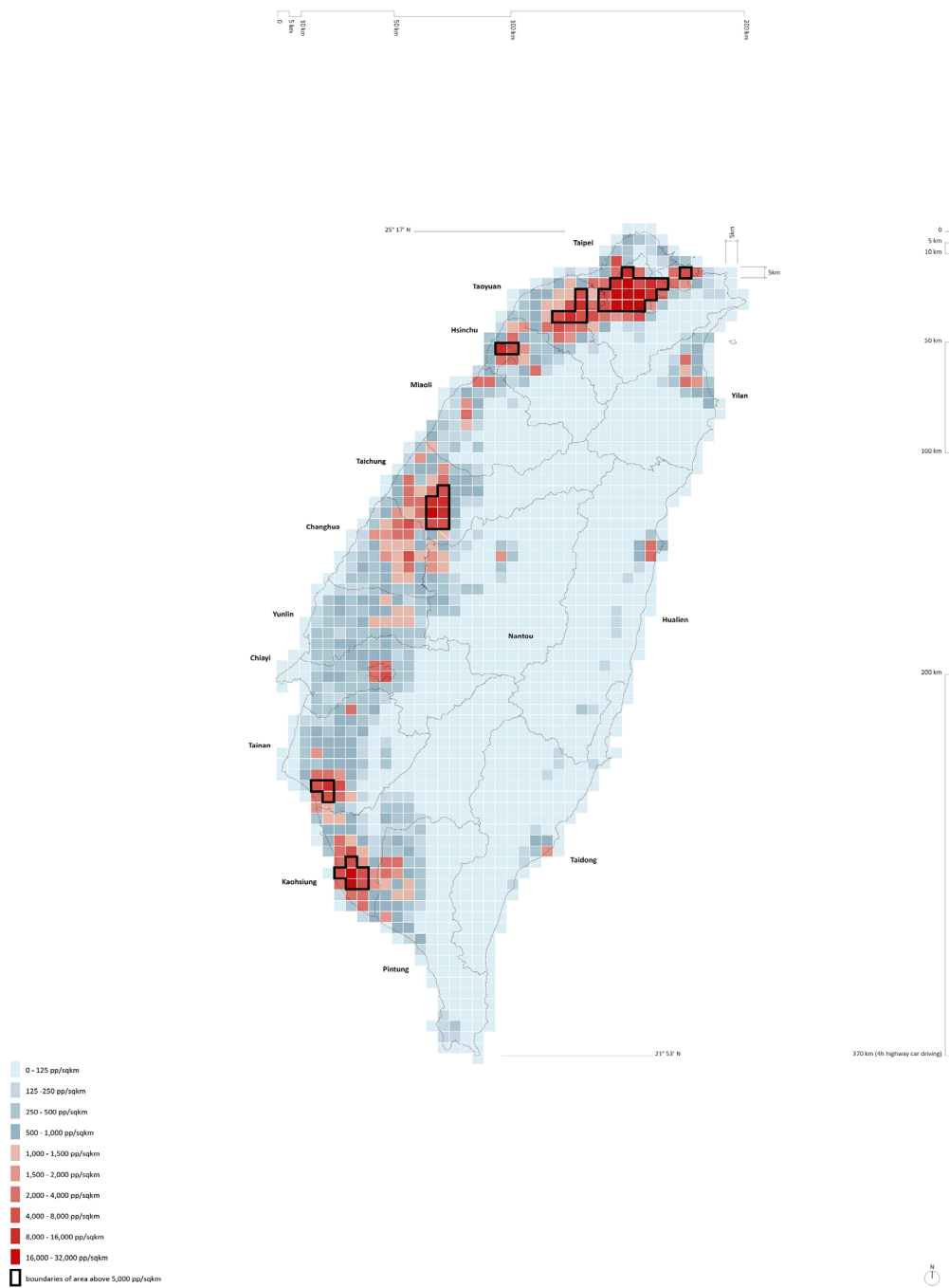
24 Taiwan’s western plain not only concentrate most of the urbanizable land of
25 the island but also corresponds to the space of the Mega Urban Region. This has
26 developed over long time through the interaction of irrigated agriculture, transport
27 infrastructure, and industrialization. Wet-rice cultivation and irrigation systems
28 have expanded historically, while twentieth-century investments and public works
29 progressively consolidated a dense territorial infrastructure. Then, after World War
30 II, land reform, export-oriented industrialization, and rural electrification
31 accelerated the diffusion of small and medium enterprises. All together, rather than
32 producing a centralized metropolitan system, these processes have generated a
33 highly interwoven urban-rural territory where industry, housing, mobility networks,
34 and agricultural land are closely articulated.

36 *Analytic model.*

38 The research is based on public accessible data retrieved from public
39 institutions and utility sources, retrieved in geospatial format and structured into a
40 coherent database. These data included topographic data from 2016, obtained from
41 the National Land Surveying and Mapping Center, Ministry of the Interior, census
42 data from 2018, acquired from the Directorate General of Budget, Accounting and
43 Statistics, the Executive Cabinet, land use data from 2017, sourced from the Center
44 for Land Use Investigation, Ministry of the Interior, water stream data from 2020,
45 provided by the Water Resources Agency, Ministry of Economic Affairs, and then

1 power grid data from 2019, provided by Taiwan Power Company. Census data were
2 integrated from the smallest available administrative units, about 3,000 people big.

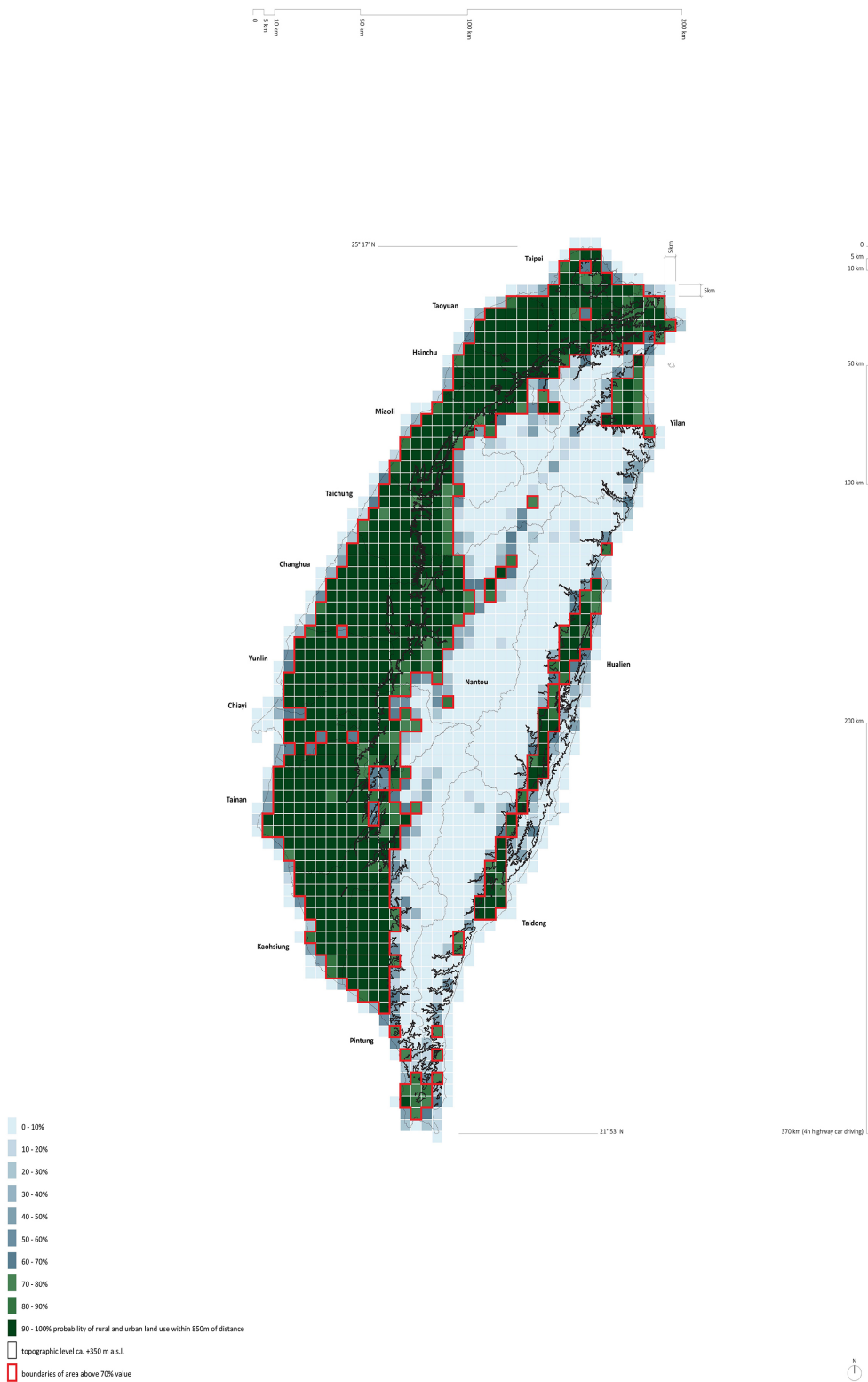
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4 **Figure 1.** *Taiwan island's population density and urban areas distribution*



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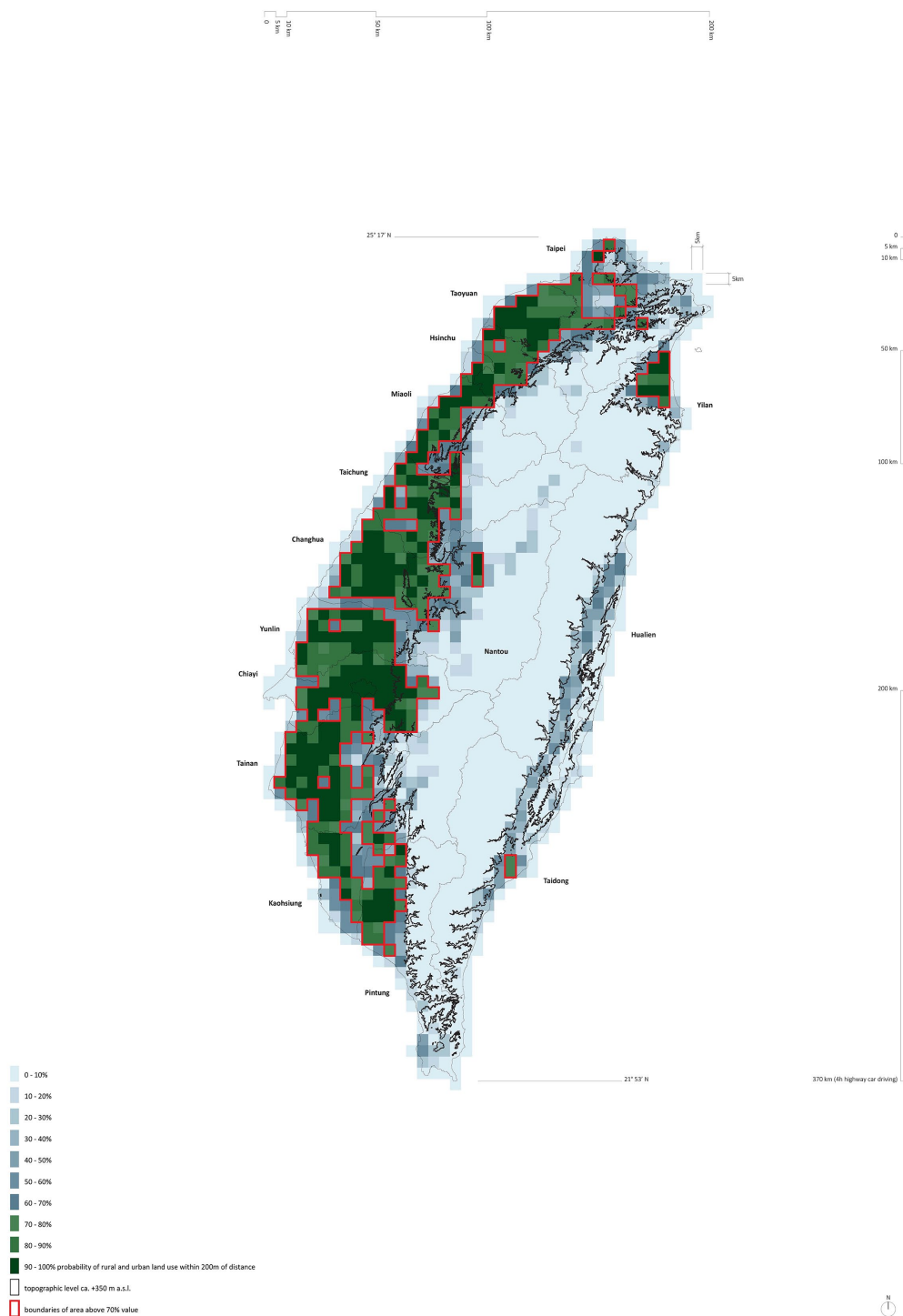
1 **Figure 2.** 850 m buffer urban-rural land use copresence distribution



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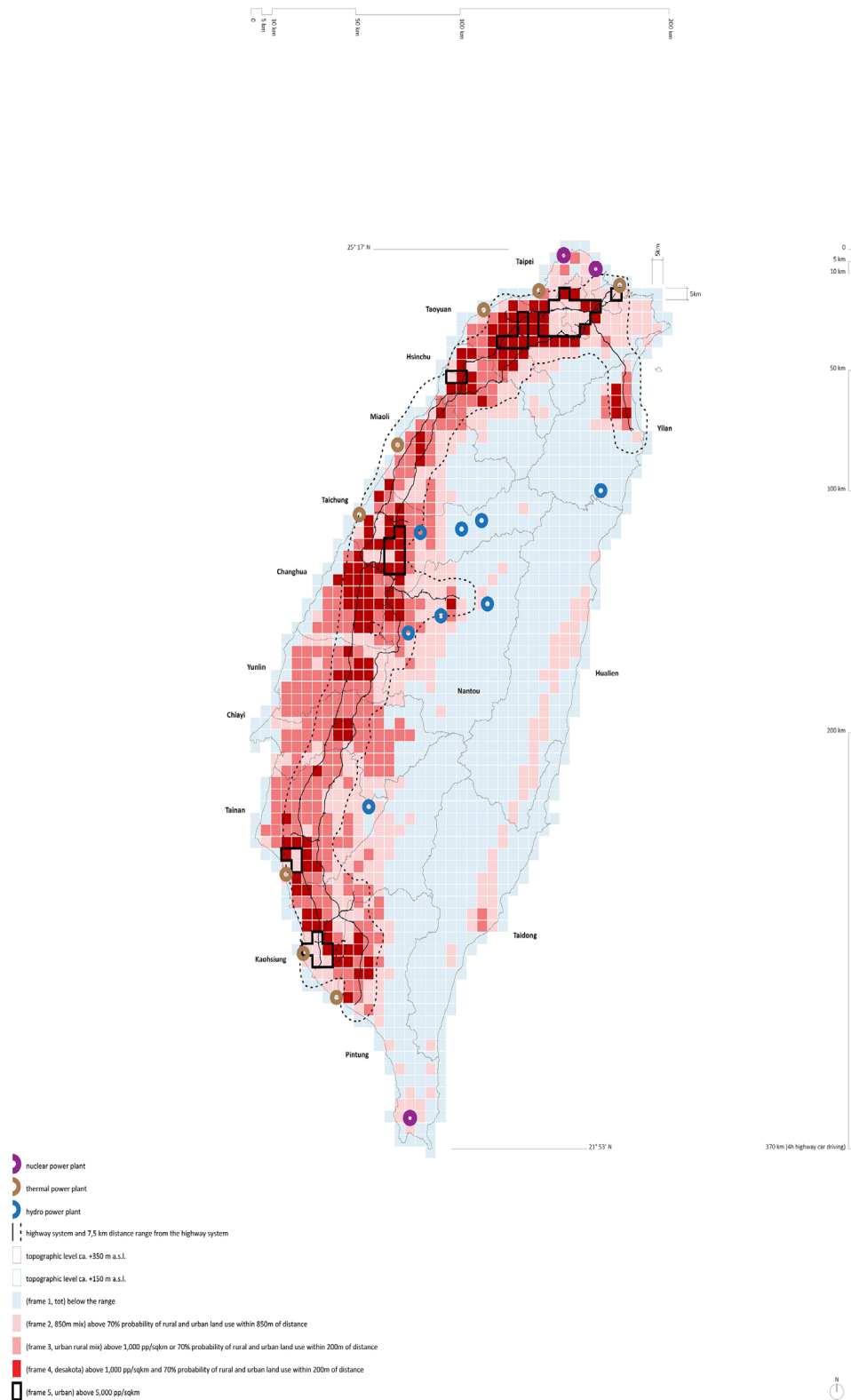
1 **Figure 3.** 200 m buffer urban-rural land use copresence distribution



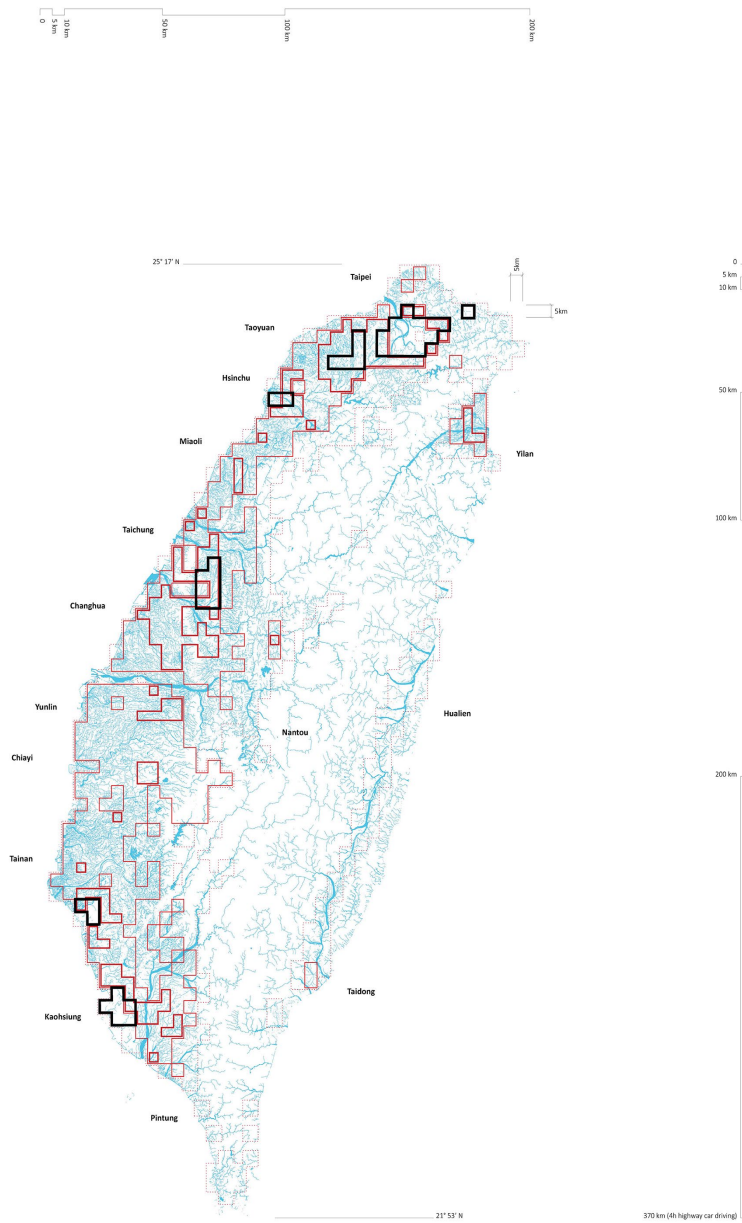
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1 **Figure 4.** *Spatial distribution of different urban forms, or frames of analysis map*



1 **Figure 5.** *Hydrologic network assessment map*



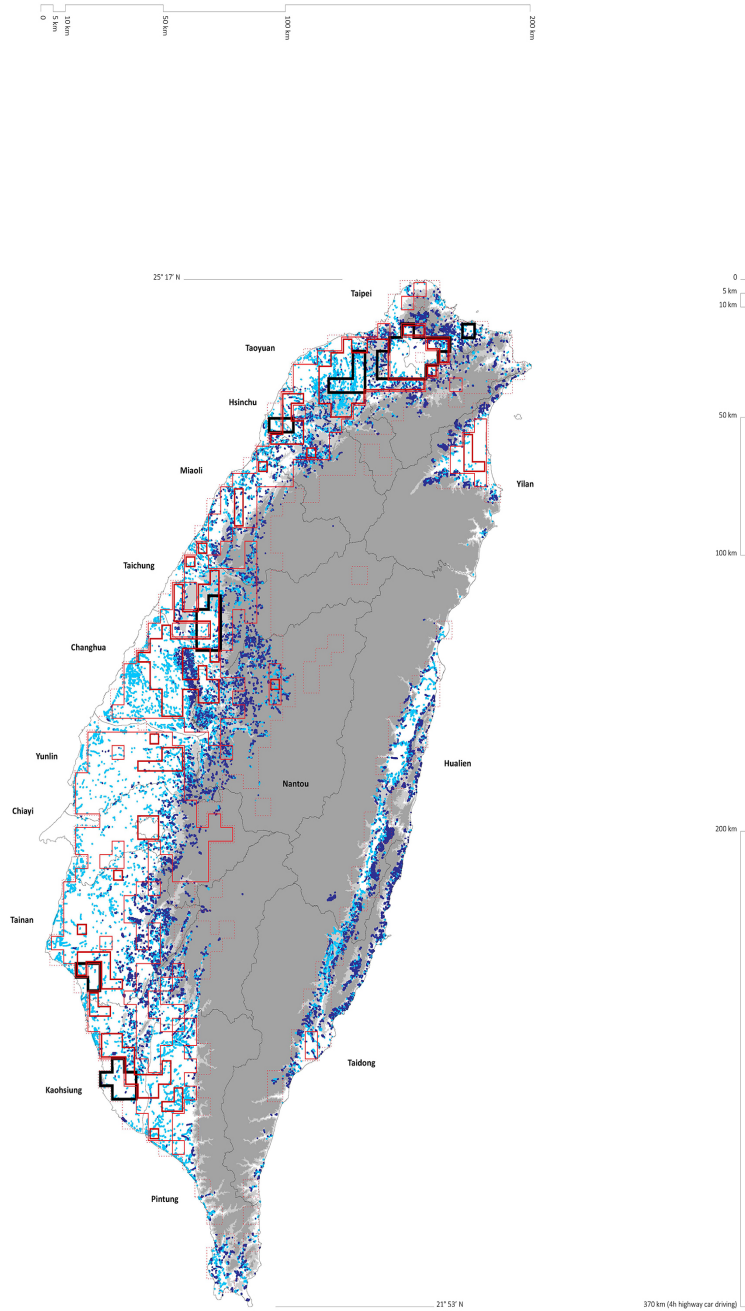
- water streams
- (frame 2, 850m mix) boundaries of area above 70% probability of rural and urban land use within 850m of distance
- (frame 3, 200m mix) boundaries of area above 70% probability of rural and urban land use within 200m of distance
- (frame 4, desakota) boundary of area above 1,000 pp/1qkm and 70% probability of rural and urban land use within 200m of distance
- (frame 5, urban) boundaries of area above 5,000 pp/1qkm



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1 **Figure 6. Waterdrops distribution assessment map**

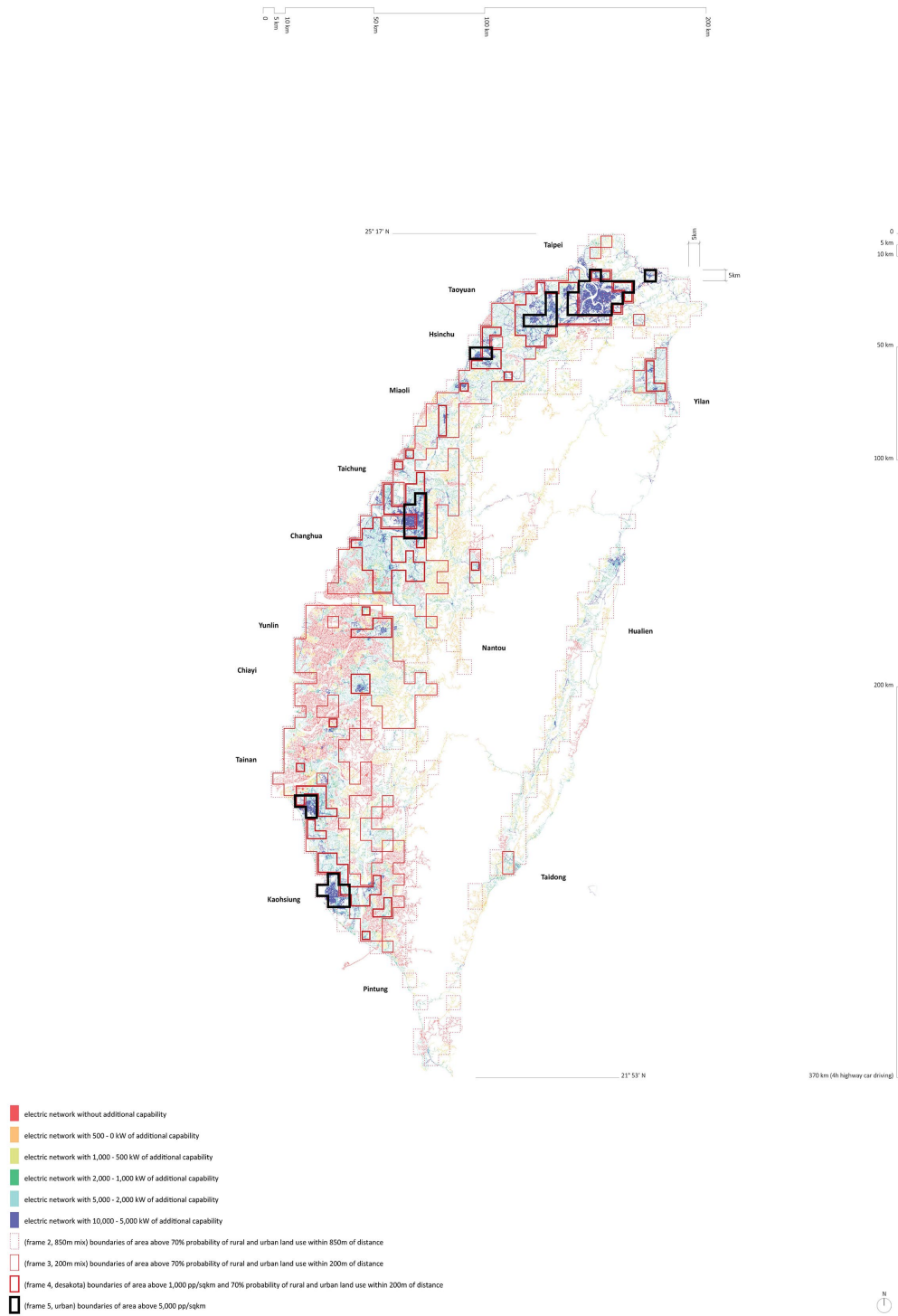


2

- topographic level ca. 350 m a.s.l.
- topographic level ca. 150 m a.s.l.
- car-accessible public sites facing water drop between 2 and 5m
- car-accessible public sites facing water drop higher than 5m
- (frame 2, 850m mix) boundaries of area above 70% probability of rural and urban land use within 850m of distance
- (frame 3, 200m mix) boundaries of area above 70% probability of rural and urban land use within 200m of distance
- (frame 4, desakota) boundary of area above 1,000 pp/sqkm and 70% probability of rural and urban land use within 200m of distance
- (frame 5, urban) boundaries of area above 5,000 pp/sqkm



1 **Figure 7. Electric network assessment map**



2
3

1 The analysis proceeded in four steps. First, urban and rural land uses and
 2 population density were assessed in order to distinguish territorial formations based
 3 on density and land use copresence. Second, the total length of watercourses—
 4 natural, regulated, and constructed—was calculated as a proxy for opportunities for
 5 low-head hydropower generation. Third, the presence of waterdrops was assessed
 6 through GIS computing by integrating the location of watercourses with
 7 topographic data, road network, and land subdivision, the parcels of public land
 8 within 5 m from a road and holding a water drop being understood as units of
 9 intervention for the possible implementation of hydropower. Important to
 10 remember, these occurrences of waterdrops should anyway be understood as
 11 candidate spatial conditions rather than actual hydropower sites. Fourth, the
 12 electricity network was assessed in terms of spatial coverage and available carrying
 13 capacity as a proxy for connection potential.

14 To operationalize land-use co-presence, all relevant layers were assigned to a 5
 15 × 5 km grid aligned with the National Topographic Survey framework. Urban and
 16 rural land-use patches were then buffered at 150, 200, 300, 500, 850, and 1,200 m.
 17 The buffered areas were rasterized to a 1 × 1 m grid, after which the percentage of
 18 each 5 × 5 km cell situated within the specified proximity to both urban and rural
 19 land-use patches was calculated. The 200 m and 850 m outputs were then used for
 20 the later research development purposes since they could better differentiate fine-
 21 grained mixed landscapes from broader mixed territorial zones.

22 Population density was projected onto the same 5 × 5 km grid and used together
 23 with the co-presence analysis. In line with the comparative literature on *desakota*
 24 and high-density rural urbanization, cells with more than 1,000 inhabitants/km²
 25 were treated as exceeding a suburban threshold and therefore as potentially pertinent
 26 to *desakota* when associated with strong urban-rural co-presence (Qadeer, 2000).
 27 Cells with more than 1,000 inhabitants/km² but lack of urban-rural co-presence were
 28 considered suburban. Cells with more than 5,000 inhabitants/km² were considered
 29 fully urban, and cells with less than 1,000 inhabitants/km² were considered rural or
 30 wild.

31 32 33 **Results**

34 35 *Spatial distribution of different urban forms within the Taipei–Kaohsiung Mega* 36 *Urban Region*

37
38 The 850 m assessment identifies a relatively compact area with more than 70%
 39 urban-rural co-presence. Its outer limit broadly follows the change in topography
 40 between the western plain and the foothill zone. By contrast, the 200 m assessment
 41 reveals a finer-grained and more discontinuous “filament” extending from the
 42 periphery of Taipei to Kaohsiung, interrupted by major rivers and their floodplains.

43 Within this finer-grained assessment, the 70% copresence ratio constitutes a
 44 threshold within the distribution of values and can therefore be interpreted as
 45 marking the transition to the more intense urban-rural mix. When this threshold is

1 combined with the population criterion of more than 1,000 inhabitants/km², the
2 resulting area is classified as *desakota*.

3 According to the analysis, *desakota* occupies 7.8% of Taiwan's total land area,
4 or approximately 29% of its inhabited land, and contains 9.84 million inhabitants,
5 roughly 42% of Taiwan's total population. According to the statistic structure of the
6 study, about 89% of this population is expected to live within 200 m of both an
7 urban and a rural land-use patch. See from Figure 1 to 3.

8 *Relation between urban forms, hydrologic, and electric networks*

10
11 For the hydrological and electricity-network assessment, five territorial frames
12 of analysis were compared: (1) the whole territory; (2) the area defined by cells with
13 more than 70% urban–rural co-presence in the 850 m assessment; (3) the area defined
14 by cells with more than 70% co-presence in the 200 m assessment; (4) the area defined
15 by cells classified as *desakota*; and (5) the area defined by cells classified as urban.
16 The 5 × 5 km cell structure remains the common unit of analysis to define the frames
17 and to assess the hydrological and electrical data within. See from Figure 4 to 7.
18 Because cumulative comparisons between nested frames could conceal the
19 characteristics of the areas added or excluded at each stage, non-overlapping areas
20 between frames were also assessed. Through this approach, the assessment identifies
21 how conditions change as the analysis moves toward increasingly fine-grained and
22 densely inhabited urban–rural formations. See Table 1.

23
24 **Table 1.** Comparative assessment across the frames of analysis. With darker grey
25 background hatch the highest values; with lighter grey, the second highest values

Frames of analysis	The data on the right refers to the avg. value in related cells.		Car accessible water drops on public land (occurrences where the road is within 5m from the drop)			Water-courses (length of stream axis) avg. km x sqkm	Grid coverage (area 50m within grid) avg. % cov. x sqkm	Grid capacities (avg. % of grid)		
	pop. (M)	area (sqkm)	avg. drop x sqkm	2-5m drops	>5m drops			0-2 MW	5 MW	10 MW
1. Whole territory	23.57	39,850	1.2	0.4	0.9	0.96	20.6	54.7	31.1	14.2
2. 850 m buffer urban-rural copresence	21.42	18,050	2.3	0.7	1.7	1.55	39.4	52.8	32.6	14.9
3. 200 m buffer urban-rural copresence	12.69	9,425	2.4	0.6	1.8	1.93	50.3	49.9	37.0	13.0
4. Desakota > 1,000	9.84	3,125	2.8	0.6	2.2	1.93	62.0	22.2	52.4	25.4

pp/sqkm										
5. Urban > 5,000 pp/sqkm	4.88	975	1.8	1.2	0.6	1.13	69.0	4.3	29.3	66.4

Reference assessment carried on the areas in between the frames of analysis

Area between frame 1 and 2	1.89	21,800	0.3	0.1	0.2	0.47	5.0	69.4	21.2	9.4
Area between frame 2 and 3	8.73	8,625	2.3	0.7	1.5	1.18	27.5	58.7	23.9	18.8
Area between frame 3 and 4	2.85	6,300	2.2	0.6	1.6	1.92	44.5	69.1	26.4	4.5

1

2

Once hydrological data were controlled against land-use data and corrected for inconsistencies, the length of watercourses and the number of waterdrops were calculated for each cell. The density of watercourses increases in the areas characterized by urban–rural co-presence. At the island scale, the average density is 0.96 km/sqkm. This value rises to 1.55 in the 850 m co-presence frame and to 1.93 in the 200 m frame. *Desakota* presents an equivalent value, whereas urban areas record a lower density, stopping at 1.13. The inter-frame assessment makes the contrast more explicit: the territory outside the 850 m co-presence frame contains only 0.47 km/km² of watercourses, the space between the 850 and 200 m frames has 1.18, and the non-*desakota* portion of the 200 m frame has the same density as the *desakota*.

12

13

This suggests that dense watercourse networks are associated with the finer-grained urban–rural landscapes. Anyhow, the waterdrop assessment provides a differentiation between *desakota* and non-*desakota*, possibly reacting to the parcel structure, public land, and road accessibility. At island scale, the average density is 1.2 waterdrops per square kilometre. Then, the value becomes 2.3 in the 850 m, 2.4 in the 200 m frame, and reach the highest value, at 2.8, in the *desakota*, i.e., twice the island-wide average and approximately 56% more than in the urban areas. The composition of these occurrences is also significant. Within *desakota*, 0.6 waterdrops per square kilometre belong to the 2–5 m height class and 2.2 to the one of 5 m or more. In the urban areas, such a relationship is reversed. Thus, the possible advantage of *desakota* is not only quantitative, but also qualitative.

23

24

The distinction becomes even more clear if *desakota* is compared with the non-*desakota* portion of the 200 m frame. Both contain approximately the same amount of watercourses, yet lower-density mixed areas contain only 2.2 waterdrops per square kilometre, compared to the 2.8 of *desakota*. The density of 2–5 m drops is identical, whereas drops exceeding 5 m increase from 1.6 to 2.2 within the *desakota*.

28

29

Once completed the hydrologic data assessment, the electricity-network data were analyzed as a raster data set in which the network is represented as a band corresponding to an approximate 50 m pertinence zone from the grid. Within each

31

1 cell, the area covered by this zone was assessed alongside the associated carrying-
2 capacity classes. The results follows a gradient. At island scale, an average of 20.6%
3 of each cell lies within the 50 m network-proximity zone. This rises to 39.4% in the
4 850 m co-presence frame, 50.3% in the 200 m frame, and 62.0% in *desakota*. Urban
5 areas then peak at 69.0%. That is, grid proximity increases with settlement density
6 and the intensity of urban–rural integration, although *desakota* only approaches the
7 coverage found in the urban areas.

8 A more substantial differentiation appears in the distribution of available
9 carrying capacity. At island scale, 54.7% of the grid-covered area falls within the 0–
10 2 MW class, 31.1% within the 2–5 MW class, and 14.2% within the 5–10 MW class.
11 The 850 m frame presents a similar distribution. In the 200 m frame, the share of
12 the intermediate class rises to 37.0%, although half remains within the 0–2 MW
13 class. *Desakota* presents a markedly different structure. Only 22.2% of grid-covered
14 area belongs to the 0–2 MW class, while 52.4% lies within the 2–5 MW class and
15 25.4% within the 5–10 MW class. The urban core is more strongly weighted toward
16 the highest-capacity class, with 66.4% of the grid in the 5–10 MW category. The
17 non-*desakota* portion of the 200 m frame presents the opposite configuration.
18 Although the watercourse density is that of *desakota* and waterdrop density remains
19 high, 69.1% of its grid-covered area falls within the 0–2 MW class. So, fine-grained
20 urban–rural co-presence and hydrological availability alone do not correspond to
21 equivalent infrastructure opportunities.

22 Taken together, these results reveal a non-linear relationship between
23 urbanization and spatial conditions for distributed low-head hydropower. Rural or
24 peripheral areas have limited grid coverage and comparatively sparse water
25 networks. Lower-density mixed areas may contain watercourses and level changes
26 but remain constrained by low carrying capacity of the grid. Urban areas have a
27 strong grid coverage and capacity, yet contain fewer watercourses and drops.
28 *Desakota* does not set record values for every individual indicator; however, it is the
29 urban form where relevant conditions overlap most consistently. The analysis
30 therefore identifies *desakota* as a distinctive opportunity field for distributed low-
31 head hydropower. Although these findings are not engineering-specific and thus
32 give strong limitations to the study, nevertheless, it remains that the combination of
33 conditions provide an evidence basis for suggesting that the *desakota* warrants more
34 detailed technical assessment.

35 36 37 **Discussion**

38 39 *Desakota as a conjunction of hydrological and electricity infrastructure.*

40
41 The findings reveal two partly opposing territorial gradients. Hydrological
42 opportunity increases markedly from peripheral areas toward finer-grained urban–
43 rural formations but declines within the urban areas. Electricity-grid coverage and
44 carrying capacity, by contrast, increase with settlement density and infrastructural
45 integration. *Desakota* occupies the area in which these two gradients most strongly
46 overlap.

1 This finding also validates the combined use of land-use co-presence and
 2 population density in the analytic model. Co-presence identifies the morphological
 3 continuity of the mixed landscape and the density criterion distinguishes the portion
 4 of that landscape in which hydraulic structures, grid infrastructure, settlement, and
 5 economic activity have become more intensively articulated. Although the adopted
 6 density thresholds clearly remain an analytical constructs, the infrastructural
 7 differences between the frames of analysis suggest that the adopted classification
 8 identifies much more than a mere demographic distinction.

9
 10 *Desakota as an infrastructural formation*

11
 12 The findings extend the interpretation of *desakota* beyond its conventional
 13 treatment as a pattern of mixed land use, economic transition, or metropolitan
 14 expansion. *Desakota* may also be understood as an infrastructural formation
 15 produced through the historical superimposition of irrigation systems, settlements,
 16 industrial activities, roads, and electricity networks. In this sense, it could be
 17 depicted as a “palimpsest” where a number of infrastructure have independently
 18 developed but they have finally become spatially interdependent.

19 This interpretation contributes to the debate between different readings of
 20 *desakota*. The analysis cannot determine whether *desakota* will remain stable over
 21 time. However, it shows that this cannot be fully described as an incomplete urban
 22 condition. This supports approaches that treat *desakota* as a distinct formation
 23 requiring *ad-hoc* planning and, thus, possibly, implying planned developmental
 24 stabilization.

25 The idea of an “energy potential landscape” can be here used to further
 26 articulate the point. The findings do not imply that *desakota* already functions as a
 27 coherent renewable-energy system. Rather, they refer to the spatial co-presence of
 28 potential generation conditions, electricity infrastructure, and users. Here, energy
 29 potential is not a property of a watercourse or turbine site, but a characteristic of the
 30 territorial configuration within which generation, connection, operation, and
 31 consumption would occur. This perspective complements the mostly technical and
 32 techno-economic orientation of small-hydropower research. Studies of irrigation
 33 canals, water-distribution systems, and existing hydraulic structures have
 34 demonstrated that water infrastructure may contain latent opportunities. The present
 35 study adds that, when it comes to distributed generation, these depends on the form
 36 of urbanization surrounding them, too.

37
 38 *Desakota as a planning and governance challenge*

39
 40 The findings therefore suggest that regional planning should incorporate
 41 territorial morphology as intermediate planning focus in between the scope of
 42 renewable-energy policies and site-specific engineering. The large number of
 43 possible distributed energy generation occurrences however raises a question of
 44 development scale, as the significance of *desakota* cannot lie in a small number of
 45 large plants but a very large portfolios of small installations. This allows
 46 standardized technical assessment, coordinated procurement, shared maintenance,

1 and aggregation of electricity production. Conversely, it can also generate high
2 transaction costs, fragmented responsibilities, cumulative ecological effects, and so
3 on. Thus, the territorial advantage identified cannot be detached by a study of the
4 institutional model capable of coordinating a very large number of distributed
5 development sites.

6 The findings finally reinforce the need to treat infrastructure governance as a
7 central dimension of *desakota* planning. However, the integration of several
8 administrative and operational domains may contrast with the institutional
9 flexibility usually associated with the *desakota*. For example, the presence of
10 candidate waterdrop on public land and near a road may help, but does not establish
11 any development right. These, together with the likes of irrigation schedules, public-
12 works regulations, environmental permits, grid-connection procedures, ownership
13 of hydraulic structures, and long-term maintenance duties would still need to be
14 resolved. That is, institutional and contractual dimensions of development may
15 finally prove more restrictive than the hydraulic or electrical conditions.

16 17 *Limitations.*

18
19 The research presented in this paper is subject to several limitations. First, data
20 sets are relatively old and produced in different years between 2016 and 2020.
21 Although they represent a concentrated period, changes in land use, population,
22 water infrastructure, and grid have obviously occurred since their production.

23 Second, the use of a 5×5 km grid allows multiple data sets to be compared at
24 the regional scale but generalizes local conditions. Results are thus affected by the
25 areal unit problem, especially where watercourses or settlement patterns cross cell
26 boundaries. The 70% co-presence threshold and the population-density thresholds
27 of 1,000 and 5,000 inhabitants/km² are analytical choices, regardless they are
28 supported by the existing scholarship.

29 Third, the waterdrop model does not calculate discharge, flow duration,
30 seasonal variability, net hydraulic head, conveyance losses, sediment load, flood
31 conditions, or actual energy yield. Nor does it determine whether a mapped
32 occurrence corresponds to a natural feature, an existing hydraulic structure, or an
33 artefact of the underlying spatial data.

34 Fourth, public ownership and road proximity are only preliminary indicators of
35 accessibility to the waterdrops. They do not resolve issues concerning water rights,
36 operational control, ecological restrictions, construction access, land-use
37 compatibility, and so on. Similarly, watercourse density does not distinguish
38 between channels that could potentially accommodate energy recovery and those
39 whose ecological, flood-control, or irrigation functions would preclude intervention.

40 Fifth, the electricity-network assessment measures proximity to mapped
41 infrastructure and the carrying-capacity categories available in the public utility
42 data. It does not represent a formal grid-connection study. Actual feasibility would
43 depend on voltage level, feeder configuration, substation conditions, protection
44 requirements, reverse-power constraints, connection queues, planned network
45 upgrades, and the location and cost of the required point of connection.

1 Sixth, population is used as a proxy for the presence of potential end users, but
2 the study does not measure electricity consumption or demand profiles. Industrial,
3 residential, agricultural, and public-service loads may differ substantially across the
4 *desakota*.

5 Finally, the analysis identifies spatial association rather than any causation and
6 is limited to the Taipei–Kaohsiung Mega Urban Region. Comparative studies of
7 other Asian Mega Urban Regions are required to determine whether the observed
8 conjunction of hydraulic infrastructure, grid capacity, and dispersed settlement is a
9 wider characteristic of *desakota* or specific to Taiwan and the localized development
10 pathway.

11 12 13 **Conclusions**

14
15 Regardless of their extent, the study’s limitations do not undermine the validity
16 of the findings or their implications. The study behind this paper asked whether
17 *desakota* provides more favourable spatial preconditions for distributed low-head
18 hydropower than urban cores and lower-density mixed territories within the Taipei–
19 Kaohsiung Mega Urban Region. The results support this proposition in a
20 comparative-territorial sense. The principal contribution is not the identification of
21 *desakota* as the territory with the maximum value for any single variable. It is the
22 demonstration that hydrological opportunity and electricity-network capacity
23 follow different spatial gradients and intersect most strongly within dense urban–
24 rural formation. This non-linear relationship distinguishes *desakota* from both the
25 urban areas and the agricultural or low-density mixed landscape.

26 Conceptually, the findings suggest extending *desakota* research from questions
27 of classification, transition, and land-use mixture toward the analysis of
28 infrastructural capacity. *Desakota* emerges as an “energy potential landscape” in the
29 specific sense of a territory where inherited hydraulic systems, electricity
30 infrastructure, settlement, and potential users are interwoven. This does not establish
31 that *desakota* is inherently sustainable or that micro-hydropower development
32 would be environmentally or economically appropriate. It indicates that the
33 morphology of *desakota* creates a distinctive “field” within which distributed-
34 energy opportunities warrant systematic investigation.

35 At least in the case study, *desakota* should therefore not be regarded solely as
36 a transitional formation awaiting consolidation into urban space. Nor should its
37 infrastructural density be treated uncritically as an energy resource. The study
38 suggests that it may be better understood as a distinctive socio-ecological and
39 infrastructural assemblage whose inherited systems may support selective forms of
40 energy transition under appropriate technical, environmental, and institutional
41 conditions.

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