

An analysis of distribution and changes of wetland types in Taiwan

臺灣濕地類型分布變遷分析

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Abstract

Taiwan has implemented wetland conservation laws for nine years to promote ecological preservation. However, fundamental and crucial issues regarding the types, distribution, and spatiotemporal changes of wetlands still need clarification. This study surveyed previous research findings from the Land Use Investigation data produced by the National Land Surveying and Mapping Center, Ministry of the Interior, for the years 2006-2008 and 2010-2011. These results were matched with the wetland classification types defined by the Ramsar Convention according to their respective definitions, and relevant reference layers and images were used primarily to extract wetland distribution maps for the two specific periods covered by the land use surveys. A geographic information system (GIS) software was employed to extract and produce wetland types

and distribution layers, allowing an understanding of the changes in wetland types. The analysis revealed changes in the area of wetland types in the two periods. The total wetland area increased by approximately 12,000 hectares, with coastal/marine wetland area increasing by nearly 9,000 hectares and inland wetland area increasing by almost 20,000 hectares. However, the anthropogenic wetland area decreased by over 16,000 hectares. Key factors influencing these changes include the westward shift of the 6-meter depth contour, reduction in southwestern coastal sandbars, mudflats, and lagoons, increased mapping quantity due to improved image resolution, changes in land management practices, and alterations in land use classification system categories.

Keywords: wetland, change, Ramsar Convention, geographic information system (GIS)

摘要

臺灣為推動濕地生態保育，濕地保育法業已施行 9 年，惟對於臺灣濕地類型、分布及時空變遷等基礎且重要問題未明瞭。本研究使用先前之研究以內政部國土測繪中心分別於 2006~2008 年與 2010~2011 年產製之國土利用現況調查成果圖層，與拉姆薩公約之濕地分類類型依其定義進行配對，配合相關參考圖層與影像，萃取濕地與產製之 2 期濕地分布圖層，以地理資訊系統軟體將 2 期圖層分別篩選各類型濕地，進行套疊與產製變遷圖層，以瞭解 2 期各類型濕地之變遷情況。2 期國土利用現況調查成果資料分析濕地類型面積變化，總濕地面積增加約 1.2 萬 ha，其中海洋／海岸濕地面積增加近 9 千 ha，內陸濕地面積增加近 2 萬 ha，人為濕地面積減少 1 萬 6 千多 ha，主要影響變化因素包括 6m 等水深線西移，西南沿海沙洲、泥灘及潟湖之縮減，影像解析度提高編繪數量增加，土地經營型態改變，以及土地利用分類系統類別變動等。

關鍵詞：濕地、變遷、拉姆薩公約、地理資訊系統

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Introduction

Wetlands refer to lands that are inundated or saturated with water, either permanently or intermittently, and encompass a wide range of definitions and classification methods. Various countries have different definitions of wetlands. According to the Ramsar Convention (1971), an international treaty on wetlands, wetlands are defined as “areas of marsh, fen, peatland, or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters.” This definition is the most widely accepted internationally. The convention categorizes wetland

types into three major groups: marine/coastal wetlands, inland wetlands, and human-made wetlands (Ramsar Convention Secretariat 2013).

Wetlands are among the most productive ecosystems on Earth, providing unique and abundant habitats for a diverse range of flora and fauna. They nurture rich biodiversity and biomass, serving as crucial repositories for plant genetic material (Ramsar Convention Secretariat 2006). The global coverage of inland and coastal wetlands exceeds 12.1 million square kilometers, with 54% permanently submerged and 46% experiencing seasonal flooding (Gardner *et al.* 2018). The largest wetland areas are found in Asia, accounting for 32% of the

global total, followed by those in North America at 27% (Davidson *et al.* 2018). Over the past few centuries, wetland areas have significantly decreased due to the dual impact of climate change and human activities, severely damaging wetland ecosystems (Morris *et al.* 2002). According to the Millennium Ecosystem Assessment (2005), wetlands are disappearing more rapidly than other ecosystems, posing a threat to species relying on wetlands for survival, such as fish, waterfowls, and sea turtles, with a quarter of them facing extinction, particularly in tropical regions (Gardner *et al.* 2018).

Recording information on the distribution and status of wetlands is crucial. With advancements in the spatial resolution and availability of Earth observation data, it can be widely applied in wetland monitoring and mapping (Fitoka and Keramitsoglou 2008). Although conflicts related to wetland use persist in many parts of the

world, societal attitudes toward wetlands are shifting. People are realizing the valuable regulatory, provisioning, and cultural services wetlands provide to society (Davidson *et al.* 2019; Cheng *et al.* 2020). Wetlands offer environmental benefits, including water purification, flood control, shoreline stabilization, groundwater recharge, river flow regulation, and ecological enhancement (Samsunlu 2002; USEPA 2002). They also provide ecological functions and services such as water supply, water quality improvement, recreation, and habitat for biodiversity. On average, the annual value of wetlands per hectare exceeds \$2,800 (Brander *et al.* 2006).

In Taiwan, efforts to promote the conservation of wetland ecosystems began with the announcement of 75 nationally important wetlands in 2007. The "National Important Wetland Conservation Plan (2011–2016)" was implemented as a wetland conservation and restoration blueprint. A Wetland

Conservation Act was promulgated on July 3, 2013, and on World Wetlands Day (February 2, 2015), it came into effect along with nine subsidiary laws. In total, 83 nationally important wetlands were designated, covering an area of approximately 47,600 hectares. This includes 41 locally important wetlands that underwent reassessment (Urban and Rural Development Branch, Construction and Planning Agency, Ministry of the Interior 2019). In 2017, the National Wetland Conservation Guidelines were submitted to the Executive Yuan for review, outlining the overall planning and strategies for promoting wetland conservation. As of the end of 2022, a total of 61 nationally important wetlands have been designated, comprising two international-level, 40 national-level, 16 local-level, and three provisional wetlands, covering an area of approximately 43,368 hectares (Urban and Rural Development Branch, National Land Management Agency, Ministry of

the Interior 2023).

However, existing research projects have primarily focused on aspects such as wetland investigation and maintenance, ecological restoration, environmental education, operational management, conservation promotion, and the study of supporting measures related to wetland conservation law. Nevertheless, fundamental and crucial questions related to the types, distribution, and spatiotemporal changes of wetlands in Taiwan remain unclear. This study utilizes the wetland distribution layers results produced by Chen (2017) and Chen *et al.* (in press), based on the Land Use Investigation data from the National Land Surveying and Mapping Center, Ministry of the Interior, for the years 2006–2008 and 2020–2021. Matching these results with the wetland classification types defined by the Ramsar Convention and using relevant reference layers and images, the study extracted and produced two

wetland distribution layers. A geographic information system (GIS) software was then employed to extract and overlay the wetland types in the two periods, creating a change layer to understand the changes in different types of wetlands over the two periods. This research addresses the issues mentioned previously and provides wetland management units with valuable references and applications for decision-making, planning, and operational management.

Materials and methods

1. Study area

The definition of wetlands in Article 4 of the Wetland Conservation Act in Taiwan is as follows: "refers to natural or artificial areas, permanent or temporary, stationary or flowing, with fresh, salt, or brackish water, including marshes, lagoons, peatlands, intertidal zones, and water areas, including areas of marine water the depth of which at low tide does not exceed six meters."

The content is nearly identical to the definition of wetlands in the international Ramsar Convention. Due to the lack of comprehensive water depth data for the surrounding sea areas of outlying islands, this study focuses only on Taiwan Island and its surrounding sea areas within the 6-meter depth contour line.

2. Material

The primary data used are from Chen (2017) and Chen *et al.* (in press), based on the Land Use Investigation data produced by the National Land Surveying and Mapping Center, Ministry of the Interior, in the years 2006–2008 and 2020–2021, respectively. These data were matched with the 42 wetland classification types defined by the Ramsar Convention (Appendix 1). With the assistance of relevant reference layers and images, land-use categories that meet the definition of wetlands were extracted. A GIS software (ESRI ArcGIS Pro) was then used to generate two wetland distribution layers for the two

periods.

3. Wetland change processing

Using a GIS software, the wetland distribution layers for the two periods are individually extracted for each wetland type. Overlay processing is then performed, with the earlier period layer in light blue placed at the bottom and the later period layer in red placed on top. The overlapping areas appear in deep blue. The resulting overlay layer displays the change in various types of wetlands between the two periods, and the area change is calculated.

Results and discussion

The data from the National Land Surveying and Mapping Center, Ministry of the Interior, for 2006-2008 and 2020-2021 were matched with the wetland classification types defined by the Ramsar Convention, resulting in the extraction of wetland types in the two periods. The Land Use Investigation data in the years 2006-2008 covered

27 out of 103 land-use categories, including rice fields, aquaculture, rivers, dredging rivers, canals, drainage ditches, reservoirs, lakes, other reservoirs, artificial lakes, canal sandbar beach places, sea, salt pans, wetlands, beaches, natural broadleaf tree pure crops, artificial broadleaf tree pure crops, elementary schools, middle schools, colleges and universities, other cultural facilities, park green squares, military-use lands, grasslands, reef rocks, disaster places, and unused lands, among others, all of which included wetlands. In the Land Use Investigation data from 2020-2021, out of the 93 land-use categories, 24 were selected, including paddy fields, aquaculture, rivers, dredging rivers, canals, drainage ditches, reservoirs, lakes, other reservoirs, canal sandbar beach places, sea, wetlands, beaches, broadleaf forests, government agencies, elementary schools, middle schools, colleges and universities, other cultural facilities, park green squares, salt

industry and related facilities, grasslands, reef rocks, and unused lands, among others (Table 1).

During 2006-2008 and 2020-2021, there were changes in the land use classification system categories based on the Land Use Investigation data. Specifically, there were modifications in the classification of certain land types:

1. Rice Fields and Other Aquatic Crops:

- In the earlier period, these were classified as separate categories.
- In the later period, they were merged into a single category called "Paddy Fields."

2. Lakes and Artificial Lakes:

- Initially, they were classified as separate categories.
- Subsequently, they were combined into a unified category called "Lakes."

3. Salt Fields and Related Facilities:

- Initially, these were categorized separately.

- Later on, they were merged into a category called "Salt Industry and Related Facilities."

4. Natural Broadleaf Tree Pure Crop and Artificial Broadleaf Tree Pure Crop:

- In the earlier period, these were classified as distinct categories.
- In the later period, they were combined into a single category known as "Broadleaf Forests."

5. Military Lands and Disaster Places:

- These categories were removed in the later classification system based on actual usage conditions.

The data from the Land Use Investigation conducted in 2006-2008 and 2020-2021, based on wetland classification definitions, are organized in Table 2. The distribution of various wetland types is illustrated in Fig.1 and 2. In the earlier period, there were 26 categories corresponding to the Ramsar wetland types, with a total area of nearly 450,000 hectares. The marine/coastal

wetland area was 103,442 hectares, accounting for 23.0% of the total wetland area. The largest category was the coastal shallow waters, covering 60,699 hectares (13.5%), followed by coastal saline lagoons with 14,370 hectares and intertidal mud or sand with 14,356 hectares. Inland wetlands covered an area of 79,727 hectares, constituting 17.7%, with rivers distributed throughout Taiwan being the largest type at 79,347 hectares (17.6%), followed by permanent freshwater lakes with an area of 279 hectares. Human-made wetlands had an area of 266,815 hectares, representing 59.3%, where rice fields in the plains of Taiwan were the largest category at 177,570 hectares (39.5%), followed by aquaculture ponds with 53,265 hectares (11.8%).

In the later period, there were 24 wetland types with a total area of nearly 462,000 hectares. The marine/coastal wetland area was 112,420 hectares, accounting for 24.3% of the total wetland

area. The largest category was coastal shallow waters, covering 74,717 hectares (16.2%). Inland wetlands covered an area of 99,458 hectares, constituting 21.5%, with rivers being the largest type at 99,064 hectares (21.4%). Among human-made wetlands, the largest category covered an area of 250,202 hectares, representing 54.2%, with paddy fields being the most extensive subcategory at 168,434 hectares (36.5%).

The changes in the areas of various wetland types based on the results of the second phase of the land use surveys (2006-2008 and 2020-2021) are described as follows:

The marine/coastal wetland area has increased by nearly 9,000 hectares. The shallow marine waters have significantly expanded by approximately 14,000 hectares. The main areas of increase include the westward shift of the 6-meter water depth line and the reduction of sandbars, mudflats, and lagoons along the coasts of Changhua, Yunlin, and

Chiayi (Fig. 3). The phenomenon is closely related to the retreat and change in the outer sandbars. The crest heights of many sandbars have significantly decreased, and the sandy beaches are rapidly receding inland. In some segments, they are approaching the average sea level, leading to the submersion and death of windbreak forests due to seawater encroachment (Su and Peng 2010). The offshore sandbar is gradually approaching inland, and coupled with the accumulation of sediment over the years, it has led to the gradual disappearance of the lagoon water area (Chen 2013). The decrease in coral reefs is primarily observed in certain regions of Hengchun, Pingtung, transforming into beaches, collapsed areas, and grasslands in the later period (Fig. 4). Reduction in rocky marine shores is prominent in specific Yilan and Hualien coastal regions, changing into grasslands and collapsed areas (Fig. 5). The decrease in sand bars or sand dunes,

approximately 2,000 hectares, is mainly attributed to the transformation into sea areas, grasslands, and embankments along the coasts of Taoyuan, Yunlin, and Chiayi (Fig. 6). The estuarine waters have significantly increased by about 3,500 hectares, mainly located along the coasts of Changhua and Chiayi (Fig. 7). The intertidal mud or sand has noticeably decreased by nearly 6,000 hectares, primarily transforming into sea areas, grasslands, unused lands, embankments, and broad-leaved forests along the coasts of Changhua and Taichung (Fig. 8). The Intertidal marshes has more noticeable increases in regions such as Dongshi Township in Chiayi and Qieding in Kaohsiung (Fig. 9). A 600-hectare increase is observed in the intertidal forested wetlands, with more noticeable growth in the coastal areas of Tainan, Chiayi, Changhua, and Taoyuan (Fig. 10). The coastal saline lagoon has decreased by approximately 1,000 hectares, with more noticeable reductions

in some regions of Chiayi's coastal saline lagoon being reclassified as sea areas, unused land, and embankments (Fig. 11).

The inland wetland area has increased by nearly 20,000 hectares, primarily due to a significant increase in the area of rivers by almost 20,000 hectares, notably in mountainous regions (Fig. 12). This is partly attributed to the improved resolution of later-stage images, leading to increased recognition and a substantial increase in the quantity of mapping. A slight reduction in the area of permanent freshwater lakes is mainly due to bridge cutting (Fig. 13). Previously categorized as saline marshes/pools, they have been reclassified as reservoirs, unused lands, and broad-leaved forests (Fig. 14). Freshwater marshes and ponds have more noticeably increased in mountainous regions (Fig. 15). The reduction in areas with freshwater springs is observed in regions such as Taoyuan and Yilan, which have been reclassified as general cultural

facilities (Fig. 16). Furthermore, there is a partial interchange between the categories of ditches and streams, and the land classification system used in the Land Use Investigation data does not specifically categorize wetlands. Consequently, classification personnel are not wetland specialists, leading to a limited understanding of wetland type definitions.

The area of human-made wetlands has significantly decreased by over 16,000 hectares, primarily attributed to a reduction in the area of aquaculture ponds by over 14,000 hectares. A noticeable decrease is observed in western coastal areas, transforming into unused land, reservoirs, agricultural production and processing facilities in the later stages (Fig. 17). The reduction in the area of aquaculture ponds is mainly attributed to the increase in production costs, which drives up pond-side prices. Factors contributing to this increase include rising costs of feed raw

materials, labor shortages, increased personnel costs, climate impacts, and the effects of the pandemic, all of which contribute to price fluctuations, as reported by the Ocean Affairs Council. While pond areas have increased by approximately 3,000 hectares, the more significant expansion is observed in regions such as Chiayi, Miaoli, Hualien, Taitung, and Nantou counties (Fig. 18). Paddy fields have decreased by around 9,000 hectares, with significant reductions in areas like Taoyuan, Tainan, and Chiayi, transitioning into dry fields, orchards, unused lands, agricultural production and processing facilities, and residential areas (Fig. 19). The areas of irrigation or drainage channels have increased by around 3,000 hectares, with noticeable increments in regions such as Tainan, Kaohsiung, and Nantou counties (Fig. 20). Salt pans have decreased by over 3,700 hectares, with significant reductions in areas along the coasts of Chiayi, Tainan, and Kaohsiung. Salt pans

have transformed into wetlands, ponds, and reservoir areas (Fig. 21). The water storage areas have increased by over 4,300 hectares, with more noticeable increments in Tainan and Chiayi coastal areas (Fig. 22). The reduced areas in excavations are reclassified as future forested areas, agricultural production and processing facilities, residential areas, and unused lands (Fig. 23). The wastewater treatment areas that have shown a more significant increase are in New Taipei and Pingtung (Fig. 24). The reduced areas in the canals are categorized as parks, green spaces, and road-related facilities (Fig. 25).

Conclusion

This study analyzes the changes in wetland areas using the second-phase Land Use Investigation data from the National Land Surveying and Mapping Center, Ministry of the Interior of Taiwan. The total wetland area increased by approximately 12,000 hectares. The

coastal/marine wetland area increased by nearly 9,000 hectares, the inland wetland area increased by almost 20,000 hectares, and human-made wetland area decreased by over 16,000 hectares. Wetland types that experienced changes exceeding 10,000 hectares include an increase in coastal shallow water area by about 14,000 hectares, an increase in stream area by nearly 20,000 hectares, and a decrease in aquaculture pond area by over 14,000 hectares. The main influencing factors for these changes include the westward shift of the 6-meter depth contour line, reduction in southwest coastal sandbars, mudflats, and lagoons, increased image resolution leading to higher mapping accuracy, changes in land management practices, and alterations in land use classification system categories.

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Table 1 The land use types cover wetlands in Taiwan.

表 1 國土利用現況調查成果資料涵蓋濕地之土地利用類型

2006-2008 Land Use		2020-2021 Land Use	
L_C3	Lcode_C3	L_C3	Lcode_C3
Rice field	010101	Paddy field	010101
Aquaculture	010200	Aquaculture	010200
River	040101	River	040101
Dredging River	040102	Dredging River	040102
Canal	040103	Canal	040103
Drainage ditch	040200	Drainage ditch	040104
Reservoir	040301	Reservoir	040201
Lake	040302	Lake	040202
Other reservoirs	040303	Reservoirs	040203
Artificial lake	040304		
Canal sandbar beach place	040400	Canal sandbar beach place	040300
Sea	040700	Sea	040600
Salt pans	080301	Salt industry and related facility	080300
Wetland	090200	Wetland	090100
Beach	090401	Beach	090301
Natural broadleaf tree pure crop	020102	Broadleaf forest	020200
Artificial broadleaf tree pure crop	020202	Governmental agency	060100
Elementary school	060202	Elementary school	060202
Middle school	060203	Middle school	060203
Universities, colleges and institutes	060204	Universities, colleges and institutes	060204
Other cultural facilities	070103	Other cultural facilities	070103
Park green square	070201	Park green square	070200
Military-use land	090100		
Grassland	090300	Grassland	090200
Reef rock	090403	Reef rock	090303
Disaster place	090600		
Unused Land	090801	Unused Land	090501

Table 2 Wetland types, area, and area changes between 2006-2008 and 2020-2021 in Taiwan.

表 2 臺灣 2006~2008 年與 2020~2021 年濕地類型、面積及面積變化

Ramsar code	Wetland Types	2006-2008 Land Use		2020-2021 Land Use		Area changes	
		Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)
	Marine/Coastal wetlands	103,442	22.99	112,420	24.33	8,977	9
A	Shallow marine waters	60,699	13.49	74,717	16.17	14,019	23
C	Coral reefs	527	0.12	349	0.08	-178	-34
D	Rocky marine shores	703	0.16	548	0.12	-155	-22
E	Sand bars or sand dune	5,172	1.15	2,982	0.65	-2,191	-42
F	Estuarine waters	6,883	1.53	10,459	2.26	3,577	52
G	Intertidal mud or sand	14,356	3.19	8,527	1.85	-5,829	-41
H	Intertidal marshes	224	0.05	433	0.09	209	93
I	Intertidal forested wetlands	508	0.11	1,131	0.24	623	123
J	Coastal saline lagoons	14,370	3.19	13,273	2.87	-1,097	-8
	Inland wetlands	79,727	17.72	99,458	21.52	19,731	25
L, M, N	Rivers	79,347	17.63	99,064	21.44	19,718	25
O	Permanent freshwater lakes	279	0.06	255	0.06	-25	-9
Sp, Ss	Saline marshes/pools	2	0.00	-	0.00	-2	-100
Tp, Ts	Freshwater marshes/pools	76	0.02	122	0.03	46	60
Y	Freshwater springs	23	0.01	16	0.00	-6	-28
	Human-made wetlands	266,815	59.29	250,202	54.15	-16,613	-6
1	Aquaculture ponds	53,265	11.84	38,894	8.42	-14,371	-27
2	Ponds	7,454	1.66	10,551	2.28	3,097	42
3	Rice fields	177,570	39.46	168,434	36.45	-9,136	-5
3, 9	Irrigation or drainage channels	15,128	3.36	18,188	3.94	3,060	20
5	Salt pans	4,224	0.94	464	0.10	-3,761	-89
6	Water storage areas	9,042	2.01	13,418	2.90	4,376	48
7	Excavations	3	0.00	0	0.00	-3	-98
8	Wastewater treatment areas	59	0.01	205	0.04	146	250
9	Canals	70	0.02	48	0.01	-22	-32
Total		449,983	100.00	462,079	100.00	12,096	3

Appendix 1 Ramsar wetland classification system.

附表 1 拉姆薩公約濕地類型分類系統

Wetland	Code/Description
Marine/Coastal Wetlands	
A --	Permanent shallow marine waters in most cases less than six metres deep at low tide; includes sea bays and straits.
B --	Marine subtidal aquatic beds; includes kelp beds, sea-grass beds, tropical marine meadows.
C --	Coral reefs.
D --	Rocky marine shores; includes rocky offshore islands, sea cliffs.
E --	Sand, shingle or pebble shores; includes sand bars, spits and sandy islets; includes dune systems and humid dune slacks.
F --	Estuarine waters; permanent water of estuaries and estuarine systems of deltas.
G --	Intertidal mud, sand or salt flats.
H --	Intertidal marshes; includes salt marshes, salt meadows, saltings, raised salt marshes; includes tidal brackish and freshwater marshes.
I --	Intertidal forested wetlands; includes mangrove swamps, nipah swamps and tidal freshwater swamp forests.
J --	Coastal brackish/saline lagoons; brackish to saline lagoons with at least one relatively narrow connection to the sea.
K --	Coastal freshwater lagoons; includes freshwater delta lagoons.
Zk(a) --	Karst and other subterranean hydrological systems, marine/coastal
Inland Wetlands	
L --	Permanent inland deltas.
M --	Permanent rivers/streams/creeks; includes waterfalls.
N --	Seasonal/intermittent/irregular rivers/streams/creeks.
O --	Permanent freshwater lakes (over 8 ha); includes large oxbow lakes.
P --	Seasonal/intermittent freshwater lakes (over 8 ha); includes floodplain lakes.
Q --	Permanent saline/brackish/alkaline lakes.
R --	Seasonal/intermittent saline/brackish/alkaline lakes and flats.
Sp --	Permanent saline/brackish/alkaline marshes/pools.
Ss --	Seasonal/intermittent saline/brackish/alkaline marshes/pools.
Tp --	Permanent freshwater marshes/pools; ponds (below 8 ha), marshes and swamps on inorganic soils; with emergent vegetation water-logged for at least most of the growing season.
Ts --	Seasonal/intermittent freshwater marshes/pools on inorganic soils; includes sloughs, potholes, seasonally flooded meadows, sedge marshes.
U --	Non-forested peatlands; includes shrub or open bogs, swamps, fens.
Va --	Alpine wetlands; includes alpine meadows, temporary waters from snowmelt.
Vt --	Tundra wetlands; includes tundra pools, temporary waters from snowmelt.
W --	Shrub-dominated wetlands; shrub swamps, shrub-dominated freshwater marshes, shrub carr, alder thicket on inorganic soils.
Xf --	Freshwater, tree-dominated wetlands; includes freshwater swamp forests, seasonally flooded forests, wooded swamps on inorganic soils.

Xp -- Forested peatlands; peatswamp forests.

Y -- Freshwater springs; oases.

Zg -- Geothermal wetlands

Zk(b) – Karst and other subterranean hydrological systems, inland

Human-made wetlands

1 -- Aquaculture (e.g., fish/shrimp) ponds

2 -- Ponds; includes farm ponds, stock ponds, small tanks; (generally below 8 ha).

3 -- Irrigated land; includes irrigation channels and rice fields.

4 -- Seasonally flooded agricultural land (including intensively managed or grazed wet meadow or pasture).

5 -- Salt exploitation sites; salt pans, salines, etc.

6 -- Water storage areas; reservoirs/barrages/dams/impoundments (generally over 8 ha).

7 -- Excavations; gravel/brick/clay pits; borrow pits, mining pools.

8 -- Wastewater treatment areas; sewage farms, settling ponds, oxidation basins, etc.

9 -- Canals and drainage channels, ditches.

Zk(c) – Karst and other subterranean hydrological systems, human-made

Data Source: <https://www.ramsar.org/>

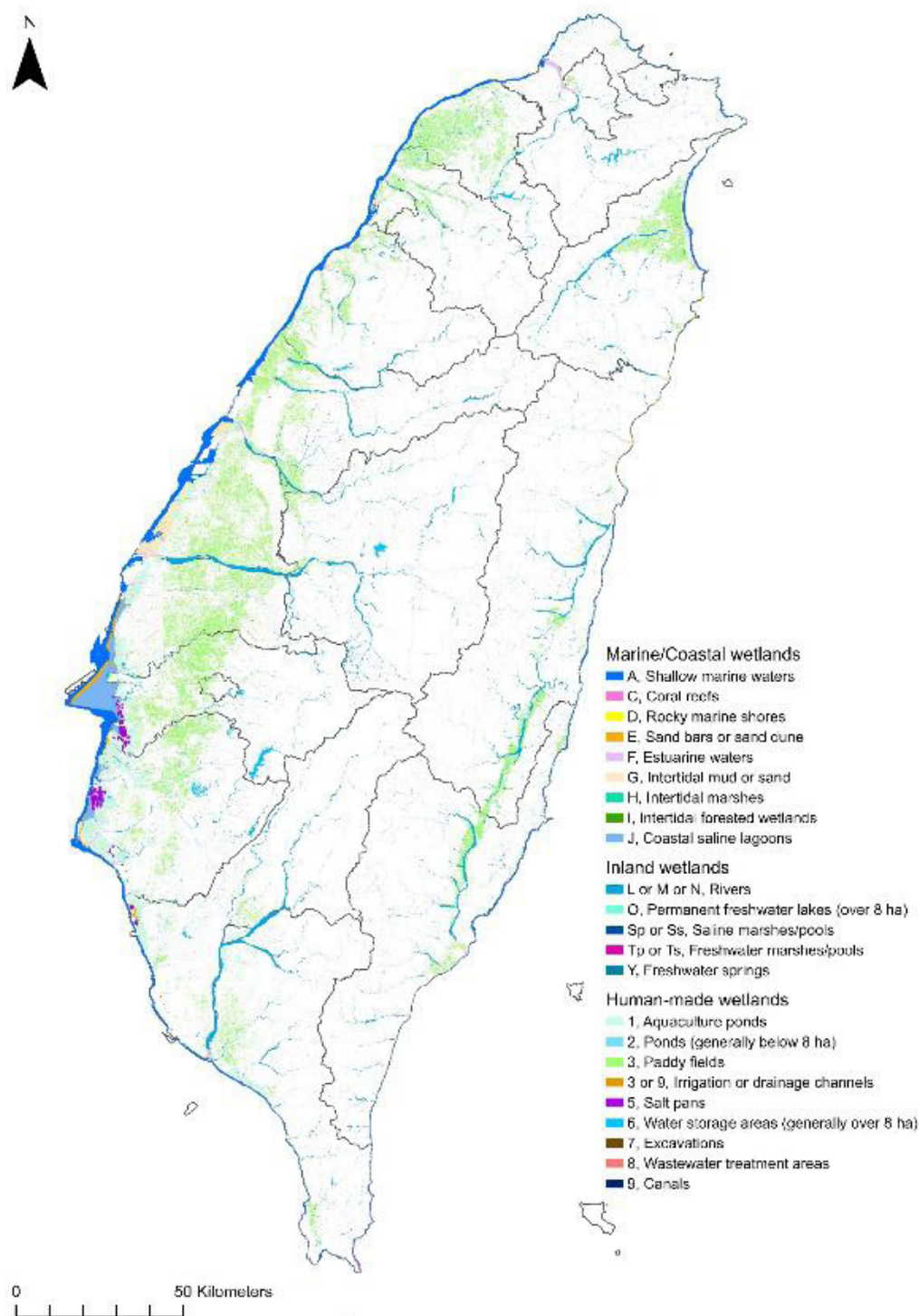


Fig. 1 Map showing 2006-2008 wetland distribution in Taiwan. (The English codes and numbers correspond to the code of the Ramsar wetland classification system.)

圖 1 臺灣 2006~2008 年濕地分布圖。

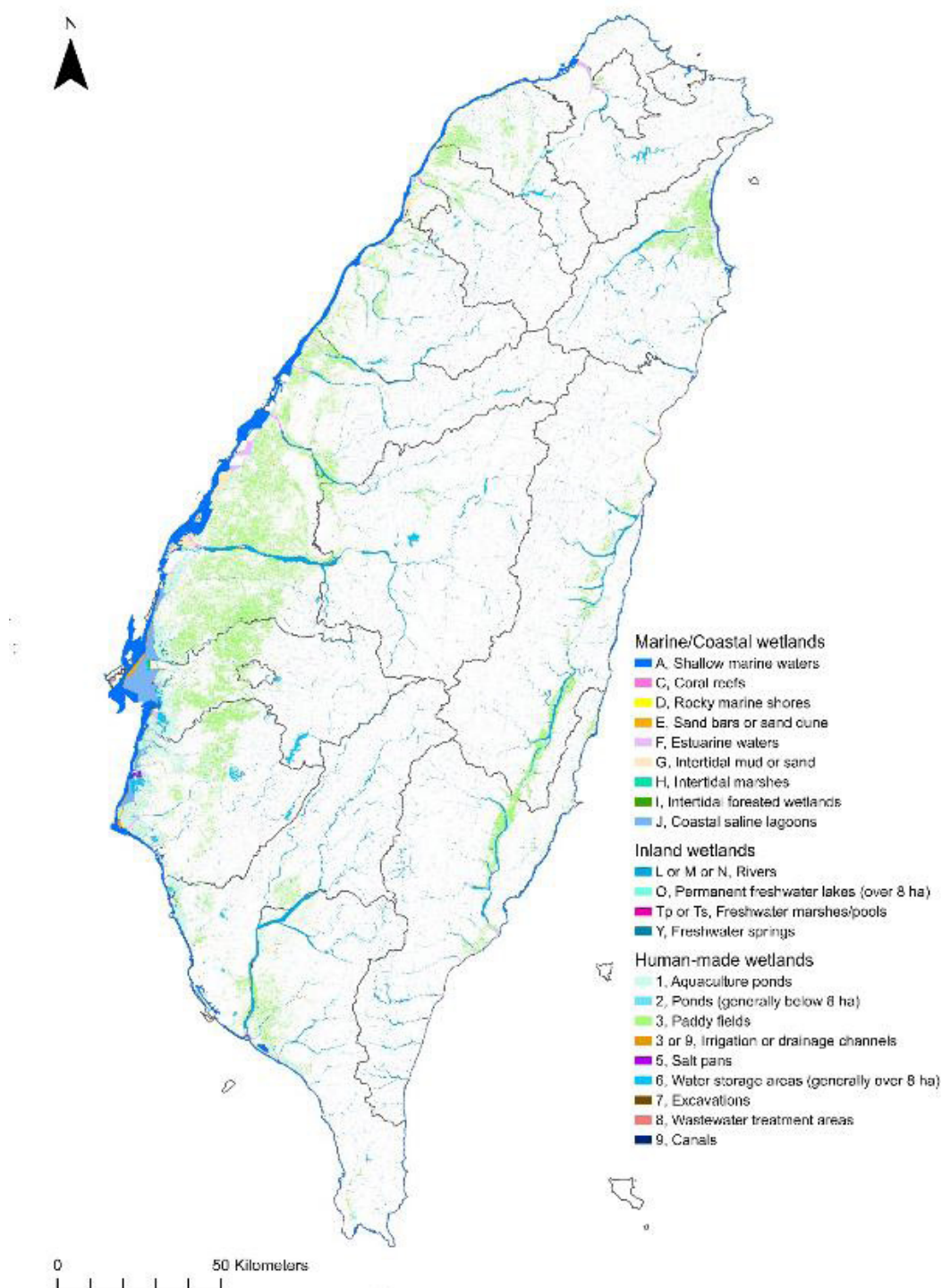


Fig. 2 Map showing 2020-2021 wetland distribution in Taiwan. (The English codes and numbers correspond to the code of the Ramsar wetland classification system.)

圖 2 臺灣 2020~2021 年濕地分布圖。

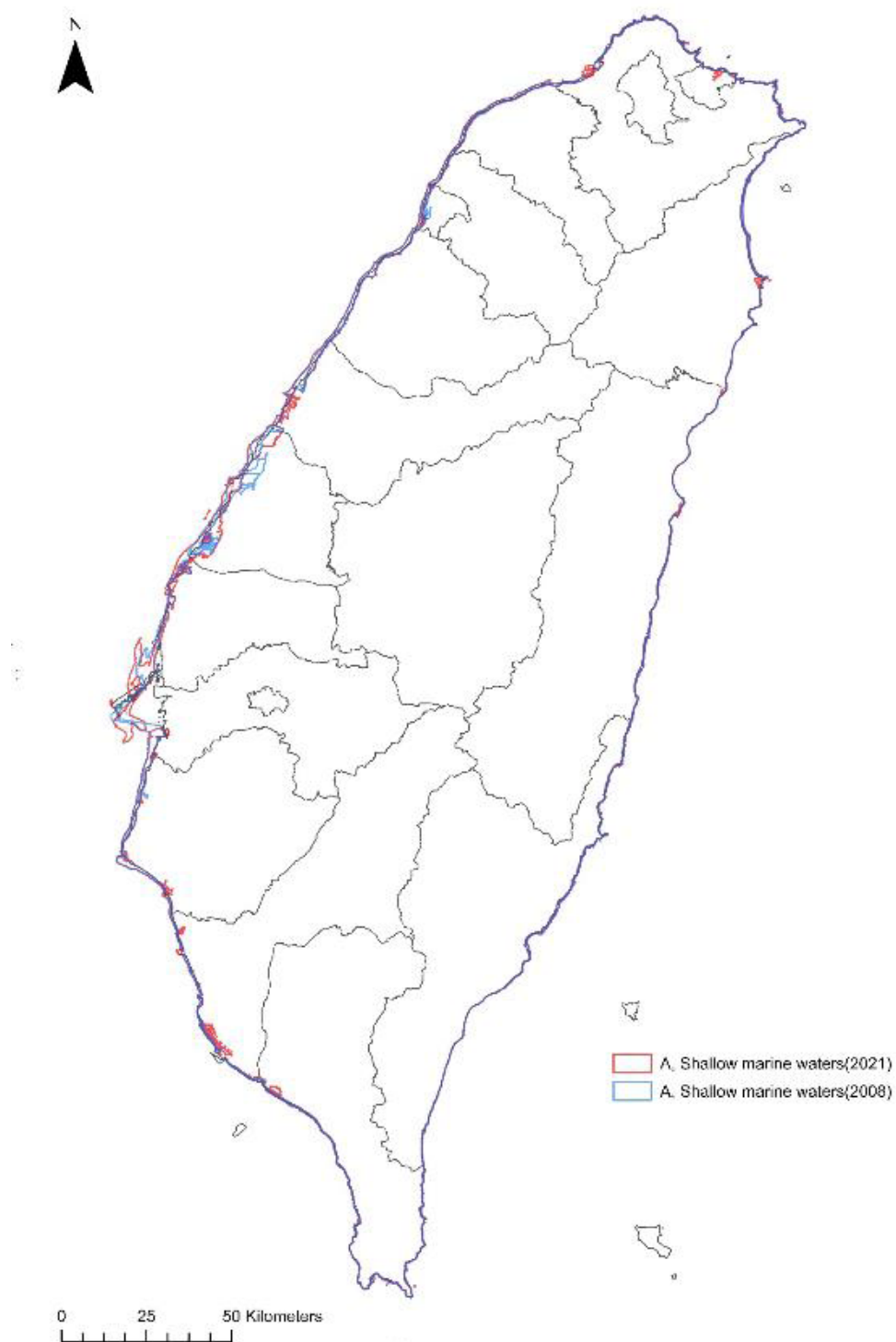


Fig. 3 Map showing shallow marine waters distribution and overlap between 2008 and 2021 in Taiwan.
圖 3 臺灣 2008 年與 2021 年海岸淺水域分布圖層套疊。



Fig. 4 Map showing coral reefs distribution and overlap in Taiwan between 2008 and 2021.

圖 4 臺灣 2008 年與 2021 年珊瑚礁分布圖層套疊。



Fig. 5 Map showing rocky marine shores distribution and overlap in Taiwan between 2008 and 2021.
圖 5 臺灣 2008 年與 2021 年岩礁分布圖層套疊。

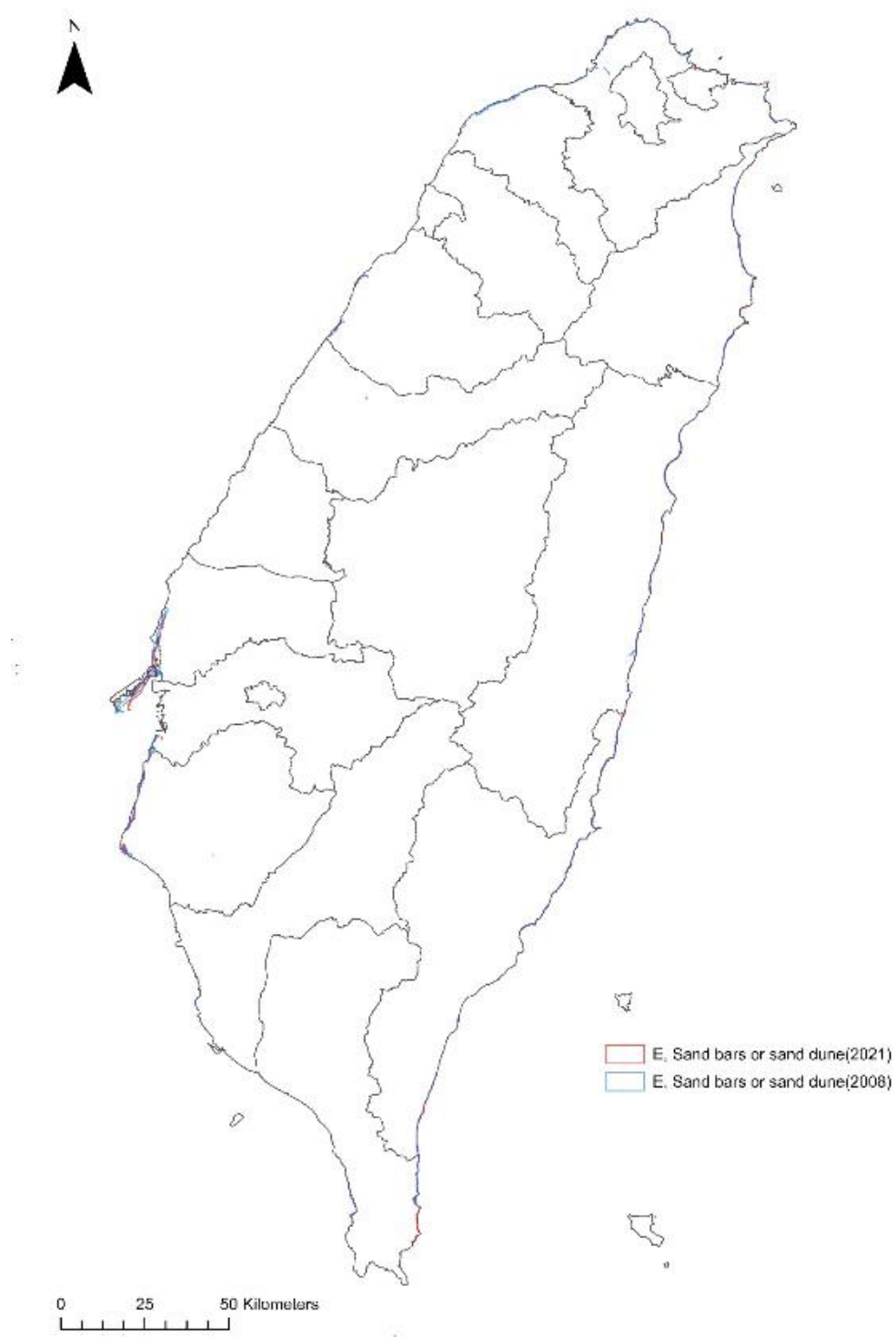


Fig. 6 Map showing sand bars or sand dune distribution and overlap in Taiwan between 2008 and 2021.
圖 6 臺灣 2008 年與 2021 年沙洲或沙丘分布圖層套疊。

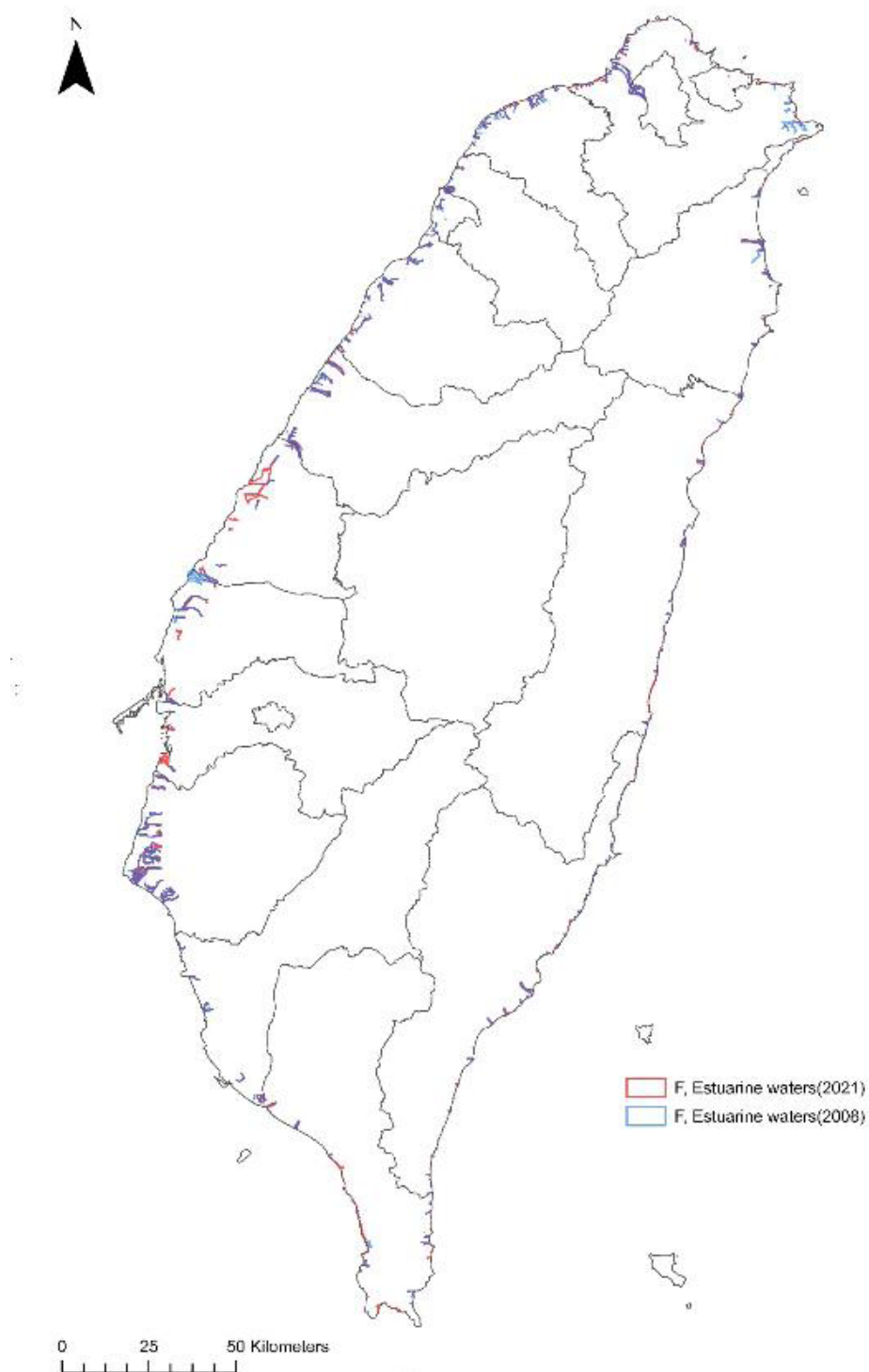


Fig. 7 Map showing estuarine waters distribution and overlap in Taiwan between 2008 and 2021.
圖 7 臺灣 2008 年與 2021 年河口分布圖層套疊。

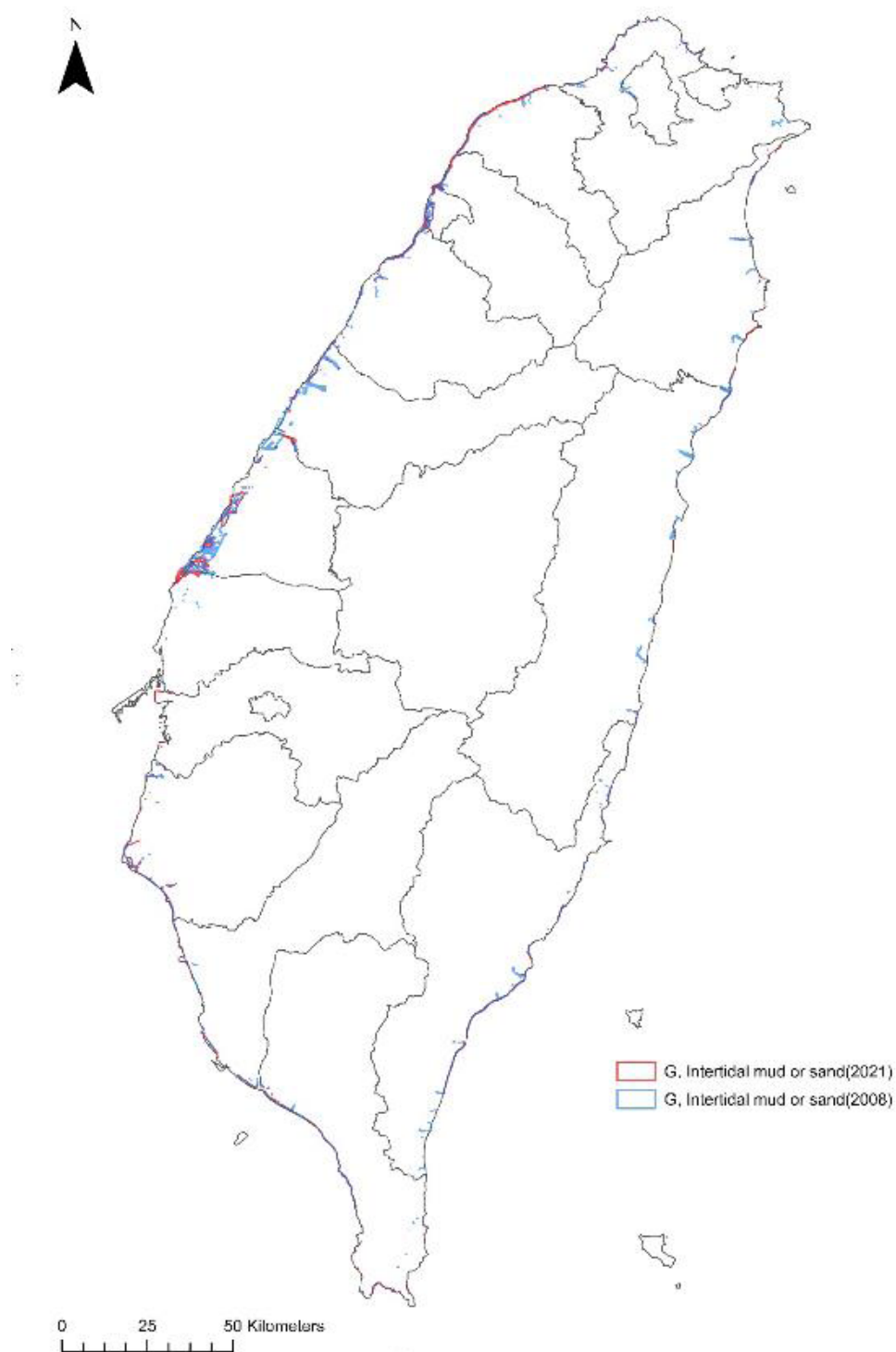


Fig. 8 Map showing intertidal mud or sand distribution and overlap in Taiwan between 2008 and 2021.
圖 8 臺灣 2008 年與 2021 年潮間帶泥灘或沙灘分布圖層套疊。



Fig. 9 Map showing intertidal marshes distribution and overlap in Taiwan between 2008 and 2021.
圖 9 臺灣 2008 年與 2021 年潮間帶草澤分布圖層套疊。

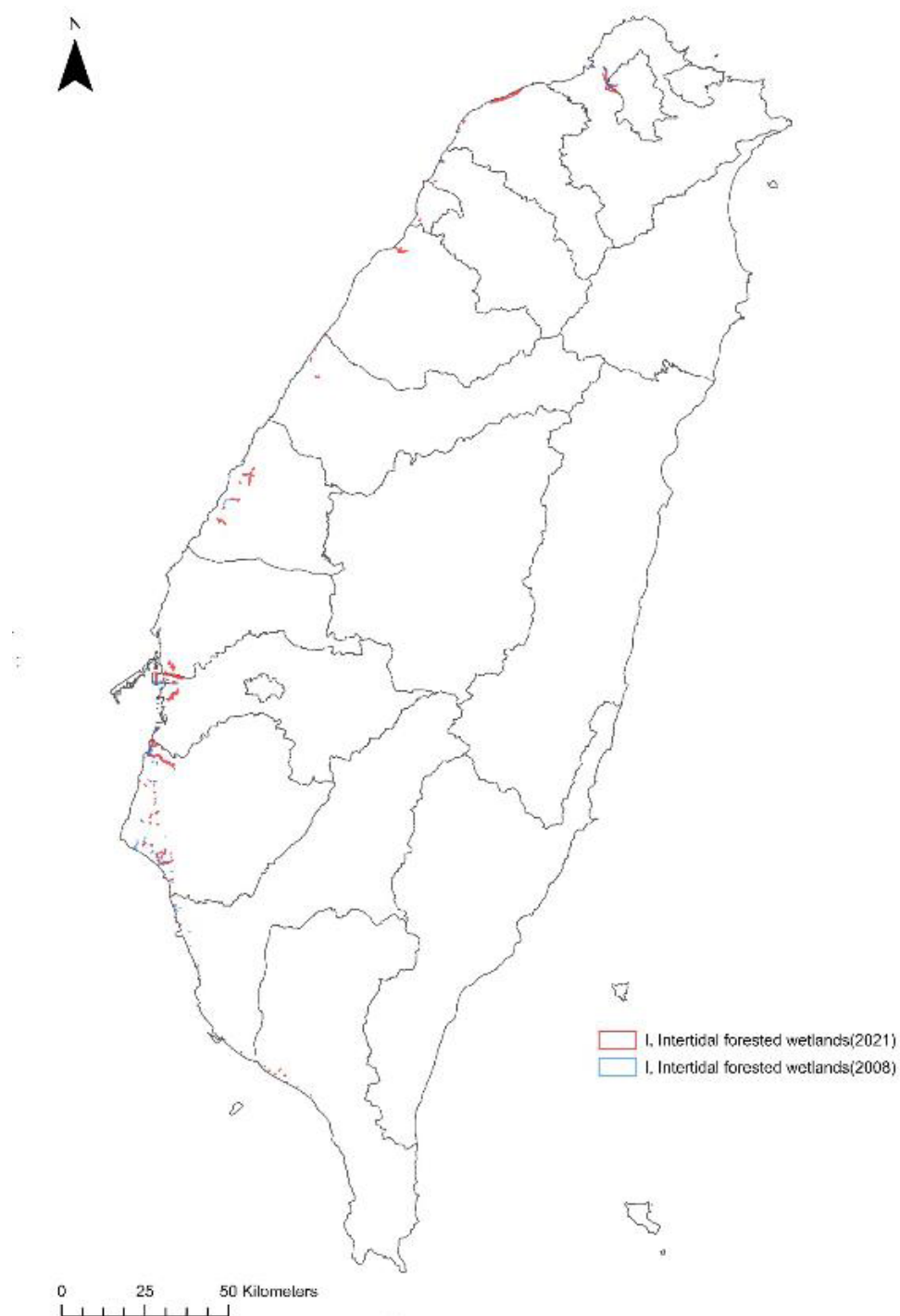


Fig. 10 Map showing intertidal forested wetlands distribution and overlap in Taiwan between 2008 and 2021.

圖 10 臺灣 2008 年與 2021 年潮間帶林澤分布圖層套疊。



Fig. 11 Map showing coastal saline lagoons distribution and overlap in Taiwan between 2008 and 2021.

圖 11 臺灣 2008 年與 2021 年海岸鹹水潟湖分布圖層套疊。

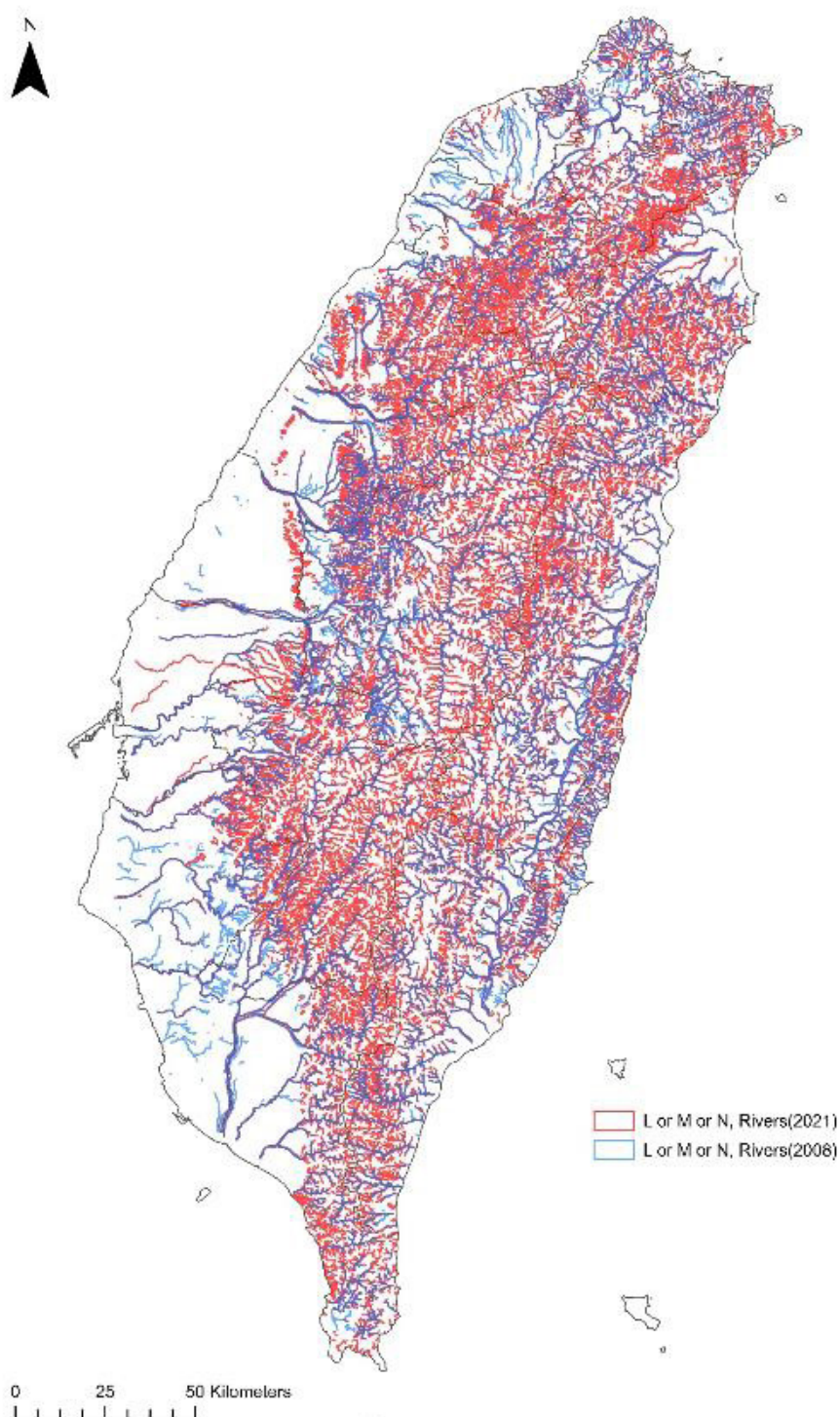


Fig. 12 Map showing rivers distribution and overlap in Taiwan between 2008 and 2021.
圖 12 臺灣 2008 年與 2021 年溪流分布圖層套疊。

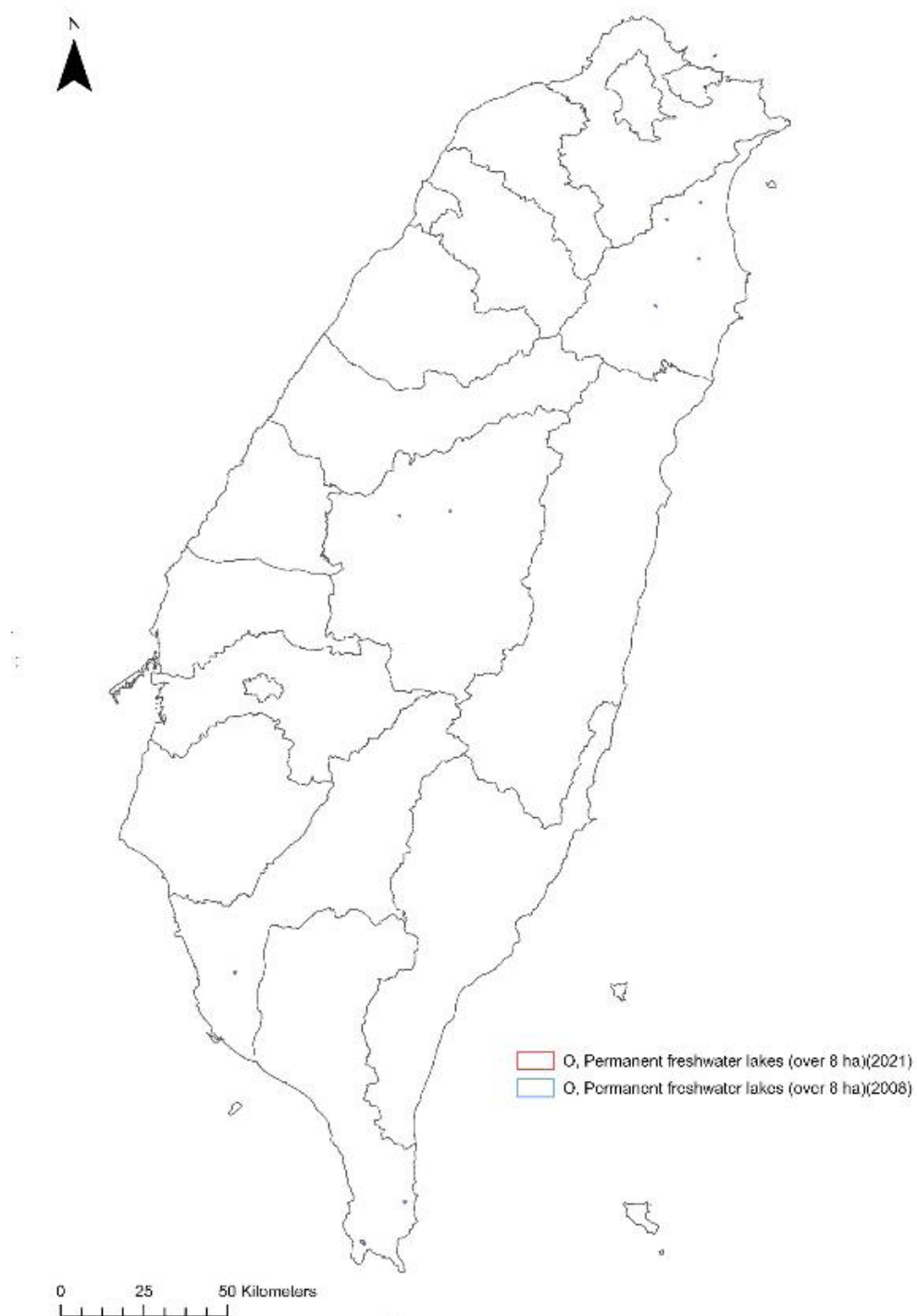


Fig. 13 Map showing permanent freshwater lakes distribution and overlap in Taiwan between 2008 and 2021.

圖 13 臺灣 2008 年與 2021 年永久性淡水湖泊分布圖層套疊。

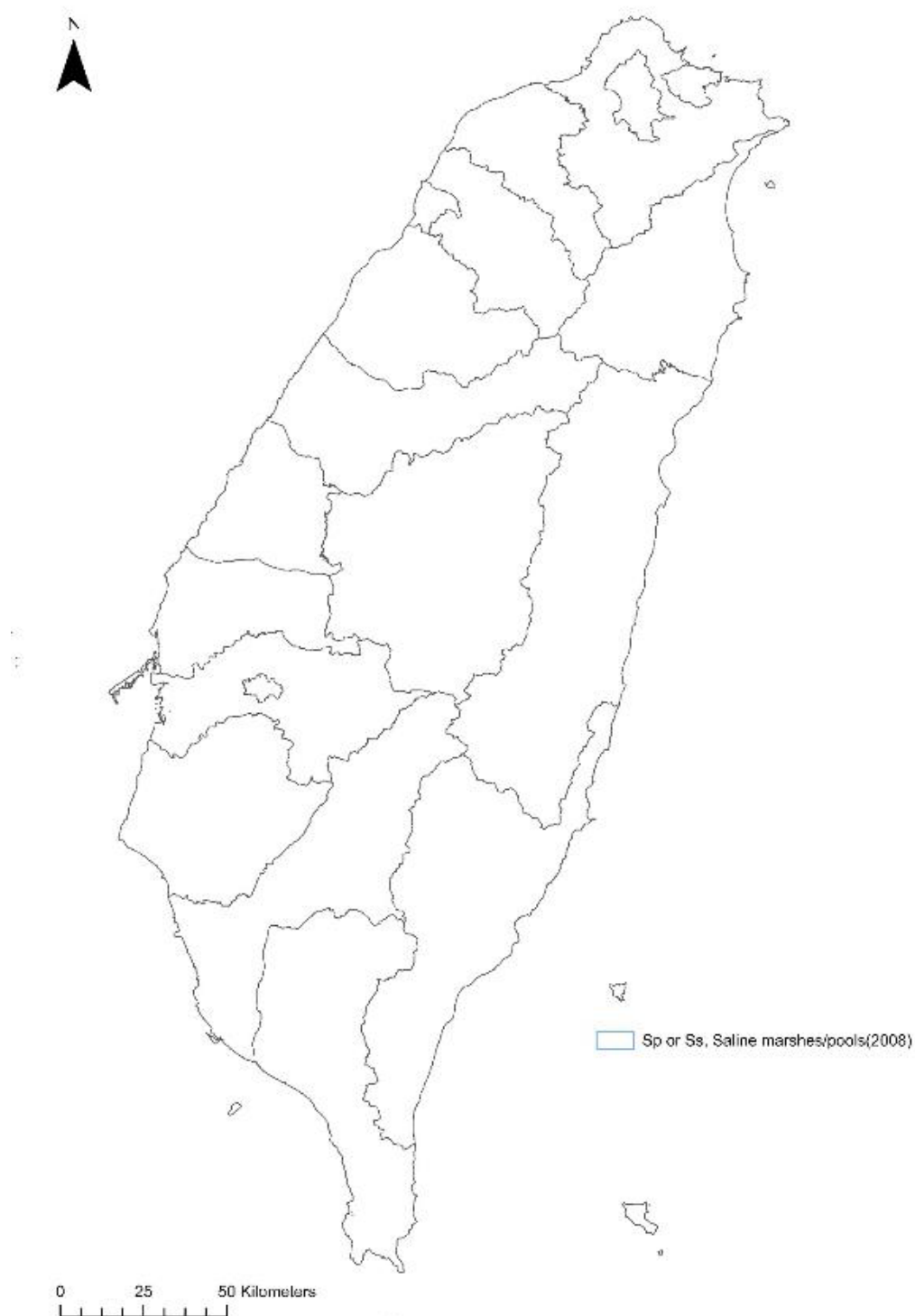


Fig. 14 Map showing saline marshes/pools distribution and overlap in Taiwan between 2008 and 2021.
圖 14 臺灣 2008 年與 2021 年鹹水沼澤與池塘分布圖層套疊。



Fig. 15 Map showing freshwater marshes/pools distribution and overlap in Taiwan between 2008 and 2021.

圖 15 臺灣 2008 年與 2021 年淡水沼澤與池塘分布圖層套疊。



Fig. 16 Map showing freshwater springs distribution and overlap in Taiwan between 2008 and 2021.
圖 16 臺灣 2008 年與 2021 年淡水湧泉分布圖層套疊。

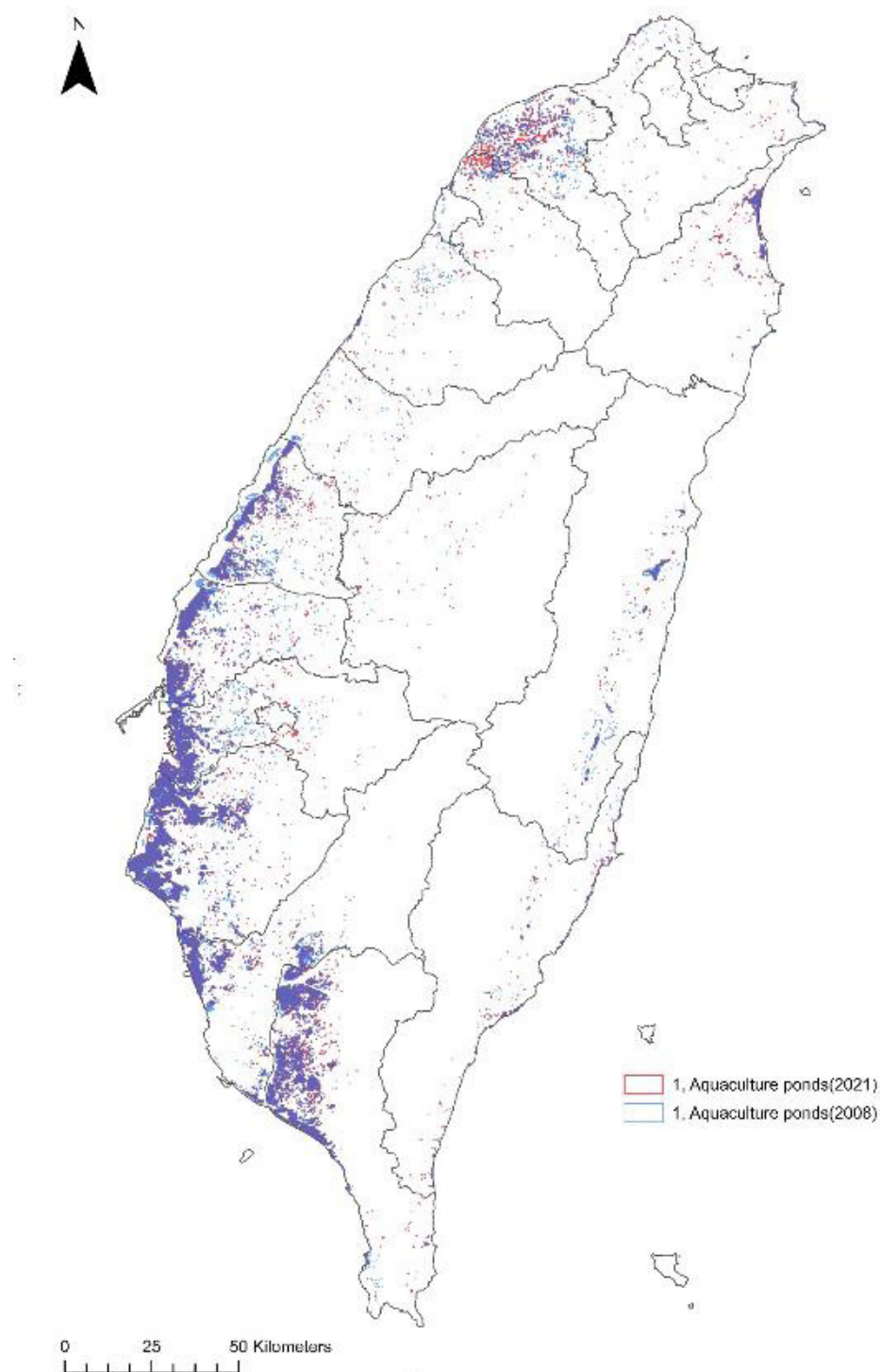


Fig. 17 Map showing aquaculture ponds distribution and overlap in Taiwan between 2008 and 2021.
圖 17 臺灣 2008 年與 2021 年養殖池分布圖層套疊。

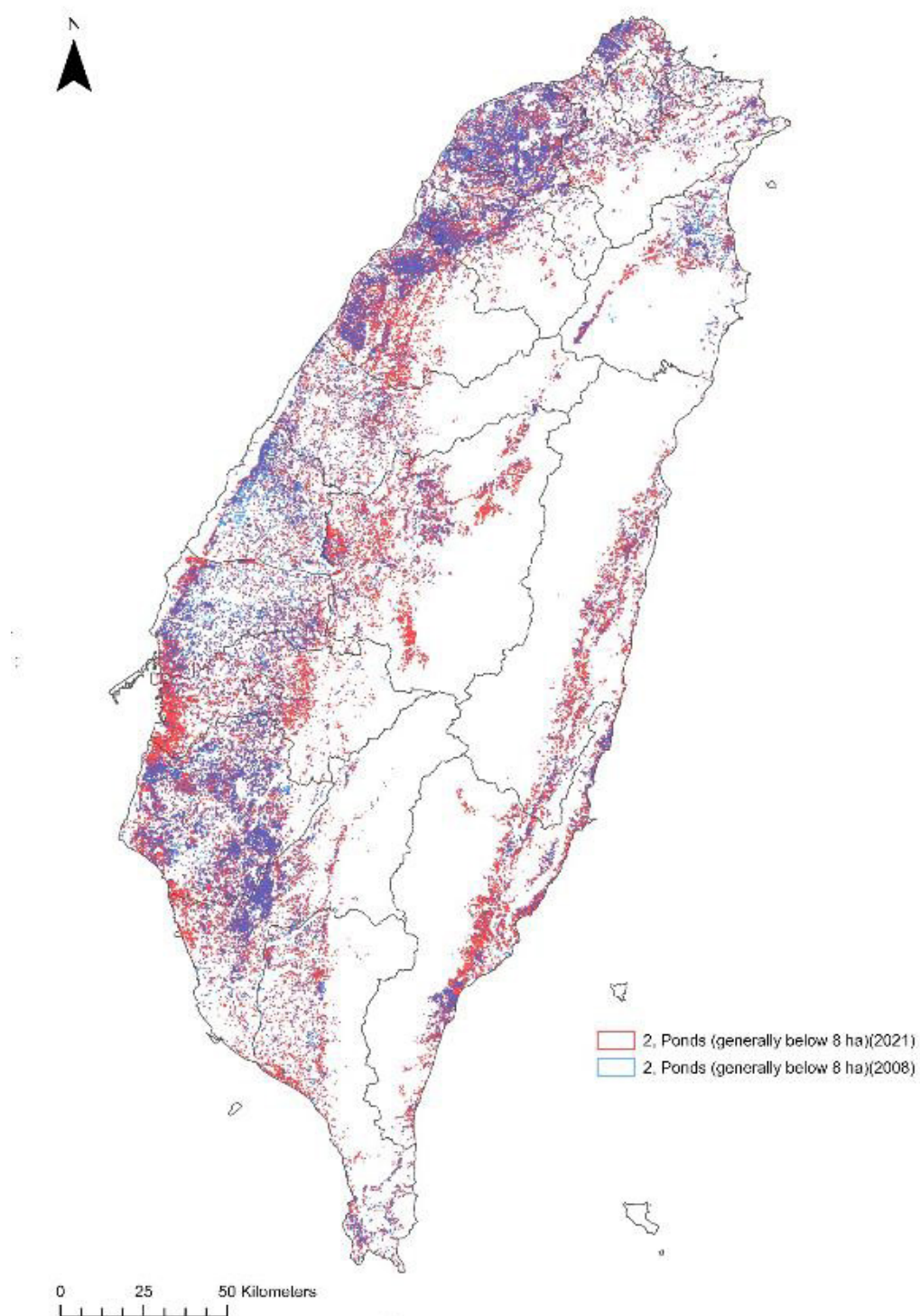


Fig. 18 Map showing ponds distribution and overlap in Taiwan between 2008 and 2021.
圖 18 臺灣 2008 年與 2021 年池塘分布圖層套疊。

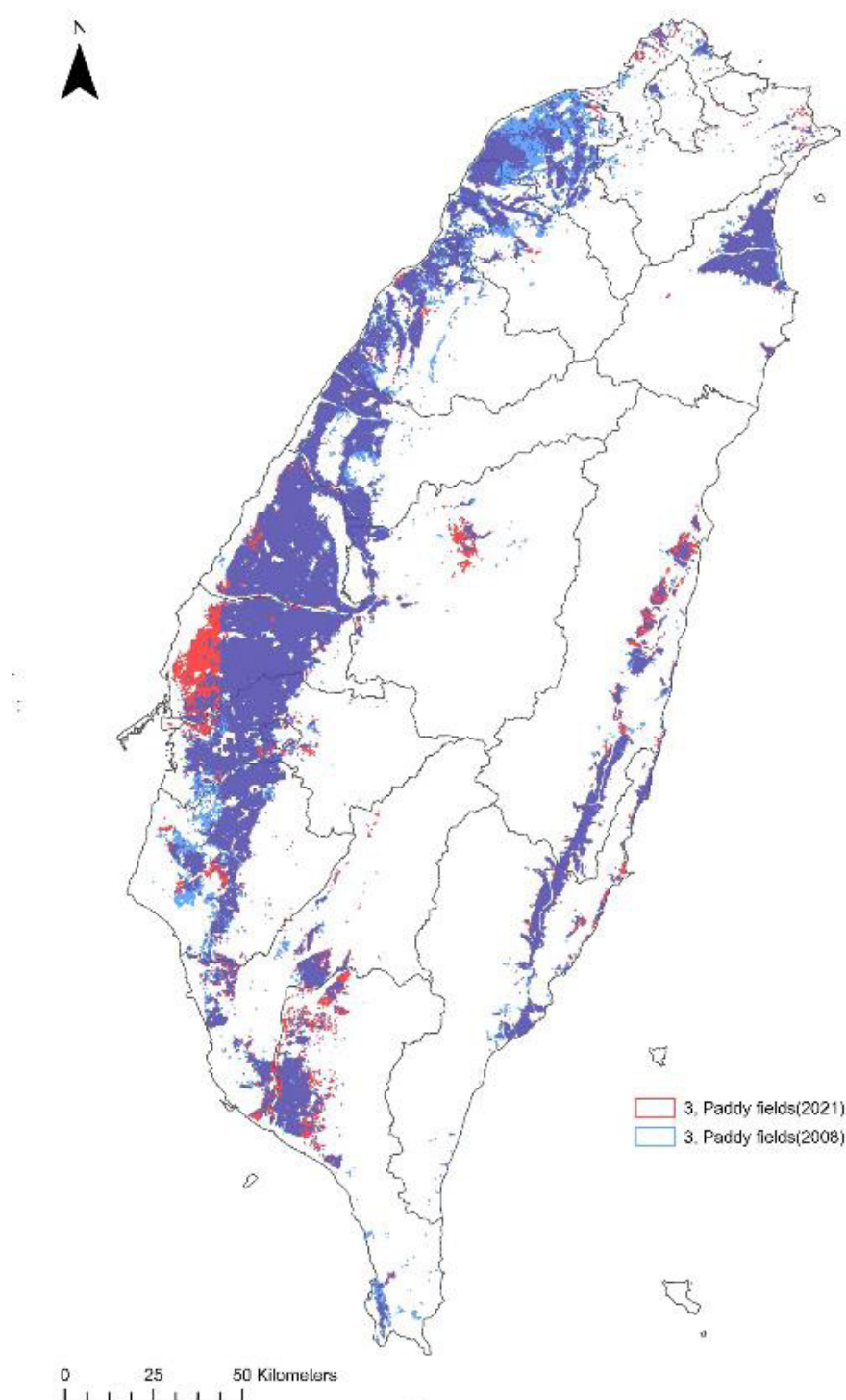


Fig. 19 Map showing paddy field distribution and overlap in Taiwan between 2008 and 2021.
圖 19 臺灣 2008 年與 2021 年水田分布圖層套疊。

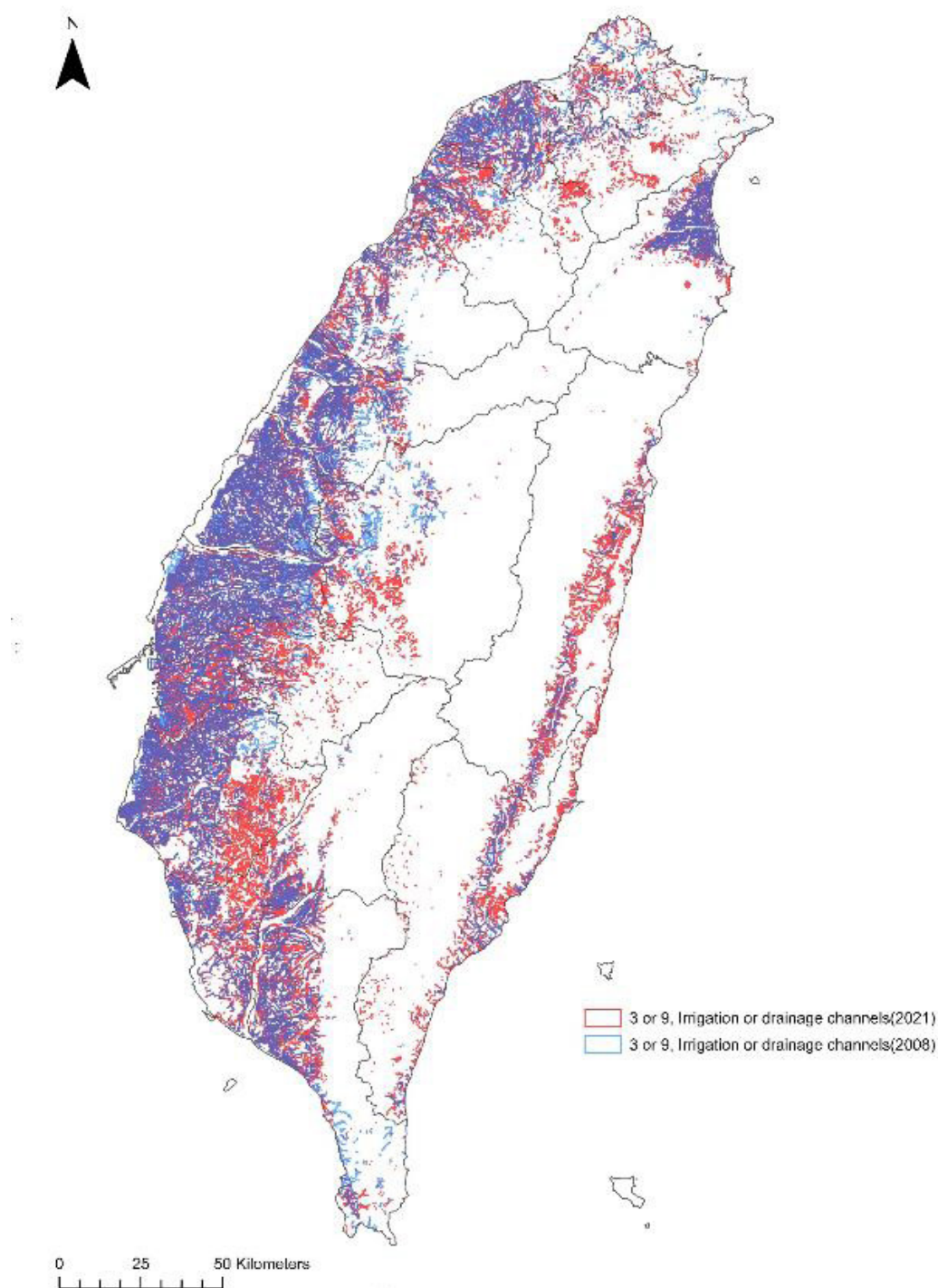


Fig. 20 Map showing irrigation or drainage channels distribution and overlap in Taiwan between 2008 and 2021.

圖 20 臺灣 2008 年與 2021 年灌溉渠道或排水道分布圖層套疊。

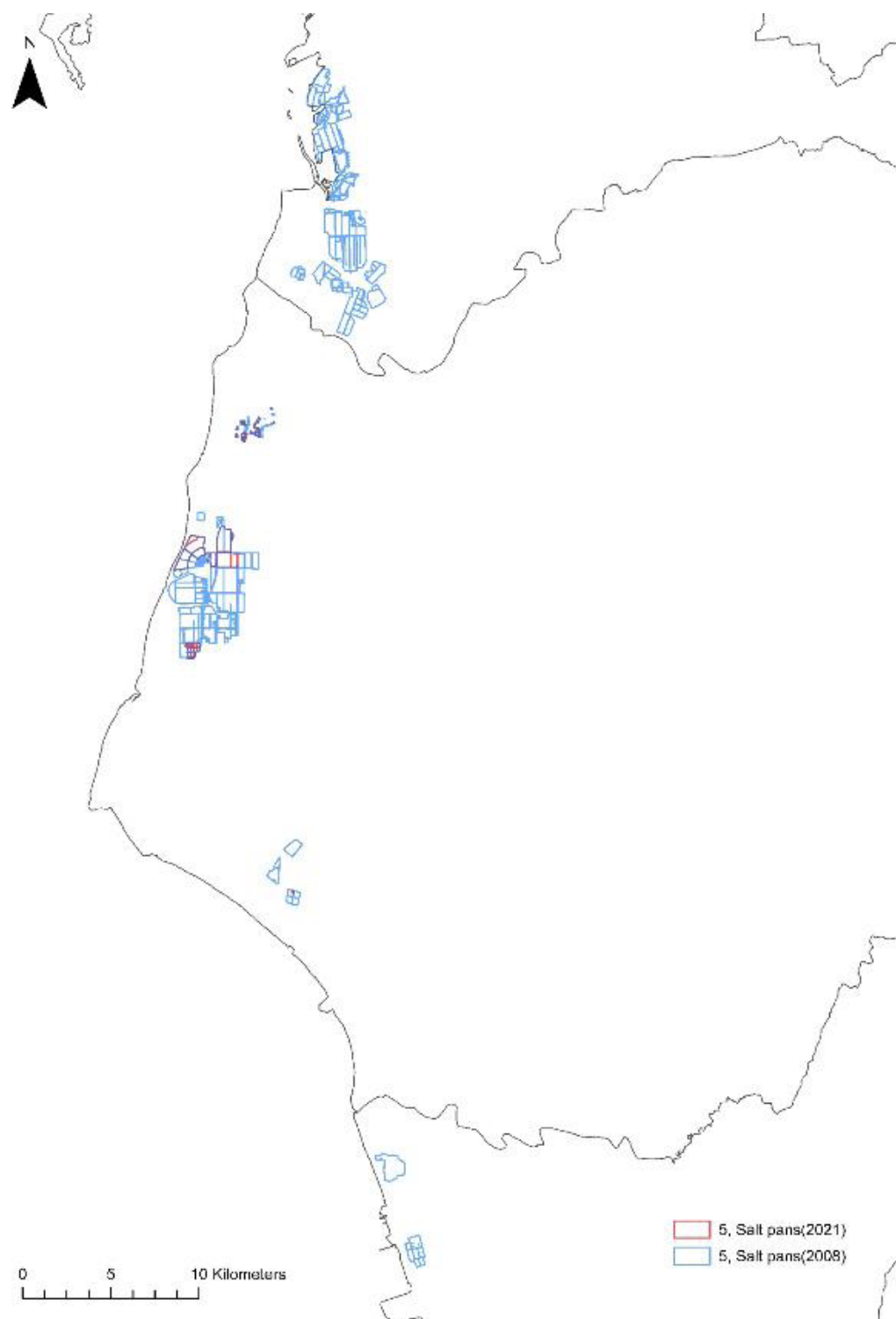


Fig. 21 Map showing salt pans distribution and overlap in Taiwan between 2008 and 2021.
圖 21 臺灣 2008 年與 2021 年鹽田分布圖層套疊。

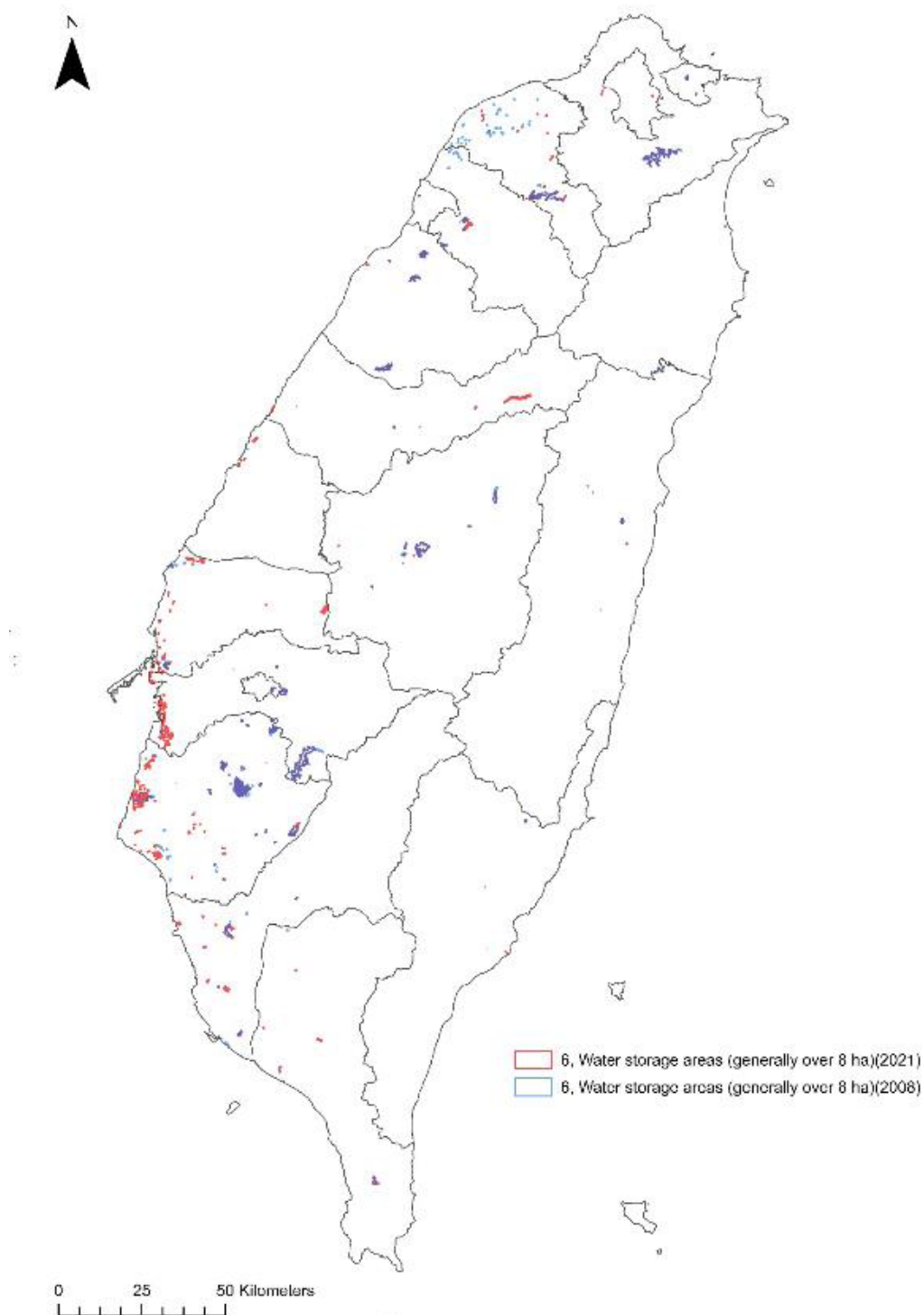


Fig. 22 Map showing water storage areas distribution and overlap in Taiwan between 2008 and 2021.
圖 22 臺灣 2008 年與 2021 年蓄水區分布圖層套疊。



Fig. 23 Map showing excavations distribution and overlap in Taiwan between 2008 and 2021.
圖 23 臺灣 2008 年與 2021 年開鑿區分布圖層套疊。

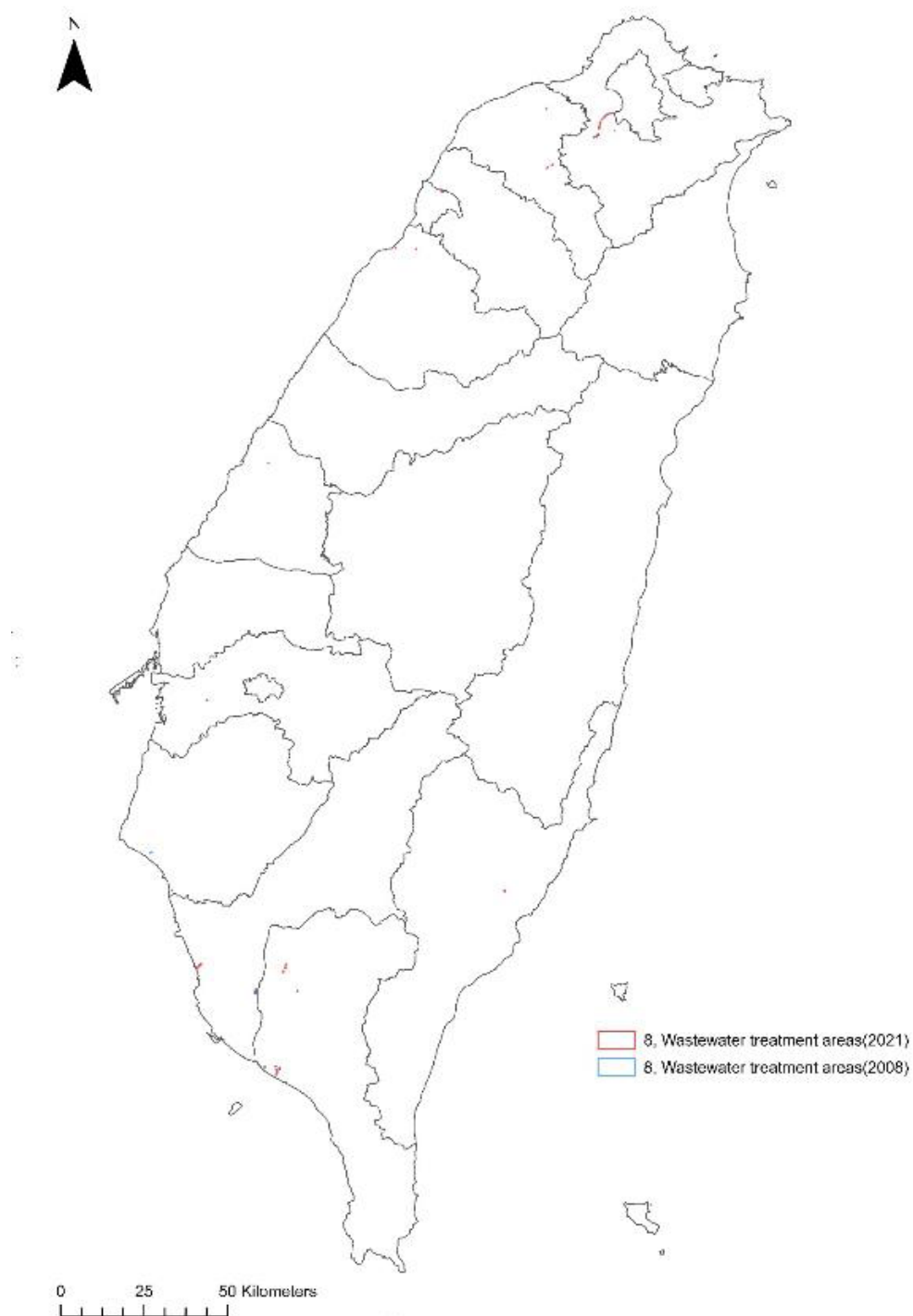


Fig. 24 Map showing wastewater treatment areas distribution and overlap in Taiwan between 2008 and 2021.

圖 24 臺灣 2008 年與 2021 年廢水處理區分布圖層套疊。

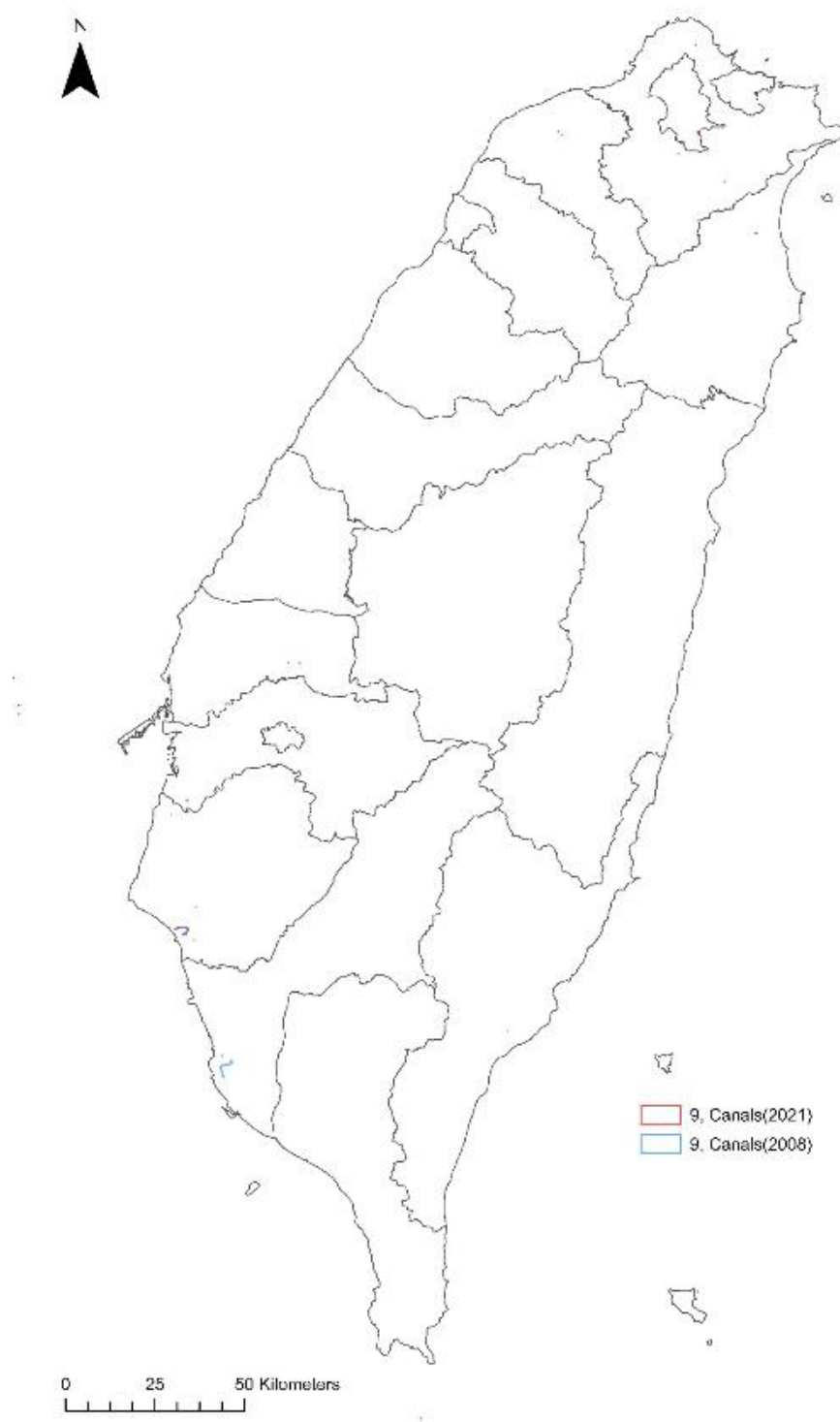


Fig. 25 Map showing canals distribution and overlap in Taiwan between 2008 and 2021.
圖 25 臺灣 2008 年與 2021 年運河分布圖層套疊。