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Artificial Surface Dataset of Urban Changes in 6 Cities in GMS (1990–2015)

Cao, H.[1] Song, W. X.[1*] He, J.[2]

1. Key Laboratory of Watershed Geographic Sciences, Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences, Nanjing 210008, China;
2. School of Economics and Management, Anhui Agricultural University, Hefei 230036, China

Abstract: Studying the urban artificial surface dynamics of typical cities in the Greater Mekong Subregion is of great significance for promoting urbanization and regional sustainable development. An artificial surface dataset of urban changes in 6 cities (Xishuangbanna, Yangon, Vientiane, Phnom Penh, Bangkok and Ho Chi Minh city) in the Greater Mekong Subregion (1990–2015) was developed based on Landsat TM/ETM+/OLI images and an object-oriented decision classification procedure. The artificial surface data were validated using *in situ* data, historical literature, and Google Earth high-resolution images. The overall accuracy is above 81.73%. The dataset consists of data covering six time periods from 1990 to 2015 (1990, 1995, 2000, 2005, 2010 and 2015) in 6 cities, including Xishuangbanna, Yangon, Vientiane, Phnom Penh, Bangkok and Ho Chi Minh city, with a spatial resolution of 30 m. It is archived in .tif format, with 180 files in total, and the data size is 4.10 MB (compressed to 1 file, 2.49 MB).

Keywords: Greater Mekong Subregion; Landsat; urban artificial surface; decision classification; 1990–2015

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Dataset Availability Statement:

The dataset supporting this paper was published and is accessible through the *Digital Journal of Global Change Data Repository* at: https://doi.org/10.3974/geodb.2023.02.04.V1 or https://cstr.escience.org.cn/CSTR:20146.11.2023.02.04.V1.

1 Introduction

Urban expansion encompasses the process by which natural landscapes are gradually eroded, occupied, and transformed by artificial landscapes due to human activities and the process by which natural and ecological systems transform into socioecological coupling systems. The main landscape characteristic of urban expansion is the transformation of non-artificial surfaces to all types of urban artificial surfaces. The dynamics of urban artificial surfaces,

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***Corresponding Author:** Song, W. X., Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences, wxsong@niglas.ac.cn

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which serve as important indicators of urban development and urbanization levels, are popular research topics regarding urban land use.

The Greater Mekong Subregion (GMS), including China (Yunnan and Guangxi), Myanmar, Laos, Thailand, Cambodia and Vietnam, is a hotspot of global biodiversity and ecosystem protection and the key region of the Belt and Road Initiative and Lancang-Mekong Cooperation strategies[1]. The social and economic development level of the Greater Mekong Subregion is lower compared to the rest of Asia and the world. The extreme urban polarization phenomenon has created situations in which a typical city can affect the overall economy of a country or region[2, 3]. Urbanization is considered a necessary process and an effective measure to promote economic growth, industrialization and modernization in GMS[4]. Therefore, studying the urban expansion/artificial surface dynamics of typical cities in the Greater Mekong Subregion is of great significance for understanding urbanization processes and trends and their possible impacts on the ecological environment; this information can promote sustainable development through effective urban planning and management in this region[5].

This study selected Xishuangbanna Dai autonomous prefecture (Yunnan province, hereinafter referred to as Xishuangbanna), Yangon (Myanmar), Vientiane (capital of Laos), Bangkok (capital of Thailand), Phnom Penh (capital of Cambodia), and Ho Chi Minh city (Vietnam) as typical cities. A decision classification procedure was applied to Landsat series remote sensing images of these cities from 1990 to 2015 to produce a dataset comprising urban artificial surfaces. High classification accuracy was guaranteed through field survey verification, comparison of high-resolution remote sensing images, and visual modification. This study, to some extent, has filled the data gaps in the long-term series of urban artificial surface dynamics of typical cities in GMS and can contribute to urban planning and sustainable development policy formulation in this region.

2 Metadata of the Dataset

The metadata of the Artificial surface dataset of urban changes in 6 cities in the Greater Mekong subregion (1990–2015)[6] are summarized in Table 1. They include the dataset full name, short name, authors, year of the dataset, temporal resolution, spatial resolution, data format, data size, data files, data publisher, and data sharing policy, etc.

3 Methods

3.1 Data Sources

The administrative boundary of Xishuangbanna was obtained from the National Catalog Service for Geographic Information[1], and the administrative boundaries of other cities were downloaded from the Database of Global Administrative Areas (GADM)[2]. Approximately 150 remote sensing images acquired from Landsat TM/ETM+/OLI sensors[3] were used for urban artificial surface interpretation of the typical cities inGMS. Considering the availability, quality and land use phenological characteristics of remote sensing images, the images of Xishuangbanna were acquired mainly in February and March (with a few in January and April). The images of other cities were acquired in both the dry season and wet season. Generally, images in the dry season were acquired from early December to the end of March of the next year, while images in the wet season were acquired from early

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[1] https://www.webmap.cn.
[2] https://gadm.org.
[3] https://earthexplorer.usgs.gov.

September to the end of November.

Table 1 Metadata summary of the Artificial surface dataset of urban changes in 6 cities in the Greater Mekong subregion (1990–2015)

Items	Description
Dataset full name	Artificial Surface Dataset of Urban Changes in 6 Cities in the Greater Mekong Subregion (1990–2015)
Dataset short name	GMS_ArtificialSurface_1990-2015
Authors	Cao, H., Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences, hcao@niglas.ac.cn Song, W. X., Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences, wxsong@niglas.ac.cn He, J., Anhui Agricultural University, 754147782@qq.com
Geographical region	Greater Mekong Subregion
Year	1990, 1995, 2000, 2005, 2010, 2015
Temporal resolution	Five years
Spatial resolution	30 m
Data format	.tif
Data size	2.49 MB (compressed)
Data files	180 files in total; data file naming rule is “city+year”
Foundation	National Natural Science Foundation of China (41561144012)
Data publisher	Global Change Research Data Publishing & Repository, http://www.geodoi.ac.cn
Address	No. 11A, Datun Road, Chaoyang District, Beijing 100101, China
Data sharing policy	*Data* from the Global Change Research Data Publishing & Repository includes metadata, datasets (in the *Digital Journal of Global Change Data Repository*), and publications (in the *Journal of Global Change Data & Discovery*). *Data* sharing policy includes: (1) *Data* are openly available and can be free downloaded via the internet; (2) End users are encouraged to use *Data* subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute *Data* subject to written permission from the GCdataPR Editorial Office and the issuance of a *Data* redistribution license; and (4) If *Data* are used to compile new datasets, the ‘ten percent principal’ should be followed such that *Data* records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new dataset[7]
Communication and searchable system	DOI, CSTR, Crossref, DCI, CSCD, CNKI, SciEngine, WDS/ISC, GEOSS

All downloaded Landsat images are L1T products with system correction, radiometric correction, geometric correction and terrain correction and meet the accuracy requirements of remote sensing interpretation. Few images with complex terrain were orthorectified using DEM and Google Earth high-resolution images. All of the above images were processed with band combination and image mosaic, resampled to 30 m, and clipped according to the administrative extents of typical cities.

3.2 Data Processing

This study applied an object-oriented classification method to extract the urban artificial surfaces of typical cities, and the classification process was carried out in eCognition 8.7 software. The images were first segmented into homogeneous polygons, and then polygon samples of urban artificial surfaces and non-urban artificial surfaces were selected. The urban artificial surfaces of typical cities were then identified through a decision classification procedure (Figure 1) based on sample shape, texture, spatial location, band attribute and other characteristics. To ensure accuracy, the classification results were visually modified, in combination with field surveys, historical literature, and Google Earth high-resolution images.

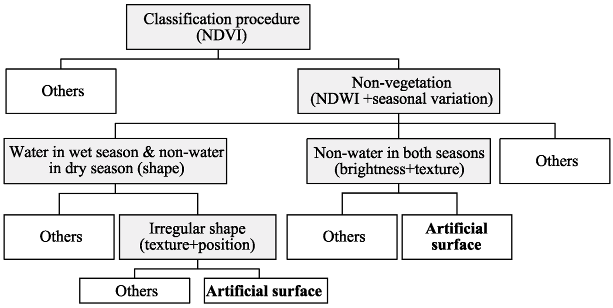

Figure 1 Decision classification procedure of the dataset development

4 Data Results and Validation

4.1 Data Composition

Artificial surface dataset of urban changes in 6 cities in the Greater Mekong subregion (1990–2015) consists of urban artificial surface data covering six time periods from 1990 to 2015 (1990, 1995, 2000, 2005, 2010 and 2015) in 6 cities, including Xishuangbanna, Yangon, Vientiane, Phnom Penh, Bangkok and Ho Chi Minh city, with a spatial resolution of 30 m. The dataset is archived in .tif format, with 180 files in total (Figure 2).

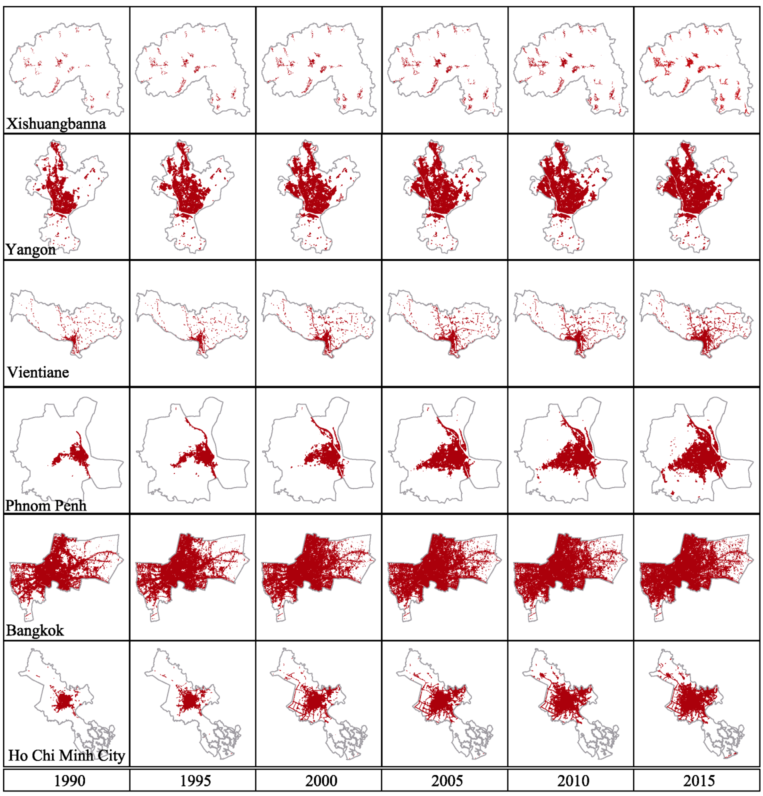

Figure 2 Maps of urban artificial surface for the typical cities in GMS

4.2 Data Products

Figure 3 and Table 2 show the area and spatial changes in the urban artificial surface of typical cities in GMS from 1990 to 2015. Bangkok, an international metropolis, has an urban artificial surface area significantly higher than that of other cities. In 2015, the urban artificial surface area of Bangkok reached approximately 720 km^2. Ho Chi Minh city is the second largest city in terms of urban artificial surface area among the typical cities in GMS. In 2015, its urban artificial surface area exceeded 450 km^2. Since a large number of satellite cities have been built around the urban center of Yangon, the urban artificial surface area of Yangon in 2015 was greater than 360 km^2. The urban artificial surface areas of both Xishuangbanna and Vientiane were approximately 230 km^2. Phnom Penh had the smallest urban artificial surface area among the typical cities, which slightly exceeded 120 km^2 in 2015.

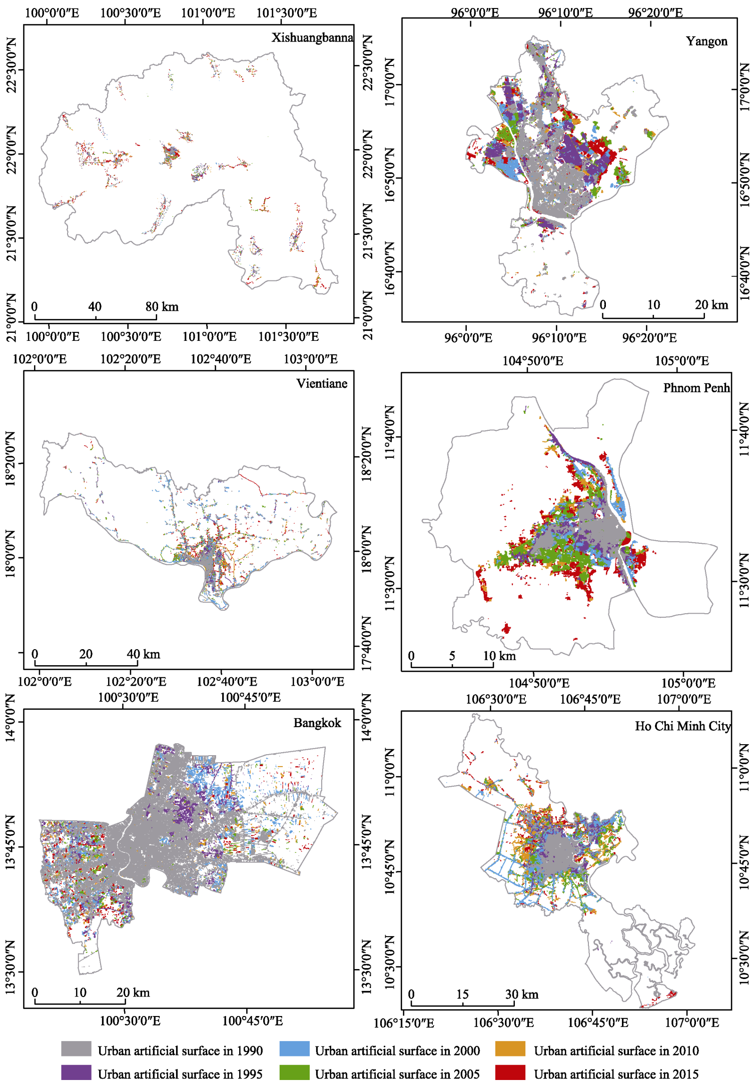

Figure 3 Maps of spatial dynamics of urban artificial surface for the typical cities in GMS (1990–2015)

The urban artificial surface of Xishuangbanna expanded the fastest among the typical cities, increasing from 40.74 km^2 in 1990 to 222.38 km^2 in 2015, with an annual expansion rate of approximately 18%. From 1990 to 2015, the area of urban artificial surface in Phnom

Table 2 Variation in urban artificial surface area (unit: km^2) for the typical cities in the Greater Mekong Subregion during 1990–2015

Cities	1990	1995	2000	2005	2010	2015
Xishuangbanna	40.74	65.82	89.94	112.53	152.61	222.38
Yangon	155.42	224.99	261.72	298.67	317.21	362.6
Vientiane	61.91	82.57	139.51	173.92	201.38	233.45
Bangkok	513.98	570.29	639.97	665.13	691.14	719.88
Phnom Penh	30.31	44.65	59.8	89.34	98.33	123.48
Ho Chi Minh city	109.08	151.32	257.36	334.85	409.76	451.61

Penh and Ho Chi Minh city increased by 90 km^2 and 340 km^2, respectively, with an annual expansion rate of nearly 12.5%. Furthermore, the annual expansion rate of urban artificial surface in Vientiane also exceeded 11%. The areas of urban artificial surface in both Yangon and Bangkok increased by more than 200 km^2 from 1990 to 2015. However, due to the large urban artificial surface areas of Yangon and Bangkok in 1990, their annual expansion rates were lower. In particular, the urban artificial surface area of Bangkok exceeded 510 km^2 in 1990, while its annual expansion rate was only 1.6%.

In regard to urban expansion direction, Xishuangbanna mainly expanded toward the northwest (Jinghong Industrial Park) and southwest (the airport and surrounding regions), which is basically in line with the spatial layout of urban development determined in the Jinghong Urban Master Plan (1999–2020). The urban artificial surface of Yangon is distributed primarily on the north bank of the Yangon River in the urban center-Inya Lake-airport direction. In 2015, the artificial surface extended to the vicinity of Hlawga Lake. The most obvious urban expansion in Yangon is the development of a large number of satellite cities. They have been used to settle the urban poor living in squatter areas; additionally, many industrial parks are distributed in these satellite cities as a result of small enterprises relocation[8]. Vientiane's urban artificial surface is mainly distributed along the Mekong River in the shape of a right angle. From 1990 to 2015, Vientiane's urban expansion was significantly affected by traffic conditions. The newly built artificial surface is mainly distributed along National Highway Line 1, Line 10, Line 13N, Line 13S and the railway to Thailand[9]. Influenced by natural conditions and administrative boundaries, the urban artificial surface of Bangkok is distributed on both sides of the Chao Phraya River and in recent decades has mainly expanded to the eastern and western peripheral areas[1]. In the past decades, Phnom Penh expanded mostly along the International Airport and the National Highway Line 4 (connecting Sihanouk Port). A large number of garment factories have moved to this area for cost and transportation reasons[10]. The expansion of artificial surface in Ho Chi Minh city is relatively scattered. In addition, the urban sprawl of Ho Chi Minh city is obvious, supposedly a result of the concentration of foreign capital investment in real estate projects outside the urban area[11].

4.3 Data Validation

This study verified the accuracies of urban artificial surface classification results of the typical cities in GMS on the basis of field surveys to Laos, Thailand, Cambodia, Vietnam and Xishuangbanna in January, March and May 2016; Google Earth's historical high-resolution images; and papers, reports, books and other literature with historical land use/planning maps. Table 3 shows the classification accuracies of urban artificial surfaces for the typical cities in GMS in different years. Among the cities, Xishuangbanna has relatively rich historical data such as maps, plans and papers that can assist in visual modification for which the classification accuracies are relatively high. Prior to 2000, there were no historical high-resolution images and fewer relevant studies. Therefore, the classification accuracies of urban artificial surfaces for most typical cities after 2005 are higher. In general, the dataset of urban artificial surfaces for the typical cities in GMS is of high accuracy and quality.

Table 3 Classification accuracies (unit: %) of urban artificial surfaces for the typical cities in the Greater Mekong subregion during 1990–2015

Cities	1990	1995	2000	2005	2010	2015
Xishuangbanna	92.12	92.50	93.85	94.42	91.73	94.23
Yangon	81.73	86.73	83.65	92.50	91.54	96.92
Vientiane	91.36	93.18	91.82	90.23	86.14	87.27
Bangkok	83.93	89.82	88.21	89.82	90.00	95.18
Phnom Penh	89.33	94.22	91.33	94.67	91.56	89.33
Ho Chi Minh city	85.94	91.62	87.50	83.53	91.91	91.41

5 Discussion and Conclusion

The GMS is one of the key regions of the Belt and Road Initiative and Lancang-Mekong Cooperation strategies. Mapping the urban artificial surfaces of typical cities in the region is of great significance for promoting urbanization and regional sustainable development. The artificial surface dataset of urban changes in 6 cities in GMS (1990–2015) consists of urban artificial surface data of Xishuangbanna, Yangon, Vientiane, Phnom Penh, Bangkok and Ho Chi Minh city in 1990, 1995, 2000, 2005, 2010 and 2015, respectively. Based on the Landsat series images, this dataset applied the object-oriented decision classification procedure to identify urban artificial surfaces of six the typical cities. Combined with visual modification, the dataset has achieved high accuracy. It can directly reflect urban artificial surface dynamics in terms of area and spatial distribution and support further studies of urban growth patterns, ecological environment effects and sustainable development planning policies of the typical cities in GMS.

Author Contributions

Cao, H. and Song, W. X. designed the algorithms of the dataset. Song, W. X. and He, J. contributed to the data processing and analysis. Cao, H. wrote the data paper.

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Cao, H., Liu, J., Chen, J. L., *et al*. Spatiotemporal patterns of urban land use change in typical cities in the Greater Mekong subregion (GMS) [J]. *Remote Sensing*, 2019, 11(7): 801–828.

[2] Rao, B. Z. The analysis of the centralized urbanization in Southeast Asia [J]. *Urban Problems*, 2004(5): 69–71.

[3] Wang, Y., Zhang, H. O., Huang, G. Z., *et al*. Different characteristics and driving factors of the comprehensive urbanization levels of countries in Southeast Asia [J]. *Tropical Geography*, 2015, 35(5): 680–686.

[4] Song, W. X., Zhu, X. G. Characteristics and causes of the urban spatial structure in Greater Mekong Subregion [J]. *Economic Geography*, 2010, 30(1): 53–58.

[5] Cao, H., Chen, J. L., Chen, C., *et al*. Identification of multi-temporal urban growth patterns with a modified urban growth index: case study of three fast growing cities in the Greater Mekong Subregion (GMS) [J]. *Ecological Indicators*, 2022, 142: 109206.

[6] Cao, H., Song, W. X., He, J. Artificial surface dataset of urban changes in 6 cities in the Greater Mekong Subregion (1990–2015) [J/DB/OL]. *Digital Journal of Global Change Data Repository*, 2023. https://doi.org/10.3974/geodb.2023.02.04.V1. https://cstr.escience.org.cn/CSTR:20146.11.2023.02.04.V1.

[7] GCdataPR Editorial Office. GCdataPR data sharing policy [OL]. https://doi.org/10.3974/dp.policy.2014.05 (Updated 2017).

[8] Boutry, M., Sone, K. P., Par, S. C., *et al*. Land dynamics and livelihoods in peri-urban Yangon [R]. 2015.

[9] Dao, K. Analysis of urban development based on the GIS technology-a case study of Vientiane [D]. Lanzhou: Lanzhou University, 2014.

[10] Mialhe, F., Gunnell, Y., Navratil, O., *et al*. Spatial growth of Phnom Penh, Cambodia (1973–2015): patterns, rates, and socio-ecological consequences [J]. *Land Use Policy*, 2019, 87: 104061.

[11] Kontgis, C., Schneider, A., Fox, J., *et al*. Monitoring peri-urbanization in the greater Ho Chi Minh city metropolitan area [J]. *Applied Geography*, 2014, 53: 377–388.