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Dataset on the dynamic stocks and flows of 20 types of plastics in China, 1978–2022

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Abstract

The widespread use of plastics has reshaped material cycles, requiring systematic understanding of their socioeconomic metabolism, encompassing material flows and stocks from production to end-of-life, to support effective policy development. Although previous studies have addressed specific aspects of plastic flows in China, existing data have been fragmented, with limited resolution and temporal consistency. Here, we develop a high-resolution, temporally consistent dynamic material flow database for China (1978–2022), covering 20 major plastic types (covering over 95% of national demand), 11 manufactured product groups, 9 end-use sectors, 4 waste disposal pathways, and international trade. The dataset is validated against published estimates and further assessed through sensitivity and uncertainty analyses, which highlight key parameters that are relatively sensitive and suggest directions for future refinement. By openly releasing all underlying data and code, we ensure full transparency and reproducibility. This work provides a database of over 60,000 data records that serves as a critical basis for quantitative research on plastic material cycles and supports further modeling of circular economy strategies.

Background & Summary

Since their invention, plastics have been valued for their light weight, ease of processing, and high durability, and these qualities have enabled them to rapidly displace traditional materials and bring transformative benefits across modern society[1,2]. However, the widespread single-use of this non-degradable material has resulted in the accumulation of plastic waste across diverse ecosystems, particularly in marine[3,4] and terrestrial environments[2,5–7], raising global concerns about plastic pollution. The ongoing Intergovernmental Negotiating Committee (INC) is advancing a life-cycle approach to develop a legally binding international instrument to end plastic pollution, necessitating systemic solutions that address all stages of the whole plastic lifecycle and engage diverse stakeholders[8].

Effective solutions must be grounded in baseline data on plastic production, consumption, and waste, and this requires detailed knowledge of the flows and stocks of plastics in order to assess progress in waste reduction and recycling. Material Flow Analysis (MFA) is a core method for quantifying material metabolism in mass units and serves as a key approach to investigate the material functioning of socio-economic systems. The primary goal of MFA is to quantify the input and output flows of specific materials throughout their life cycles, providing a foundational tool for generating essential baseline data[9–11]. Material Flow Analysis also serves as the fundamental basis for further in-depth studies on related issues, including emissions, energy consumption, circularity, waste management, and environmental exposure[12–17]. As the world's largest producer and consumer of plastics[18], China's approach to plastic governance holds global significance. Developing a comprehensive and high-resolution database on plastic flows and stocks within China's socio-economic system has become a shared priority for both the scientific community and policy-makers.

Most existing studies employ dynamic MFA to examine the stocks and flows of China's five major commodity plastics—polyethylene (PE), polypropylene (PP), polyvinyl chloride (PVC), polystyrene (PS), and acrylonitrile butadiene styrene (ABS)[13,19–22]—along with polyethylene terephthalate (PET)[17,20–24]. These analyses predominantly rely on industry statistics from the China Plastics Processing Industry Association (CPPIA)[25]. In contrast, research on plastic types beyond the major categories remains relatively limited, primarily due to data scarcity and the specialized nature of their application contexts. For example, studies on polyurethane (PU)[1,10,14–16,26,27], engineering plastics (including polyamides (PA)[1,10,14–16,26], polycarbonates (PC)[15,16,26], and polymethyl methacrylate (PMMA)[16], and thermosetting plastics[26] are still largely confined to a few countries, with narrow coverage of material categories.

The data foundation for analyzing plastic stocks and flows in China remains limited in several aspects. First, the coverage of major plastic categories in existing studies remains incomplete or inconsistently addressed, in part owing to varying definitions and classification systems. Non-commodity plastics, in particular, have received relatively less attention[28]. Second, much of the available data is presented at a high level of aggregation, while access to disaggregated or process-level datasets remains limited. This lack of granularity may hinder transparency and reduce the reproducibility of model-based assessments. Third, time-series data are not always systematically updated, and temporal coverage is often fragmented, which may limit their utility for long-term trend analysis. Addressing these limitations would help advance high-resolution plastic socioeconomic metabolism research.

Based on our previous modeling efforts targeting China's commodity[19] and non-commodity plastics[28], we systematically integrated and enhanced these approaches to construct a high-temporal-resolution database of plastic stocks and flows from 1978 to 2022. Employing an updated and harmonized framework, the dataset covers 20 major plastic types, representing over 95% of national plastic consumption, and achieves improved consistency across material types, product groups, and end-use sectors. This study advances plastic metabolism modeling in China by systematically harmonizing heterogeneous data sources and applying dynamic material flow analysis (dynamic-MFA) to quantify stocks and flows across the entire plastic lifecycle, including polymer production, product manufacturing, sectoral use, international trade, and end-of-life management. The resulting database comprises more than 60,000 data records, with full transparency ensured through open access to all input data and computational code. Robustness and reproducibility are strengthened via cross-study validation, sensitivity analyses, Monte Carlo uncertainty assessments, and expert consultation. By providing consistent, detailed, and verifiable data, the database offers a critical foundation for identifying key intervention points in plastic governance and supports downstream applications such as lifecycle assessment of environmental impacts and modeling of microplastic emissions along the entire value chain.

Methods

Framework

This study focuses on the socioeconomic metabolism of 20 key plastic types in China, including: commodity plastics (high-density polyethylene (HDPE), low-density polyethylene (LDPE), linear low-density polyethylene (LLDPE), polypropylene (PP), polyvinyl chloride (PVC), polystyrene (PS), expanded polystyrene (EPS), and acrylonitrile butadiene styrene (ABS)), polyethylene terephthalate (PET), polyurethane (PU), various engineering plastics (e.g., polyamide (PA), polycarbonate (PC), polyoxymethylene (POM), polybutylene terephthalate (PBT), polyphenylene oxide (PPO), polymethyl methacrylate (PMMA)), and thermosetting plastics (e.g., epoxy resins (EPO), phenolic resins (PF), unsaturated polyester resins (UPR)). Five core stages are integrated into our dynamic-MFA model: polymer production, plastic product manufacturing, sectoral use, waste management, and international trade. Non-plastic polymer applications (e.g., fibers, rubbers[28]) are explicitly excluded. In line with prevailing MFA methodologies, the scope is limited to plastics' socioeconomic metabolism, with upstream chemical production[29] and environmental leakage beyond system boundaries.

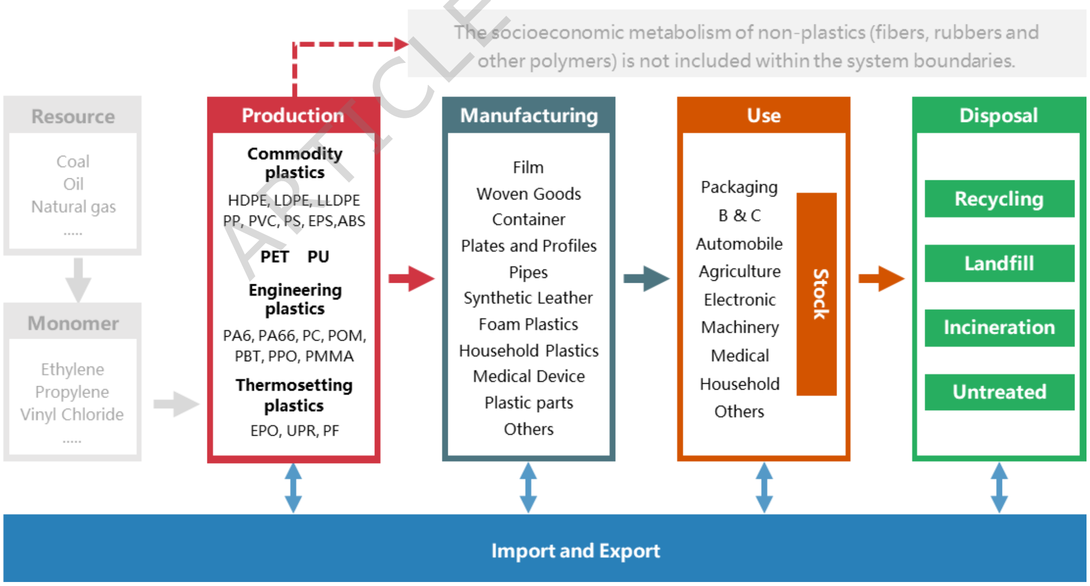

Figure 1. The Framework of the Dynamic Material Flow Analysis Model for Plastics in China. Abbreviations: B&C (Building & Construction).

Data collection and compilation

- **Polymer Production:** The apparent consumption of plastic-related polymers is quantified by combining domestic production, secondary materials, and net imports, as formalized in Equation 1:

$$P_{com,i,t} = P_{dom,i,t} + P_{im,i,t} - P_{ex,i,t} + P_{re,i,t} \quad (1)$$

$P_{dom,i,t}$, $P_{im,i,t}$, and $P_{ex,i,t}$ refer to the domestic production, import, and export of virgin polymer i in year t, respectively. $P_{re,i,t}$ refers to the production of recycled polymer i. $P_{com,i,t}$ represents the apparent consumption of polymer i in China. Virgin polymer production data are obtained from several authoritative sources, including the China Plastics Industry Yearbook[25], World Chemical Industry Yearbook[30], China Chemical Industry Yearbook[31], China Petrochemical Bulk Products Report[32], supplemented by relevant literature. Notably, there are slight variations in the production data across different sources. Detailed source attributions are presented in the input_data.xlsx file within the dataset.

- **Product Manufacturing:** During product manufacturing, base polymers are compounded with additives to achieve desired form and functional properties[33]. Pre-consumer waste generated during this process is negligible in quantity and predominantly recycled at production sites, making it peripheral to our core analysis[19]. Furthermore, primary polymers are also transformed into fibers, rubber, and other material categories, all of which are explicitly differentiated from plastic products in our classification system (Equation 2).

$$M_{com,i,j,t} = P_{com,i,t} \cdot m_{ratio,i,j,t} \cdot (1 + m_{additivies,i,t}) + M_{im,i,j,t} - M_{ex,i,j,t} \quad (2)$$

where, $M_{com,i,j,t}$, $M_{im,i,j,t}$ and $M_{ex,i,j,t}$ refer to the apparent consumption, import, and export of plastic i's products j in year t, respectively. $m_{ratio,i,j,t}$ refers to the ratio of polymer i allocated to product j, and $m_{additivies,i,t}$ indicates the additive content ratio in plastic i's products. Details of products and additives are provided in the input_data.xlsx file within the dataset.

- **Flow and Stock in Sectors:** In the usage stage, plastic products are allocated across nine sectors, as illustrated in Figure 1 and mathematically represented in Equation 3:

$$U_{com,i,k,t} = \sum_{j} M_{com,i,j,t} \cdot u_{ratio,i,j,k,t} + U_{im,i,k,t} - U_{ex,i,k,t} \tag{3}$$

where, $U_{com,i,k,t}$, $U_{im,i,k,t}$ and $U_{ex,i,k,t}$ represent the apparent consumption, import, and export of plastic i for each sector k in year t, respectively. The parameter $u_{ratio,i,j,k,t}$ denotes the allocation ratio of plastic i's product j flowing into sector k. Details of sectors can be found in the input_data.xlsx file within the dataset.

In-use plastic products exhibit delayed disposal, instead accumulating as socioeconomic stocks that deplete gradually. This stock dynamics follows product-specific lifetime patterns, captured in our dynamic-MFA framework by Equation 4:

$$S_{i,k,t} = \sum\nolimits_{t_0=1978}^{t} (U_{com,i,k,t} - O_{i,k,t}) \tag{4}$$

where $S_{i,k,t}$ refers to plastic i's stock in sector k in year t; $O_{i,k,t}$ refers to plastic i's outflow from sector k in year t, which is calculated via the lifetime distribution function (Equation 5):

$$f_{k,t} = \frac{1}{\sqrt{2\pi} D_k} \times e^{-\frac{(t-T_k)^2}{2D_k^2}} \tag{5}$$

where $f_{k,t}$ is the probability of the plastics in sector k being discarded over time t. D_k and T_k refer to the shape and position parameter of sector k. Since t-T_k may take negative values, the probability density cannot be properly normalized under the current leading factor. To ensure theoretical consistency, we adopt a truncated formulation that considers only the positive portion of the probability density function and normalizes it accordingly. As products within the same sector are generally disposed of collectively regardless of plastic type, we use representative average lifetime parameters for all plastics in that sector. The complete set of lifetime distribution parameters is provided in the input_data.xlsx file within the dataset. Then $O_{k,t}$ is calculated via Equation 6:

$$O_{i,k,t} = \sum\nolimits_{t_i}^{t} (U_{com,i,k,t} \times f_{k,t-t_i}) \quad (6)$$

- **End-of-life Disposal:** Plastic waste volumes are calculated with the following Equation 7:

$$W_{i,t} = \sum_{1978}^{t} \sum_{k} O_{i,k,t} + W_{im,\mathrm{i},t} - W_{ex,\mathrm{i},t} \quad (7)$$

where, $W_{i,t}$ represents waste plastic i in year t, and $W_{im,i,t}$ and $W_{ex,i,t}$ are its import and export, respectively.

Discarded plastic waste undergoes diverse management pathways. Following collection and sorting, a fraction of the waste stream is diverted to recycling operations, where mechanical processing regenerates secondary polymers or chemical treatment produces intermediate compounds. The non-recycled fraction is disposed of through landfilling, incineration, or untreated. We employ a hybrid method that integrates top-down and bottom-up strategies to analyze the waste management system[28]. The bottom-up approaches uses public data on plastic recycling from public sources, including the China Plastic Industry Yearbook[25] and the Development Report of the China's Plastic Recycling Industry[34]. The top-down approach enables sector-specific refinement of the rates of incineration, landfill, and untreated based on recycling volumes[25,28,34]. Given current technological and systemic constraints in plastic recycling, a portion of the material stream remains non-recoverable and re-enters the waste management process for additional treatment. Details of disposal are provided in the input_data.xlsx file within the dataset.

- **Trade of Plastics:** We employ customs data (UN Comtrade)[35] to quantify the trade of plastic-related polymers, products, and plastic waste. To harmonize UN Comtrade classifications with our study's needs, we utilize a proportional analysis strategy[28]. We identify plastic-related categories (polymers, products, and plastic waste) in the UN Comtrade system. As UN Comtrade does not provide sufficiently detailed trade data (e.g. specific plastic sub-products), we collect corresponding domestic data and assume that the distribution of sub-products within each UN Comtrade category parallels the distribution patterns observed in domestic production quantities[36,37]. This analytical framework enables the disaggregation of composite trade data into specific plastic categories relevant to our study. We determine the embedded trade of plastics within sectors by combining domestic sectoral plastic consumption with trade-to-domestic-production ratios derived from related industries. While this assumption may not fully reflect variations in product quality, specialization, or trade partner composition, it nonetheless provides a reasonable basis for estimating trade flows. Details are presented in the input_data.xlsx file within the dataset.

Sensitivity and uncertainty analysis

To ensure the robustness of our results, we incorporate both sensitivity and uncertainty analyses, with all analytical procedures implemented through standardized scripts to guarantee methodological transparency and full reproducibility.

- **Sensitivity analysis:** We test 41 groups of input parameters (see Figure 6), covering key categories such as polymer production and trade, product allocation coefficients and trade, sector allocation coefficients and trade, and end-of-life disposal parameters. In each test, we perturb the value of a group of parameters by ±10%, while keeping values of the other input parameters constant[19]. The responses of 38 groups (see Figure 6) of dynamic-MFA model results to these perturbations are investigated, including polymer apparent consumption, plastic product apparent consumption, apparent consumption of application sectors, in-use stock across application sectors, and disposal rates.
- **Uncertainty analysis**: We utilize Monte Carlo simulations to systematically evaluate the effect of input parameter uncertainties on the model. In generating random samples, we assume normal distributions for all parameters[38]. To ensure feasibility of the sampled values, the same set of proportion parameters was normalized to ensure they remained within valid bounds. For inputs corresponding to strictly non-negative flows, any negative values produced by the sampling process are set to zero, while positive values are retained.

  The standard deviations are derived through date quality assessment (DQA) and uncertainty characterization (UC)[38,39]. We evaluate the data quality from five dimensions (Reliability, Completeness, Temporal Correlation, Geographical Correlation, and Other Correlation). Then we use the uncertainty characterization to obtain the coefficient of variance (CV), which represents the level of uncertainty associated with the key parameters in our calculations.

$$CV = \begin{cases} 0 & if\ score\ =\ 1 \\ 1.5 \cdot e^{1.105 \cdot (score-1)} & if\ score\ \in [2,4] \\ 0.75 \cdot e^{1.105 \cdot score} & for\ reliability\ and\ expert\ consultation \\ 1.5 \cdot e^{1.105 \cdot score} & for\ expert\ consultation\ only \end{cases} \quad (8)$$

$$CV_{total} = \sqrt{CV_{reliability}^2 + CV_{completeness}^2 + CV_{temp.corr.}^2 + CV_{geogr.corr.}^2 + CV_{other\ corr.}^2} \quad (9)$$

The Monte Carlo simulation incorporates 30,000 randomly generated parameter sets, producing a range of model outputs. Subsequent statistical analysis yields the mean estimates along with their 95% confidence intervals[38].

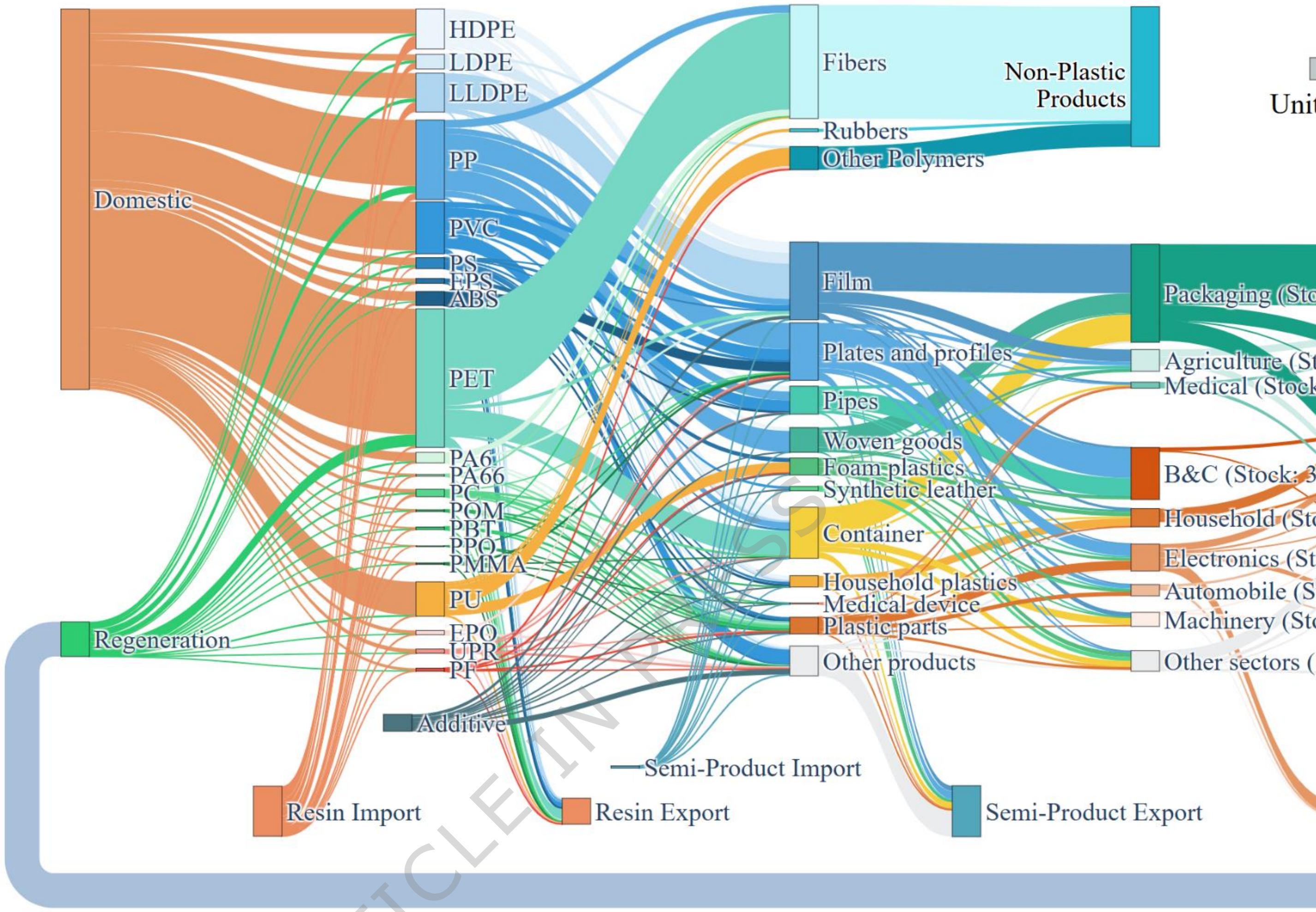

Figure 2. Simplified diagram of plastic flows and stocks in China in 2022.

Data Record

The dataset is available at the Science Data Bank repository[40] (https://doi.org/10.57760/sciencedb.27927), which systematically presents stocks and flows of plastic in China. All subset datasets are stored in structured tabular formats and are accompanied by quantified uncertainty analysis to ensure data quality. The dataset comprises two core components:

High-resolution dataset

It comprises 60,000+ entries (see output_long_data.xlsx), with each entry containing labeled metadata including year, socioeconomic metabolism stage, process, plastic type, product type, end-use sector, and waste management method. All quantitative values are presented as mean estimates with corresponding 95% confidence intervals derived from uncertainty analysis. Figure 2 illustrates a simplified Sankey diagram of plastic flows and stocks in China in 2022, demonstrating the database's analytical capabilities for visualizing complex flow patterns.

Aggregated dataset

The aggregated database (output_wide_data.xlsx) contains 12 structured worksheets, including:

1) **Polymer production and consumption:** providing time-series data of domestic production and apparent consumption for 20 major plastic types, as illustrated in Figures 3a, 3b.
2) **Plastic products manufacturing and consumption:** providing time-series data of manufacturing and consumption for 11 principal product types (e.g. films, containers, and pipes), as illustrated in Figures 3c, 3d.

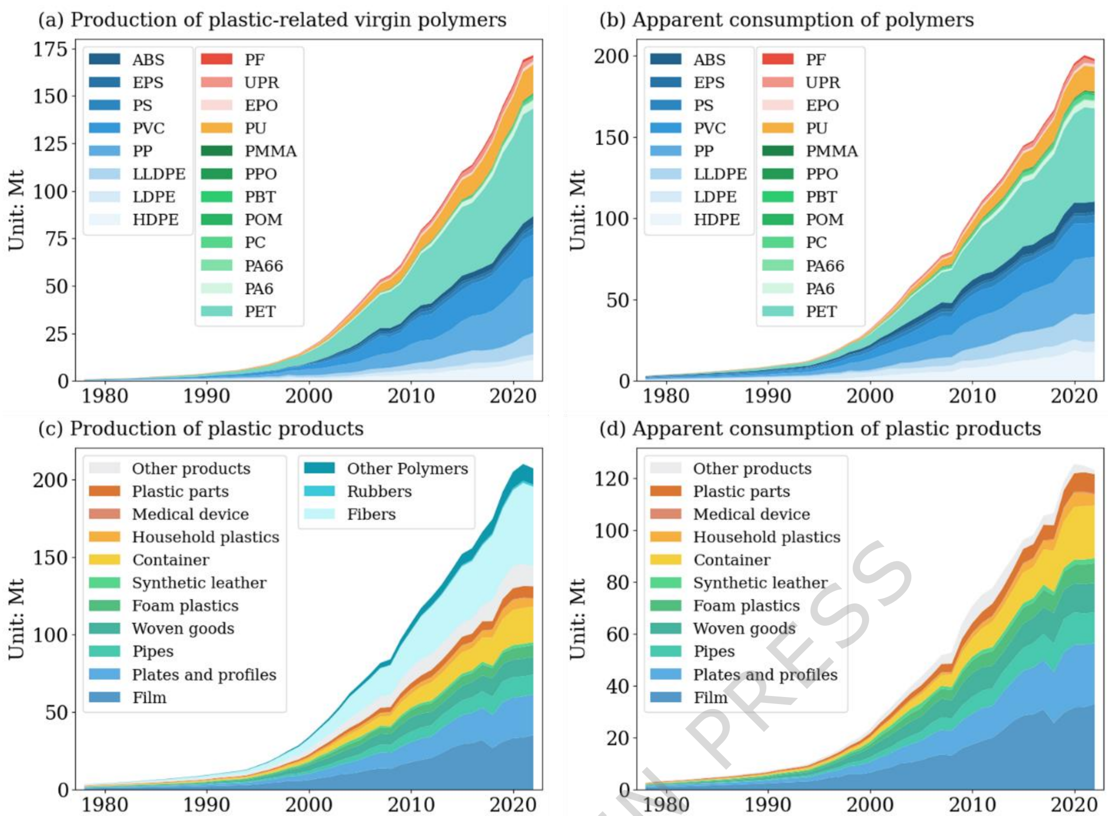

Figure 3. Temporal patterns of plastic production in China from 1978 to 2022: (a) virgin polymer production, (b) apparent polymer consumption, (c) plastic product manufacturing, and (d) apparent plastic product consumption.

3) **Sectoral inflows (consumption):** providing time-series data of inflows (consumption) of 9 major sectors (e.g. packaging, automotive, electronics, and agriculture) by plastic type and sector, as illustrated in Figures 4a, 4b.
4) **Sectoral stocks:** Estimating plastic stocks accumulated in 9 major sectors (e.g., packaging, automotive, electronics, and agriculture), with time-series data of stocks by plastic type and sector that reveal accumulation patterns in socioeconomic systems, as illustrated in Figures 4c, 4d.

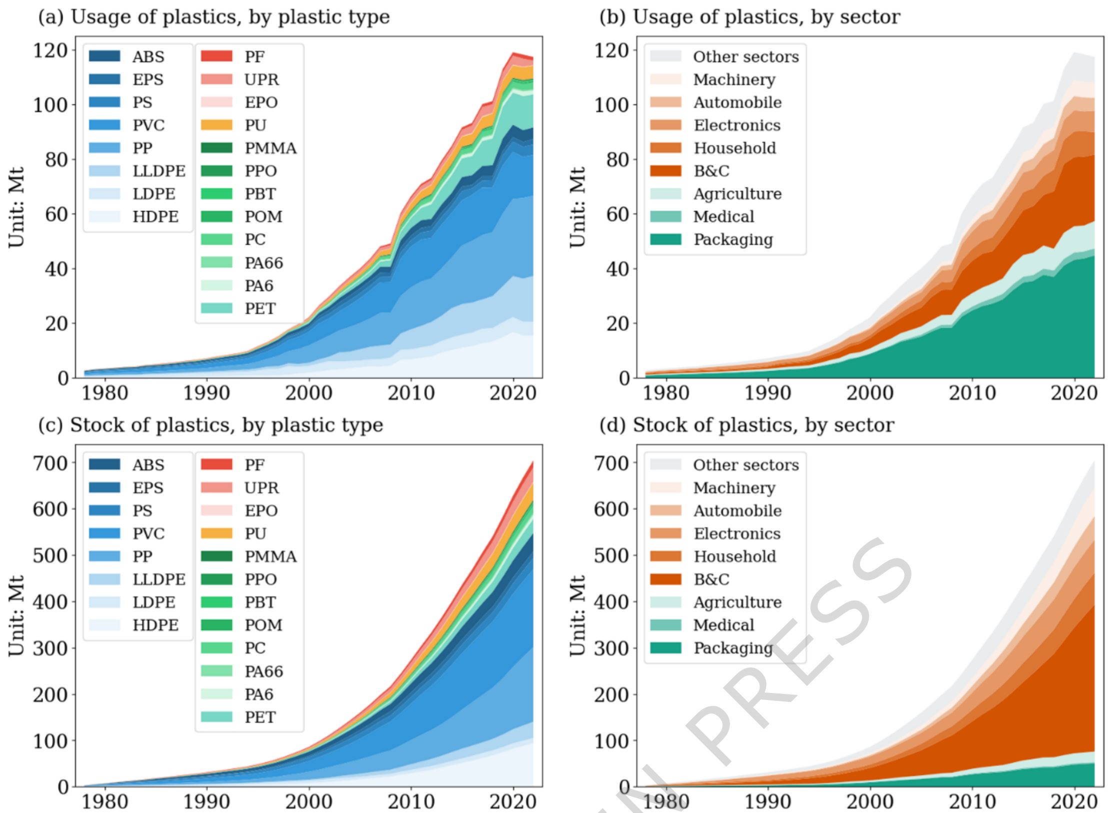

Figure 4. Temporal patterns of plastic sectoral use and stock in China from 1978 to 2022: (a) usage of plastics by plastic type, (b) usage of plastics by sector, (c) stock of plastics by plastic type, and (d) stock of plastics by sector. Abbreviations: B&C (Building & Construction).

5) **Sectoral outflows (plastic waste generation):** providing time-series data of outflows (plastic waste) of 9 major sectors (e.g. packaging, automotive, electronics, and agriculture) by plastic type and sector, as illustrated in Figures 5a, 5b.
6) **Plastic waste management:** providing plastic waste disposal through 4 disposal methods (landfill, incineration, recycling, etc.), including time-series data for both domestic post-consumer plastic waste and all plastic waste (accounting for imports/exports), as illustrated in Figures 5c, 5d.

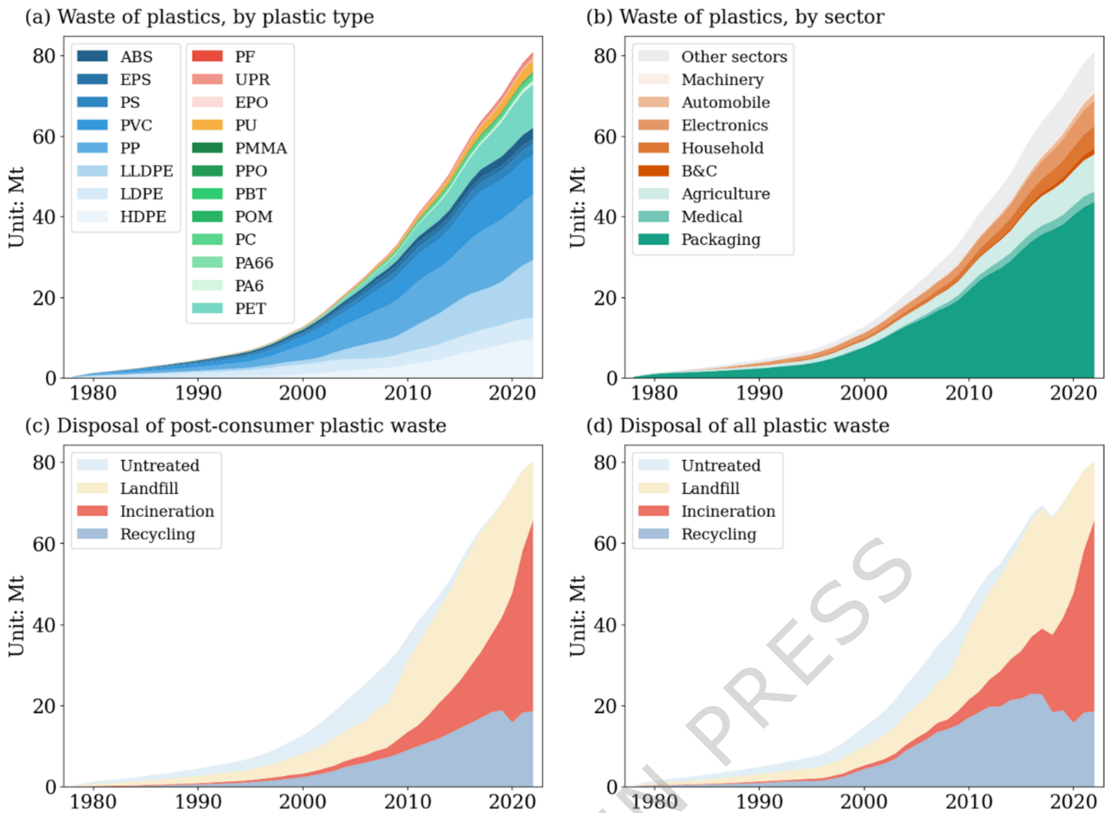

Figure 5. Temporal patterns of plastic waste in China from 1978 to 2022. (a) waste of plastics by plastic type (b) waste of plastics by sector (c) disposal of post-consumer plastic waste, and (d) disposal of all plastic waste (including import and export). Abbreviations: B&C (Building & Construction).

Technical Validation

Comparison with existing studies

This work integrates our two previous studies[19,28] into a consistent analytical framework and advances our earlier study[19] by incorporating updated data, recalibrated coefficients, and refined model structures. It further extends the analytical scope by covering a wider range of use sectors and plastic categories. We compared our results with existing studies on plastic flows and stocks in China[13,17,20], including our prior analysis on commodity plastics[19].

In the comparative analysis, we focus on plastic flows and in-use stocks. Although production data are important, most studies, and our study as well, rely on the same source. This source is the official statistical yearbooks, which we consider relatively reliable. Therefore, we direct our comparison toward two aspects with greater methodological variability: in-use stocks across sectors (Table 1) and end-of-life disposal flows (Table 2). The comparison of in-use stock covers five key sectors, including packaging, construction, transportation, electronics, and agriculture, together with their aggregated totals. They represent the intersection of sectors reported across all studies, ensuring comparability. Our results fall within the mid-range of total in-use stock estimates reported in existing studies. Sectoral differences are primarily driven by variations in the data sources and assumptions used for product-to-sector allocation coefficients across studies.

The comparison of disposal includes four pathways, namely landfilling, incineration, recycling, and untreated. These are presented as proportional shares, together with their aggregated totals. For each referenced study, we aligned our data aggregation to match the reported scope. Our model indicates slightly lower total waste generation due to refined sectoral resolution—particularly through disaggregation of long-life sectors (e.g., machinery, household durables) from "other sectors," resulting in higher in-use stock retention rather than immediate waste flows. The proportions for disposal pathways of our study generally fall within the range of existing studies.

Additionally, another study[41] examined the plastic content in incinerated municipal solid waste (MSW). As shown in Table 3, our calculations indicate that the plastic content in MSW was 14.9% in 2006 and 19.1% in 2020, closely aligning with the literature-reported values of 14.6% and 19.3%, respectively. This consistency further supports the reliability of our data.

Table 1. Comparison of in-use stock with existing studies (Unit：Mt).

Study	Year	Plastic Coverage	Packaging	B&C	Automobile	Electronics	Agriculture	Total
Luan et al, 2021[20]	2020	PE, PP, PVC, PS, ABS, PET, others	27.6	361.3	43.9	79.2	13.7	525.7
This study	2020	All 20 types of plastics	47.7	271.4	44.2	68.7	21.8	453.7
Liang et al, 2023[17]	2020	HDPE, LDPE, PP, PVC, PS, EPS, ABS, PET	0.01	195.0	31.0	46.0	7.0	279.0
This study	2020	HDPE, LDPE, LLDPE, PP, PVC, PS, EPS, ABS, PET	46.5	237.3	22.9	47.5	20.9	375.1
Jian et al, 2022[13]	2019	PE, PP, PVC, PS, ABS	81.6	167.2	47.6	72.8	34.5	403.7

This study	2019	HDPE, LDPE, LLDPE, PP, PVC, PS, EPS, ABS	33.7	216.2	19.1	45.9	19.9	334.7
Jiang et al, 2020[19]	2017	PE, PP, PVC, PS, ABS	9.7	182.6	16.4	50.4	7.2	266.3
This study	2017	HDPE, LDPE, LLDPE, PP, PVC, PS, EPS, ABS	33.4	177.4	15.3	44.0	18.3	288.5

Table 2. Comparison of end-of-life disposal data with existing studies. Compared with Table 1, PET and "others" are excluded here because the reference study did not report end-of-life data for "others," and the scope of PET is not directly comparable with this study.

Study	Year	Plastic Coverage	Landfill rate	Incineration rate	Recycling rate	Untreated rate	Total (Mt)
Luan et al, 2021[20]	2020	PE, PP, PVC, PS, ABS	33.9%	31.9%	29.4%	4.8%	68.1
This study	2020	HDPE, LDPE, LLDPE, PP, PVC, PS, EPS, ABS	37.6%	46.0%	16.2%	0.2%	57.4
Jian et al, 2022[13]	2000-2019	PE, PP, PVC, PS, ABS	33.9%	32.4%	27.5%	6.2%	590.4
This study	2000-2019	HDPE, LDPE, LLDPE, PP, PVC, PS, EPS, ABS	46.0%	18.7%	21.0%	14.3%	639.9
Jiang et al, 2020[19]	2017	PE, PP, PVC, PS, ABS	45.9%	27.5%	25.0%	1.5%	52.8
This study	2017	HDPE, LDPE, LLDPE, PP, PVC, PS, EPS, ABS	49.6%	27.4%	21.7%	1.3%	51.7

Table 3. Comparison of end-of-life Incinerated plastic waste data with existing studies.

		2006	**2020**
This study	Plastic content	14.9%	19.1%
Liu et al, 2025[41]	Plastic content	14.6%	19.3%

Uncertainties, limitations, and future work

Due to limited statistical data, we integrated multiple sources, including literature, industry reports, statistical estimations, and expert consultations. To improve data quality, we applied systematic uncertainty analysis and incorporated uncertainty ranges. Sensitivity analysis identified the main sources of uncertainty in the database (Figure 6) and assessed the impact of key assumptions on the results. Parameters with high sensitivity and strong dependence on assumptions were identified as priorities for refinement in future model updates. The specific findings are summarized as follows:

1) **Product and sector allocation coefficients:** Sensitivity analysis indicates that allocation parameters related to certain product categories (e.g., other plastic products) and aggregated sectors (e.g., other sectors) can noticeably influence the results. In this study, we adopted coefficient values based on the best available literature and empirical data. As summarized in Table 1, despite differences in parameterization across studies, the overall allocation patterns remain broadly consistent.

   Additive Ratios: Considerable variability in plastic formulations makes precise additive ratio determination challenging. This study synthesized formulation data and expert estimates, assuming constant additive ratios within each year. Sensitivity analysis indicates that additive ratios have limited impact (±2%) on most results, except for the apparent consumption of specific products.

2) **Recycling volume:** Since detailed data on plastic waste recycling are scarce and high-resolution data from the Plastic Recycling Association of the China National Resources Recycling Association[34] have only become available in recent years, our analysis adopts

estimation-based approaches, following the practice of previous studies[28]. Sensitivity analysis indicates that the recycling volume exerts a strong influence on the estimated recycling rate. During expert consultations, several industry experts suggested that China's actual recycling volume and rate may be underestimated and could be higher than values reported in recent publications. For example, one team employed a combination of enterprise surveys, urban modeling, and life-cycle assessment to mutually cross-validate their results, estimating plastic waste generation, collection, and recycling in China. Their findings indicate a significant discrepancy between reported plastic recycling data and actual industrial practices in the country[42]. This highlights the need for future studies to better verify and calibrate national-level recycling flows and rates.

Disposal Parameters: Other disposal pathways are associated with inherent uncertainties in parameter selection, particularly under top-down estimation approaches. Given current data limitations, we adopted commonly used assumptions that reflect the best available knowledge. Moreover, the dynamic MFA framework requires iterative calculations to account for recycling loops, which adds to the complexity of parameter calibration. Our sensitivity analysis indicates that assumptions on waste disposal rates can noticeably affect the results, suggesting the need for continued refinement as more detailed data become available.

3) **Plastic Trade Data:** Resin trade data from customs is considered reliable, but product trade data lacks resolution and requires disaggregation[28]. Sectoral allocation relies on assumed plastic intensities due to limited data[28]. Sensitivity analysis indicates that uncertainties in resin imports and sectoral product exports may affect the results; the influence of uncertainties in most plastic product trade is comparatively small (±2%).

4) **Lifetime Distribution Parameters:** The choice of distribution functions and input parameters substantially affects estimates of plastic stocks and end-of-life flows. Future improvements require more detailed, survey-based lifetime distributions.

Here, we systematically identify key sources of uncertainty and outline possible directions for model improvement. While further refinements could help improve accuracy, particularly those based on more detailed primary data and parameterization, our current approach represents a careful and transparent treatment based on the best information available. These efforts also help inform future modelling work.

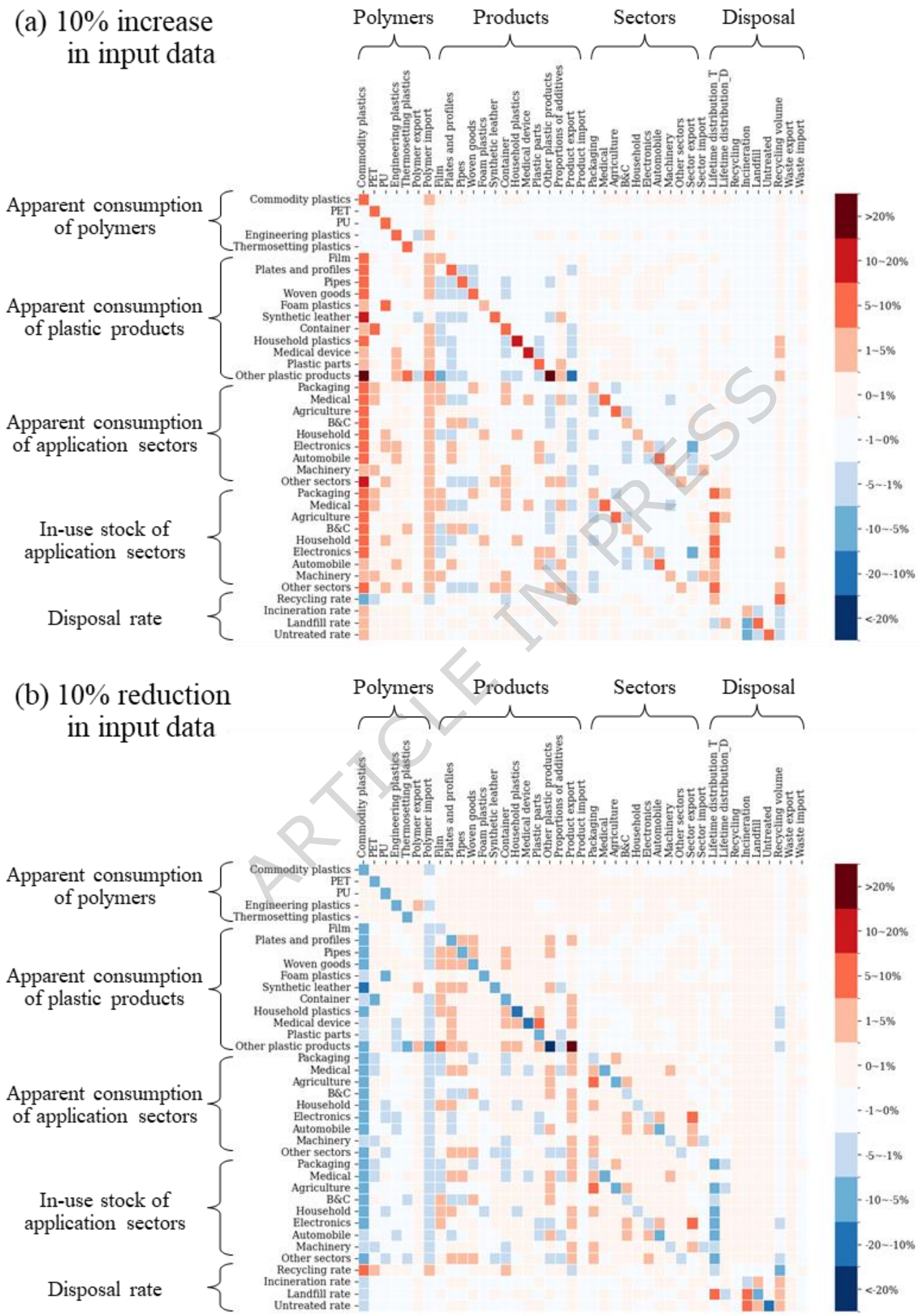

Figure 6. The results of sensitivity analysis. The x-axis represents the modified input parameters

(adjusted by ±10% from their baseline values), while the y-axis lists the output metrics in 2022 used for sensitivity evaluation. The color gradient reflects the relative deviation (%) of each output metric from its unperturbed baseline.

Usage Notes

This work provides systematic data to identify plastic pollution policy priorities. The structured dataset enables direct use of output data or customized calculations using shared raw data and codes, supporting value-chain analyses, environmental assessments, and plastic pollution mitigation strategies. For instance, it can support (1) coupling with life cycle assessment (LCA) models to quantify environmental impacts, (2) integrating microplastic release factors to evaluate ecological risks of different plastic categories, or (3) conducting scenario-based analyses and policy assessments under diverse future conditions.

Data Availability

The dataset is available the Science Data Bank repository[40] (https://doi.org/10.57760/sciencedb.27927).

Code Availability

All computations in this study, including data preprocessing and material flow modeling, were performed in Python (calculate.py), processing the raw input dataset (input_data.xlsx) to generate the output dataset (baseline_long_data.xlsx and baseline _wide_data.xlsx). Supplementary Python scripts (sensitivity.py and uncertainty.py) enable statistical validation and uncertainty quantification, generating analytical outputs (output_sensitivity_data.xlsx, output_uncertainty_long_data.xlsx and output_uncertainty_wide_data.xlsx). All the codes can also be obtained from the Science Data Bank repository[40] (https://doi.org/10.57760/sciencedb.27927).

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Author Contributions

B.Z., D.C. and M.J. conceptualized, advised and managed this study. Y.R., H.Z., Y.C., X.J. and

M.J. collected the data, developed the model, and analyzed the results. All authors (Y.R., H.Z., Y.C., X.J., D.C., M.J., M.X., B.G. and B.Z.) wrote the paper. Y.R., H.Z., Y.C. and X.J. contributed equally.

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Competing Interests

The authors declare no competing interest.

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