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内蒙古植被 NDVI 变化趋势及影响因子数据集（2000–2015）

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摘　要：基于2000–2015年每月的分辨率为1 km的SPOT/VEGETATION NDVI数据，运用最大值合成法生成每年的NDVI数据；结合统计年鉴数据，采用趋势分析法和地理探测器模型，计算得到内蒙古植被NDVI变化趋势及影响因素数据集（2000–2015）。该数据集包括地理信息系统空间数据和统计表格数据两种类型。空间数据包括：（1）内蒙古2000–2015年NDVI年变化趋势1 km栅格数据；（2）基于2000–2015年NDVI年变化趋势的变化程度分类1 km栅格数据；（3）自然因素数据，包括2000–2015年的降水量、平均气温变化趋势、坡向、坡度分级和植被类型1 km栅格数据；（4）以旗、县为基础单元的人为因素地理信息系统数据，包括2000–2015年乡村人口变化趋势、乡村户数变化趋势、乡村劳动力变化趋势、粮食产量变化趋势、农牧民人均纯收入变化趋势和牲畜数量变化趋势等6项属性数据。表格数据包括：（1）基于植被NDVI变化划分的植被变化等级所占的面积及比例；（2）导致内蒙古牧业旗县和非牧业旗县植被NDVI变化的主要影响因素及*q*值。数据集存储为.tif、.shp和.xlsx格式，由47个文件组成，数据量为65.4 MB（压缩为1个文件，12.7 MB）。

关键词：地理探测器；植被NDVI；内蒙古；人为因素；自然因素

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数据可用性声明：

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1　前言

植被是陆地生态系统重要的组成部分[1]，是陆地生态系统物质循环、能量流动、信息传递的重要枢纽[2]。植被覆盖度变化表示着整个陆地生态系统一定程度上的波动或变化[3]。特别是在干旱半干旱地区，植被覆盖度变化是监测和评价生态环境变化的一个重要指标[4]。所以定量分析区域植被覆盖度变化并探寻其驱动因素对于生态环境建设具有重要的意义。内蒙古地域辽阔，地势较高，全区地貌以蒙古高原为主体，具有复杂多样的形态[5]。除东南部外，基本都是高原。内蒙古是我国北部的重要生态屏障，属于干旱、半干旱气候，是

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[2] 陈宽, 潮洛濛. 内蒙古植被NDVI变化趋势及影响因子数据集（2000–2015）[J/DB/OL]. 全球变化数据仓储电子杂志, 2020. DOI: 10.3974/geodb.2020.05.07.V1.

全球变化最为敏感的区域之一[4]。

内蒙古自治区旗（县、区）按照产业特点主要分为牧区、半农半牧区、农区和城区等类型。牧区以放牧为主，天然草地为主要植被类型，其余旗县以非牧业为主，农田为主要植被类型[6]。

本数据集基于连续时间序列的SPOT/VEGETATION NDVI卫星遥感数据和统计年鉴数据，以内蒙古为研究对象，利用地理探测器模型计算了2000–2015年自然和人为因素对内蒙古植被NDVI变化的影响数据集。地理探测器是探测空间分异性，以及揭示其背后驱动力的一组统计学方法。它能探测各因子对模型的贡献率，能从庞大的空间数据库中提取有用的空间关联规则[7]。该数据集对区域生态文明建设和合理引导城乡人口迁移提供一定的参考。

2 数据集元数据简介

《内蒙古植被NDVI变化趋势及影响因子数据集（2000–2015）》[8]的名称、作者、地理区域、数据年代、时间分辨率、空间分辨率、数据集组成、数据出版与共享服务平台、数据共享政策等信息见表1。

表1 《内蒙古植被NDVI变化趋势及影响因子数据集（2000–2015）》元数据简表

条　目	描　述
数据集名称	内蒙古植被NDVI变化趋势及影响因子数据集（2000–2015）
数据集短名	NDVIChange.InnerMongolia_2000-2015
作者信息	陈　宽，内蒙古大学，im_chk@163.com 潮洛濛，内蒙古大学，colmvn@aliyun.com
地理区域	内蒙古　　数据年代　2000–2015
数据格式	.tif、.xlsx、.shp　　数据量　51.7 MB（压缩后）
数据集组成	空间数据包括：（1）内蒙古2000–2015年NDVI年变化趋势1 km栅格数据；（2）基于2000–2015年NDVI年变化趋势的变化程度分类1 km栅格数据；（3）自然因素数据，包括2000–2015年的降水量、平均气温变化趋势、坡向、坡度分级和植被类型1 km栅格数据；（4）以旗、县为基础单元的人为因素地理信息系统数据，包括2000–2015年乡村人口变化趋势、乡村户数变化趋势、乡村劳动力变化趋势、粮食产量变化趋势、农牧民人均纯收入变化趋势和牲畜数量变化趋势等6项属性数据。表格数据包括：（1）基于植被NDVI变化划分的植被变化等级所占的面积及比例；（2）导致内蒙古牧业旗县和非牧业旗县植被NDVI变化的主要影响因素及q值。
基金项目	中华人民共和国科学技术部（2016YFC050604-4）；国家自然科学基金（31060117）
出版与共享服务平台	全球变化科学研究数据出版系统 http://www.geodoi.ac.cn
地址	北京市朝阳区大屯路甲11号100101，中国科学院地理科学与资源研究所
数据共享政策	全球变化科学研究数据出版系统的“数据”包括元数据（中英文）、通过《全球变化数据仓储电子杂志（中英文）》发表的实体数据和通过《全球变化数据学报（中英文）》发表的数据论文。其共享政策如下：（1）“数据”以最便利的方式通过互联网系统免费向全社会开放，用户免费浏览、免费下载；（2）最终用户使用“数据”需要按照引用格式在参考文献或适当的位置标注数据来源；（3）增值服务用户或以任何形式散发和传播（包括通过计算机服务器）“数据”的用户需要与《全球变化数据学报》（中英文）编辑部签署书面协议，获得许可；（4）摘取“数据”中的部分记录创作新数据的作者需要遵循10%引用原则，即从本数据集中摘取的数据记录少于新数据集总记录量的10%，同时需要对摘取的数据记录标注数据来源[9]
数据和论文检索系统	DOI，DCI，CSCD，WDS/ISC，GEOSS，China GEOSS，Crossref

3　数据研发方法

本研究是基于连续时间序列的 SPOT/VEGETATION NDVI 卫星遥感数据[10]，采用最大值合成法生成的年度 NDVI 植被指数。自然因素包括气候、高程、植被。其中气候数据是通过插值计算的分辨率为 1 km × 1 km 的年降水量和年平均气温栅格图。高程是基于最新的 SRTM V4.1 数据经重采样生成的 1 km 数据。植被类型分布数据分别来源于 1：100 万植被图数字化生成的图，分辨率为 1 km；坡度、坡向由分辨率为 1 km 的 DEM 数据计算获取。以上数据来源于（http://www.resdc.cn）[11]。人为因素数据来源于内蒙古统计年鉴[12]，包括乡村人口、乡村劳动力、乡村户数、粮食产量、农牧民人均收入、牲畜数量（统一换算成羊单位：骆驼、马、牛相当于 5 只绵羊，山羊则为 1 只）。

3.1　算法原理

本研究采用趋势线分析方法对研究时间段内 NDVI、气候和人为因素的变化趋势进行分析[6]，即以时间 t 为自变量，分别对 NDVI、年均气温、年降水量以及 6 个人为因素进行一元线性回归分析。

利用 NDVI 序列与时间的相关系数 R 判断了植被覆被变化程度和性质，并且利用相关系数的大小进行显著性判断[6]。显著性临界值由查相关系数检验临界值表获得（样本数为 16 时，显著性水平在 0.05 和 0.01 时临界值分别为 0.468、0.590）。根据 NDVI 变化趋势斜率及显著性临界值，将植被变化类型分为极显著退化、显著退化、无显著变化、显著改善、极显著改善五类。

利用地理探测器模型[9]的空间分异及因子探测分析自然和人为因素对内蒙古植被 NDVI 的影响。

4　数据结果与验证

4.1　数据集组成

《内蒙古植被 NDVI 变化趋势及其影响因素数据集（2000–2015）》主要包括 11 组空间数据（表 2）和 2 个统计表数据（包括内蒙古植被 NDVI 不同变化等级面积及占比数据；导致内蒙古牧业旗县和非牧业旗县植被 NDVI 变化的主要影响因素及 q 值）。

表 2　影响内蒙古植被 NDVI 变化的自然因素和人为因素对比表

类别	因素	说明	对应文件或字段
自然因素	年降水量	2000–2015 年降水量变化趋势	IM_pre00_15slope.tif
	年平均气温	2000–2015 年平均气温变化趋势	IM_tem00_15slope.tif
	坡度	由分辨率为 1 km 的 DEM 数据计算	IM_slope.tif
	坡向	由分辨率为 1 km 的 DEM 数据计算	IM_aspect.tif
	植被类型	1995 年编制《1：100 万中华人民共和国植被图》数字化生成的图，分辨率为 1 km	IM_vegatation_type.tif
人为因素	乡村人口变化	2000–2015 年乡村人口变化率	Rp_slope
	乡村户数变化	2000–2015 年乡村户数变化率	house_slope
	乡村劳动力变化	2000–2015 年乡村劳动力变化率	labor_slope
	粮食产量变化	2000–2015 年粮食产量变化率	grain_slope
	农牧民人均纯收入变化	2000–2015 年农牧民人均纯收入变化率	Rgdp_slope
	牲畜数量变化	2000–2015 年牲畜数量变化率	sheep_slope

4.2 数据结果

由于地理探测器是针对离散数据的算法，所以对连续变量（本文 11 个自变量中，除了植被类型、坡向，其他均是连续变量）进行了离散化处理。本文采取自然断点法[13]，将坡度分为 9 类，其余因素分为 10 类（图 1）。

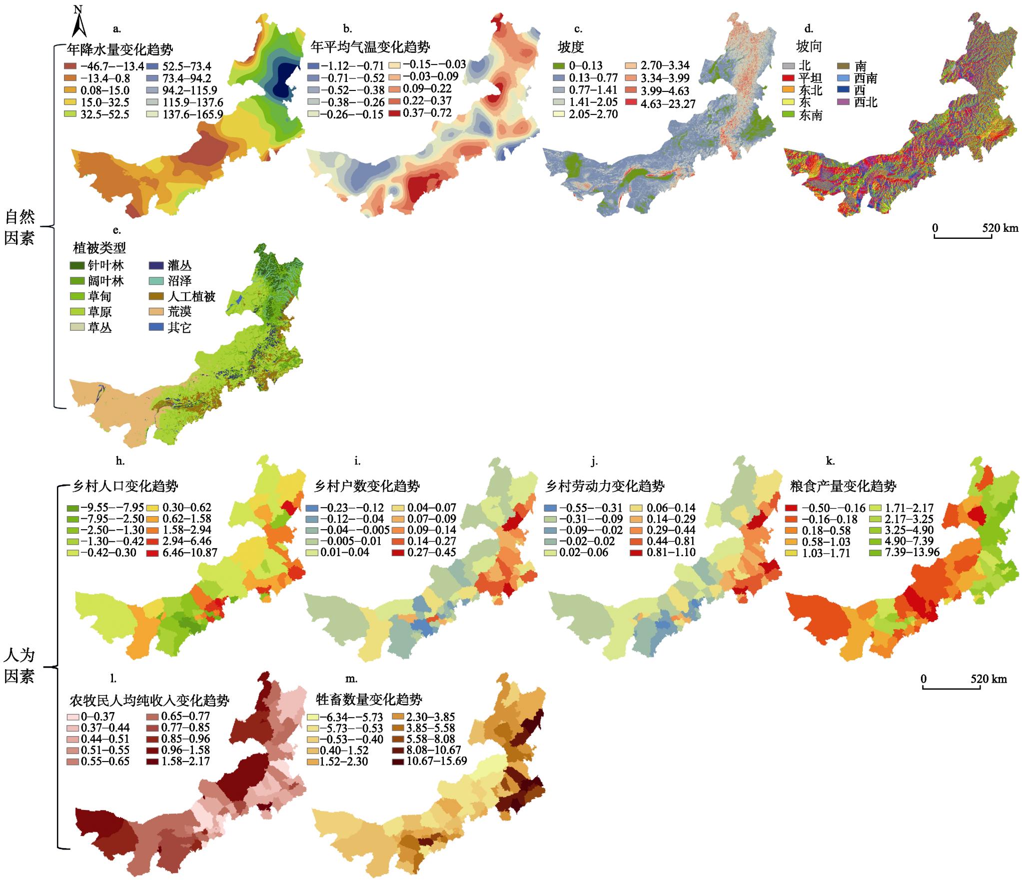

图 1 2000–2015 年自然因素与人为因素的空间分布图

2000–2015 年，16 年间整个研究区 NDVI 在空间上增加和减少共存，总体上呈增加趋势。空间上显现出西部减少，东部与南部增加的趋势，其余地区变化较小。整个研究区植被极显著改善面积达到了 249,842.65 km^2，占整个内蒙古总面积的 21.88%，显著改善面积占 10.88%，无变化 64.38%，显著退化 1.88%，极显著退化 1.00%（表 3）。可以看出在研究时段内植被改善面积大于植被退化面积，植被覆盖度增加明显。在空间上植被退化与植被改善区域分布不均匀，退化区域主要分布在阿拉善盟的西北部和个别城镇周围。牧业旗县植被极显著改善面积占比达到了 9.65%，显著改善 7.24%，无变化 79.34%，显著退化 2.56%，极显著退化 1.20%（表 3）。牧业旗县植被退化面积占比超过了整个研究区植被退化面积占比，表明牧业旗县植被退化相对于整个研究区较严重；植被改善面积占比低于整个研究区改善面积占比，表明相对于整个研究区改善水平低于全局改善水平。非牧业旗县植被极显

著改善面积占比达到了 47.54%，显著改善 18.52%，无变化 33.00%，显著退化 0.35%，极显著退化 0.57%（表 3）。可以看出植被改善区域主要分布在非牧业旗县。

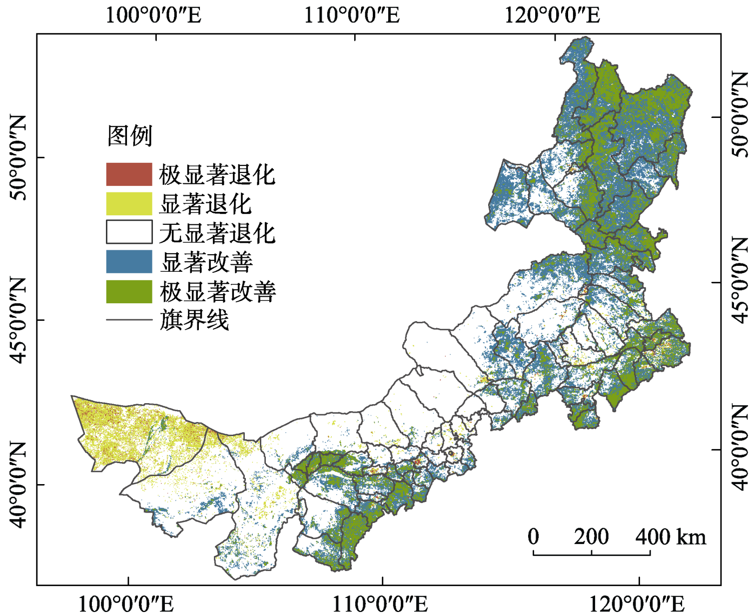

图 2　2000–2015 年内蒙古基于 NDVI 年际变化趋势及其显著性的植被变化空间分布图

表 3　NDVI 不同变化等级面积及占比统计表

分区	分级	极显著退化	显著退化	无显著变化	显著改善	极显著改善	总和
全部区域	面积（km^2）	11,458.14	21,105.13	734,992.38	124,233.05	249,842.65	1,141,631.35
	百分比（%）	1.00	1.84	64.38	10.88	21.88	100
牧业旗县	面积（km^2）	9,335.95	19,785.55	613,648.39	56,000.29	74,631.31	773,401.50
	百分比（%）	1.20	2.56	79.34	7.24	9.65	100
非牧业旗县	面积（km^2）	2,118.41	1,312.53	121,529.47	68,199.76	175,069.49	368,032.66
	百分比（%）	0.57	0.35	33.00	18.52	47.54	100%

地理探测器因子探测器表示各自然与人为因素对植被 NDVI 变化的影响，用 q 值来表示。其因子探测模块的核心思想是：地理事物总是存在于特定的空间位置上，影响其发展变化的环境因素在空间上具有差异性，若某环境因素和地理事物的变化在空间上具有显著的一致性，则说明这种环境因素对地理事物的发生和发展具有决定意义[7]。整个研究区来看，各因素对植被 NDVI 变化影响程度排序为：年降水量>土壤类型>植被类型>粮食产量>牲畜数量>农牧民人均纯收入>乡村户数>乡村人口>地貌类型>乡村劳动力>年平均气温>坡度>坡向。影响植被 NDVI 的前五个主要影响因子中前三个为自然因素，随后两个是人为因素，表示自然因素的影响力大于人为因素。牧业旗 q 值从大到小排序依次为：年降水量>土壤类型>植被类型>粮食产量>农牧民人均纯收入>牲畜数量>乡村户数>地貌类型>乡村人口>乡村劳动力>年平均气温>坡面>坡度（图 3），前五个主要影响因子中自然因素三个、

人为因素两个，表明自然因素对植被 NDVI 的变化的影响比人为因素较强。非牧业旗县 q 值从大到小排列依次为：粮食产量>乡村劳动力>年平均气温>土壤类型>年降水量>乡村户数 > 农牧民人均纯收入>牲畜数量>乡村总人口>地貌类型>坡度>植被类型>坡向（图 3）。前五个主要影响因子中前两个均为人为因素，表明除了牧业旗以外的非牧业旗县人为因素是影响植被覆盖度变化的主导因素。

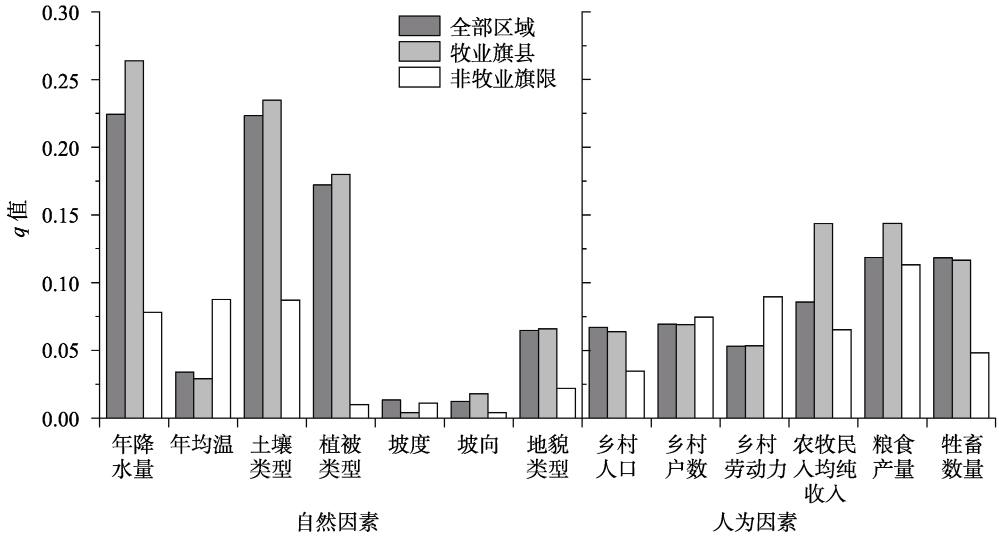

图 3 导致内蒙古植被 NDVI 变化分布的 7 个自然因素和 6 个人为因素的 q 值对比图

4.3 数据结果验证

NDVI 所表示的植被覆盖度精度大小在于所用原始数据的空间分辨率，本文利用分辨率为 1 km 的 SPOT/VEGETATION NDVI 数据，在结果上与前者的研究结果一致[14]。

地理探测器是探测空间分异性，以及揭示其背后驱动力的一组统计学方法。在分析地理要素格局演变和地域空间分异等方面具有非常广泛的应用[7]。但需要指出的是，由于研究区的数据最大行数超过了地理探测器模型运行的上限，运用 ArcGIS 软件的 Create Random Points 功能来按比例随机提取适宜样本来进行因素探测，可能会对最终的研究结果产生一定影响。

5 讨论和总结

研究区域植被覆盖度变化并探寻其驱动因素对于生态环境建设具有重要意义。本文将内蒙古旗县分为牧业旗县和非牧业旗县，并且应用线性趋势分析和地理探测器探讨 2000–2015 年自然和人为因素对植被 NDVI 变化的影响。从结果可以看出 2000–2015 年内蒙古植被覆盖度时空变化明显，总体上呈增加趋势。在空间上呈现西部减少，东部与南部增加趋势，其余地区变化不明显。全区中改善区域占 32.76%，退化区域 2.88%。整个研究区，植被 NDVI 变化受自然因素的影响大于人为因素，降水和土壤类型是主要驱动因素，其解释率在 22%以上。牧业旗县的自然因素对植被 NDVI 变化的影响大于人为因素。而在非牧业旗县，植被 NDVI 变化受人为因素的影响大于自然因素，粮食产量是主要驱动因素，

其解释率在 11%以上。本研究可以作为区域生态文明建设和合理引导城乡人口迁移的参考，亦可为内蒙古植被 NDVI 变化的深入研究提供一定的数据基础。

作者分工：潮洛濛对数据集的开发做了总体设计；陈宽采集和处理了数据并撰写了数据论文。

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Global Change Research Data Publishing & Repository

NDVI Change Trend and Impact Factors Dataset in Inner Mongolia (2000–2015)

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Abstract: Based on monthly 1 km SPOT/VEGETATION NDVI data from 2000 to 2015, a dataset of annual NDVI data was generated using the maximum value synthesis method. Then statistical yearbook data, trend analyses, and a geographical detector model were used to calculate the trend of change in the NDVI and to assess the impact factors for Inner Mongolia. The dataset is categorized into GIS 1 km raster data; information on the degree of change in the NDVI; data on natural phenomena such as precipitation, average temperature, slope aspect, and so on; and human-related components such as changes in rural populations, labor force, grain output, and per capita net income of farmers and herdsmen, among others. Some data are also provided in table format, including the area and proportion of change in vegetation and the main impact factors.

Keywords: geographical detector; vegetation NDVI; Inner Mongolia; human factors; natural factors

Dataset Available Statement:

The dataset supporting this paper was published at: Chen, K., Chao, L. M. Dataset of NDVI change trends and impact factors in Inner Mongolia (2000–2015) [J/DB/OL]. *Digital Journal of Global Change Data Repository*, 2020. DOI: 10.3974/geodb.2020.05.07.V1.

1 Introduction

Vegetation is a vital part of terrestrial ecosystems that serves as a hub of material circulation, energy flow, and information transmission[1–2]. Changes in vegetation coverage can indicate fluctuations or changes in whole ecosystems to a certain degree[3]. Particularly in arid and semi-arid areas, changes in vegetation coverage are an important indicator for monitoring and evaluating changes in ecology[4]. Therefore, it is of great significance to quantitatively analyze changes in regional vegetation coverage and explore the driving factors.

Inner Mongolia is a vast territory with a high diversity of ecosystems, although the main landform is the Mongolian Plateau[5]. Due to this plateau, Inner Mongolia is an important ecological barrier in northern China. The region has an arid and semi-arid climate, and has been reported to be particularly sensitive to global climate change[4].

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Regarding human industry, the counties in the Inner Mongolia autonomous region are mainly divided into pastoral, agricultural, semi pastoral, semi agricultural and urban areas. Pasture area is dominated by grazing, where natural grassland is the main vegetation type. Non-animal husbandry is the main vegetation type in other counties, and farmland is the main land use type[6].

The dataset is developed based on the SPOT/VEGETATION NDVI database. Then we calculated the trend of change in the NDVI for 2000 to 2015 and assessed the natural and human factors using statistical data, trend analyses, and a geographical detector model[7]. The dataset provides a useful reference on the vegetation in this region, how it has changed, and the main driving factors, and may serve as a guide for urban and rural developmental decisions.

2 Metadata of the Dataset

The metadata summary of the "Dataset of NDVI change trends and impact factors in Inner Mongolia (2000–2015)" is shown in Table 1.

Table 1 Metadata summary of the dataset

Items	Description		
Dataset full name	Dataset of NDVI change trends and impact factors in Inner Mongolia (2000–2015)		
Dataset short name	NDVIChange.InnerMongolia_2000-2015		
Authors	Chen, K., College of Ecology and Environment, Inner Mongolia University, im_chk@163.com Chao, L. M., College of Ecology and Environment, Inner Mongolia University, colmvn@aliyun.com		
Geographical region	Inner Mongolia	Year	2000–2015
Data format	.tif, .xlsx, .shp	Data size	51.7 MB (after compression)
Data files	Spatial data include (1) annual variation trend of NDVI in Inner Mongolia from 2000 to 2015, 1 km raster data; (2) Categorize 1 km raster data based on the degree of change annual variation trend of NDVI from 2000 to 2015; (3) Natural factor data, including 2000–2015 precipitation, average temperature change trend, slope aspect, slope classification and vegetation type 1 km grid data; (4) Human-factor GIS data based on county units, including six attribute data from 2000 to 2015, including the trend of change in rural population, the trend of change in rural household number, the trend of change in rural labor force, the trend of change in grain output, the trend of change in per capita net income of farmers and herdsmen, and the trend of change in livestock quantity. Tabular data include the (1) area and proportion of vegetation change grade divided based on vegetation NDVI change. (2) Main impact factors and *q* values of vegetation NDVI change in Pastoral banner county and non-pastoral banner county in Inner Mongolia.		
Foundations	Ministry of Science and Technology of P. R. China (2016YFC050604–4); National Natural Science Foundation of China (31060117)		
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 per cent 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[9]		
Communication and searchable system	DOI, DCI, CSCD, WDS/ISC, GEOSS, China GEOSS, Crossref		

3 Data Development

This study used time series SPOT/VEGETATION NDVI data from 2000–2015[10] with the maximum synthesis method to generate an annual NDVI. The natural factors considered were climate, elevation, and vegetation. The climate data included annual precipitation and annual average temperature with 1 km resolution calculated by interpolation. Elevation with 1 km resolution was generated by resampling based on the latest SRTM V4.1 data. Vegetation types were derived from 1:1 million vegetation maps of China with a resolution of 1 km. Slope and aspect were calculated from DEM data with a resolution of 1 km[11]. Data on human factors were taken from the "Inner Mongolia Statistical Yearbook"[12]. The components included data on rural population, rural labor force, number of rural households, grain production, per capita income of farmers and herdsmen, and number of livestock (in 'sheep units', where a camel, horse, and cow are equivalent to five sheep each, and a goat is the same as one sheep).

3.1 Algorithm

The trend line analysis method was used to analyze the trend of change in the NDVI as well as climate and human factors for the study period[6]. In other words, taking time as an independent variable, the NDVI, annual average temperature, annual precipitation, and six individuals were analyzed by univariate linear regression. The correlation coefficient (R) between NDVI sequence and time (Year) was used to judge the degree and nature of change in vegetation cover, and the magnitude of the coefficient was used to judge the significance[6]. The critical value of significance was obtained from the critical value table of correlation coefficient test (when the number of samples was 16, the critical value of significance level was 0.468 and 0.590 at 0.01 and 0.05). Vegetation change was divided into five categories, according to the trend slope and critical value of NDVI: extremely significant degradation, significant degradation, no significant change, significant improvement, and extremely significant improvement.

The influences of natural and human factors on the NDVI were analyzed using the geographical detector model[7].

4 Data Results and Verification

4.1 Data Composition

The dataset includes 11 spatial data files (Table 2) and one statistical table data (including the area and proportion data of NDVI of different grades in Inner Mongolia; the main impact factors and q value of NDVI changes in pastoral and non pastoral counties of Inner Mongolia). Table 2 explains the data and describes the file or field names corresponding to the data.

4.2 Data Results

Because the geographical detector model employs an algorithm for discrete data, continuous variables (all data except vegetation type and slope aspect) were discretized using the natural breakpoint method[13]. The slope was divided into 9 categories and the other factors were divided into 10 categories (Figure 1).

Table 2 Natural and human factors affecting variation in NDVI in Inner Mongolia (2000–2015)

Category	Factors	Details	File or field
Natural factors	Annual precipitation	Variation in precipitation from 2000 to 2015	IM_pre00_15slope.tif
	Annual mean temperature	Average change in temperature from 2000 to 2015	IM_tem00_15slope.tif
	Slope	Calculated from DEM data with a resolution of 1 km	IM_slope.tif
	Aspect	Calculated from DEM data with a resolution of 1 km	IM_aspect.tif
	Vegetation type	In 1995, a 1:1 million vegetation map of China was digitally generated with a resolution of 1 km	IM_vegatation_type.tif
Human factors	Change in rural population	Rate of change in the rural population from 2000 to 2015	Rp_slope
	Change in number of rural households	Rate of change in number of rural households from 2000 to 2015	house_slope
	Change in rural labor force	Rate of change in rural labor force from 2000 to 2015	labor_slope
	Change in grain yield	Rate of change in grain output from 2000 to 2015	grain_slope
	Change in per capita net income of farmers and herdsmen	Rate of change in per capita net income of farmers and herdsmen from 2000 to 2015	Rgdp_slope
	Change in number of livestock	Rate of change in livestock number from 2000 to 2015	sheep_slope

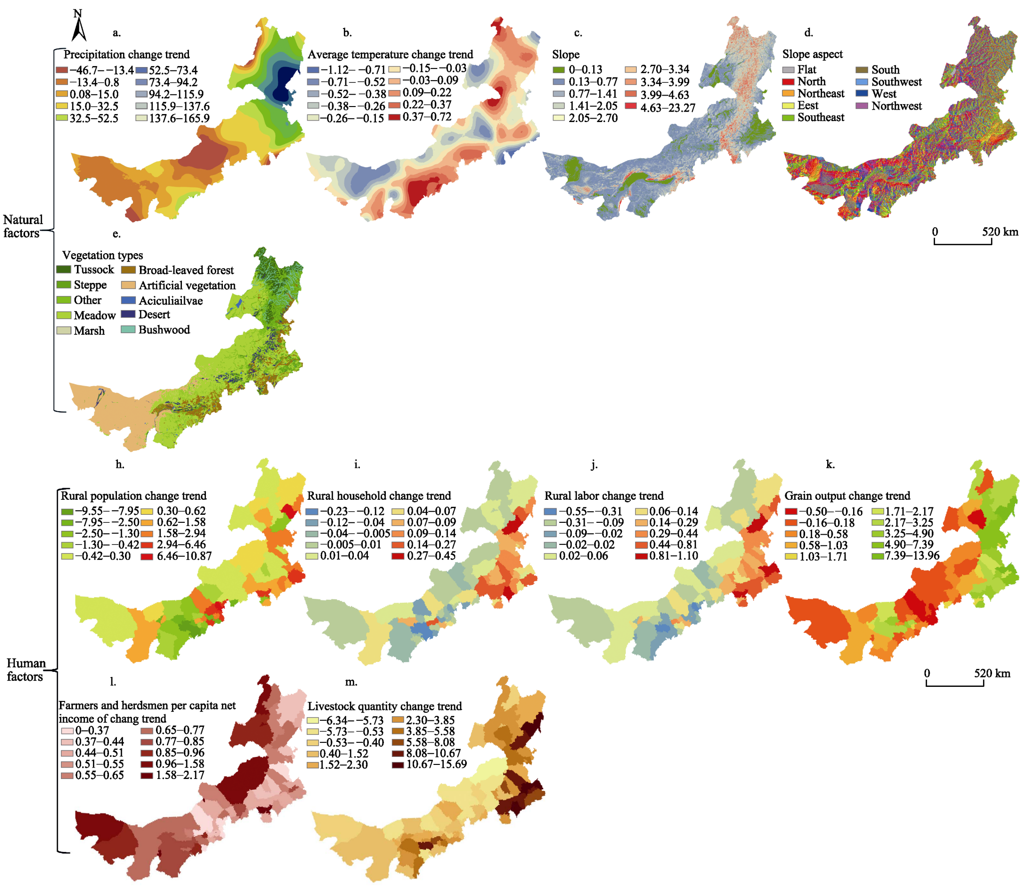

Figure 1 Map of natural and human factors affecting the NDVI for Inner Mongolia during 2000–2015

During the 16 years from 2000 to 2015, the NDVI showed an overall increasing trend. In general, it tended to decrease in the west and increase in the east and south; in other areas, it changed very little (Figure 2). Overall, an area of about 249,842.65 km^2 showed improved vegetation coverage, accounting for 21.88% of the total area of Inner Mongolia; about 64.38%, 10.88%, 1.88%, and 1.00% of the area experienced no change, a significant improvement, significant degradation, and extremely significant degradation, respectively (Table 3). These results indicate that the area of vegetation improvement was significantly greater than that of vegetation degradation. Furthermore, degraded areas were mainly distributed in the northwestern region around individual towns. NDVI varying grade is shown in Table 3. The vegetation of animal husbandry banner (county) was improved very significant, accounting for 9.65% of the total area (significant improvement: 7.24%; no change: 79.34%; significant degradation: 2.56%; very significant degradation 1.20%). The proportion of vegetation degradation area in animal husbandry banner (county) exceeds that of the whole study area, which indicates that vegetation degradation is more serious (and vegetation improvement is lower) in pastoral counties than in other areas. The vegetation of non-pastoral counties was improved very significant, accounting for 47.54% of the total area (significant improvement: 18.52%, no change: 33.00%; significant degradation: 0.35%; very significant degradation: 0.57%). Improved areas were mainly distributed in non-pastoral counties.

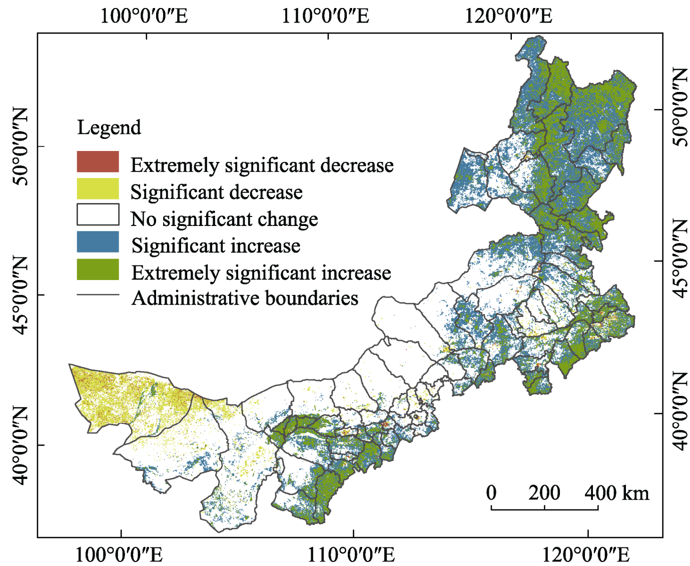

Figure 2 Spatial distribution of vegetation change in Inner Mongolia from 2000 to 2015 based on the interannual variation trend of NDVI and its significance

The factor detection of geographic detector model was used to assess the influences of natural and human factors on the NDVI, expressed using *q* values. The core rationale of the factor detection module is that geographic phenomenon always exists in a certain place in space and is affected by environmental factors. If certain environmental factors change with geographic phenomenon in a remarkably consistent spatial pattern, then it indicates these environment factors have great effect on the occurrence and development of geographic phenomenon[7]. Across the whole study area, the order of the degree of influence on NDVI was as follows: annual precipitation > soil type > vegetation type > grain yield > number of livestock > per capita net income of farmers and herdsmen > number of rural households > rural population > landform type > rural labor force > annual average temperature > slope > slope aspect. The first three factors are natural factors and the following two are human factors, which suggests that the influence of natural factors is greater than that of human factors. Similarly, for non-pastoral counties, the order was annual precipitation > soil type > vegetation type > grain yield > per capita net income of farmers and herdsmen > number of livestock > number of rural households > landform type > rural population > rural labor force > annual average temperature > slope > slope (Figure 3), again showing that natural factors had a greater impact. In contrast, the order for non-pastoral counties was grain output > rural labor force > annual average temperature > soil type > annual precipitation > number of rural households > per capita net income of farmers and herdsmen > number of livestock > total rural population > landform type > slope > vegetation type > slope aspect (Figure 3). These results indicate that human factors were dominant in such areas.

Table 3 Area and proportion of NDVI varying grades

Region	Classification	Very significant degradation	Significant degradation	No change	Significant improvement	Very significant improvement	Total
All counties	Area (km^2)	11,458.14	21,105.13	734,992.38	124,233.05	249,842.65	1,141,631.35
	Percentage (%)	1.00%	1.84%	64.38%	10.88%	21.88%	100%
Pastoral counties	Area (km^2)	9,335.95	19,785.55	613,648.39	56,000.29	74,631.31	773,401.50
	Percentage (%)	1.20%	2.56%	79.34%	7.24%	9.65%	100%
Non-pastoral counties	Area (km^2)	2,118.41	1,312.53	121,529.47	68,199.76	175,069.49	368,032.66
	Percentage (%)	0.57%	0.35%	33.00%	18.52%	47.54%	100%

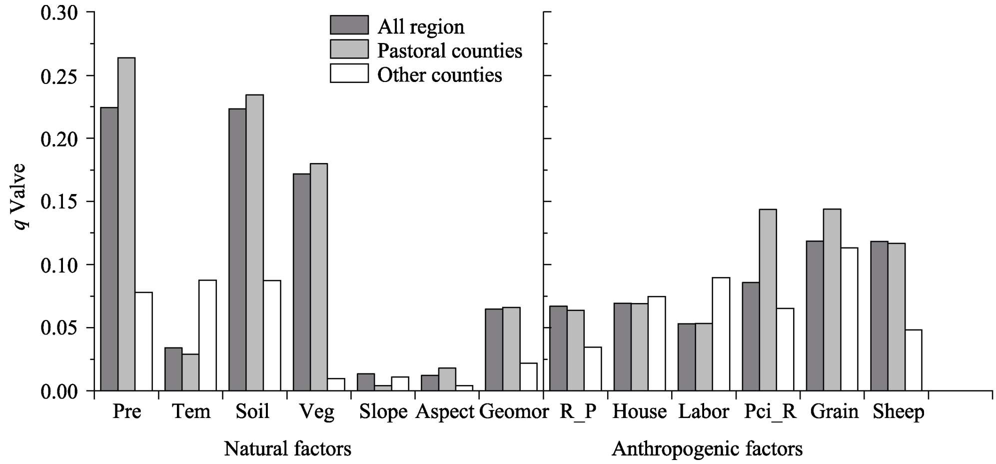

Figure 3 *q* values of seven natural factors and six human factors leading to variation in the NDVI in Inner Mongolia（Note：In natural factors, Pre, Tem, Soil, Veg, Slope, Aspect and Geomor respectively refer to annual precipitation, annual average temperature, soil type, vegetation type, slope, aspect and geomorphic type; In anthropogenic factors, R_P, House, Labor, Pci_R, Grain and Sheep respectively refer to rural population, rural household number, rural labor, per capita net income of farmers and herdsmen, grain output and livestock number）

4.3 Data Validation

The precision of VEGETATION coverage represented by NDVI lies in the spatial resolution of the source data used. In this paper, the SPOT/VEGETATION NDVI data with a resolution of 1 km is consistent with the research results of the former[14].

Geographic detector method is useful for detecting spatial differentiation and revealing the driving forces behind it. It is widely used in analyzing the evolution of geographical element pattern and regional spatial differentiation[7]. However, it should be pointed out that, as the maximum number of rows of data in the research area exceeds the upper limit of the operation of the geographic detector model, the use of the Create Random Points function of ArcGIS software to randomly extract appropriate samples in proportion for factor detection may have a certain impact on the final research results.

5 Discussion

It is of great significance to understand not only changes in regional vegetation coverage but also their driving factors over time. We used linear trend analyses and a geographical detector method to explore the impact of natural and human factors on changes in the NDVI from 2000 to 2015. Our results reveal obvious changes with an overall increasing trend in vegetation coverage. Regionally, vegetation tended to decrease in the west and increase in the east and south, with other areas showing little change. Across the entire region, about 32.76% of the area showed improvement, whereas only 2.88% showed degradation. The NDVI was affected more by natural factors than by human factors, with precipitation and soil type having the main effects. However, in non-pastoral counties, human factors had a greater impact, with grain yield being the main effect. Our dataset provides a useful reference on the vegetation in this region, how it has changed, and the main driving factors, and should help guide urban and rural developmental decisions.

Author Contributions

Chao, L. M. designed the dataset and Chen, K. collected and processed the data, and wrote the paper.

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