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Original scientific paper

Urban Green Space Planning and Design Based on Big Data Analysis and BDA-UGSPD Model

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Abstract: Green cities are described as the environmental influences by expanding recycling, decreasing waste, increasing housing density, lowering emissions while intensifying open space, and boosting sustainable local businesses. Green infrastructures (GI) are progressively related to urban water management for long-term transitions and immediate solutions towards sustainability. Urban green spaces (UGS) play a vital role in conserving urban environment sustainability by giving various ecology services. In this study, big data analytics-based urban green space planning design (BDA-UGSPD) has been introduced. Luohe city and the Shali River area have been chosen as the study area owing to the high number and a considerable assortment of UGS. Monitoring has been conducted in the Shali river to evaluate water quality for irrigation for agriculture. The Master Plan Scenario had a compact green space system, and the urban land use layout has been categorized by systematization and networking, and it did not consider the service capacity of green spaces. The Planning Guidance Scenario initialized constraint states, which provide more rigorous and effective urban spaces. It enhanced the service functions of the green space model layout. The simulation findings illustrate that the proposed BDA-UGSPD model enhances the land-use classification accuracy ratio by 92.0%, probability ratio by 90.6%, decision-making ratio by 95.0%, climate change adaptation ratio by 94.5%, water quality assessment ratio by 95.9%, and reduces the root mean square error ratio by 9.7% compared to other popular approaches.

Keywords: BDA-UGSPD; green infrastructure; Shali river; urban green space

1 INTRODUCTION

With the rapid growth of industrialization and urbanization, China's natural ecosystems and ecosystem services are experiencing landscape fragmentation and degradation due to urban sprawl [1]. Urban green space (UGS) is the natural ecology linking humans with nature, like forests, parks, river corridors, grassland, and wetland [2]. UGS provides several ecosystem services that inhibit urban water logging, decrease the urban heat island effects, and purify air and water [3]. These subsidize the sustainability and resilience of the urban community [4]. UGS offers leisure, fitness, entertainment, noise reductions, aesthetics, and other services to the population, reducing chronic diseases' prevalence [5]. The UGS system serves numerous functions with enhancing human well-being and health, urban living environment, regulating the urban climate, promoting sustainable urban development, and preserving the urban ecological biodiversity [6]. Identifying appropriate places for urban green space is the main task of enhancing urban ecological environments [7]. UGS system planning instructs enlargement, implements layouts, controls, and handles the UGS [8]. Ecological appropriateness assessment is a significant quantitative analytic technique for guaranteeing sustainable land-use and can be understood as evaluating land development potential [9]. It offers the basis for scientific decision-making for the rational usage of the land resource [10]. Urban environment services of the green space have been quantified, recognized, and evaluated to notify tax payers and help decision-making and urban planning [11]. Urban environment services are infrequently incorporated in urban planning and design since UGS ecosystem services have not been properly researched [12]. The decline in UGS ecosystem service functions has led to a rapid increase in supply gaps, and population and industrial agglomeration have led to a rapid increase in urban demand for ecological functions. This imbalance between supply and demand has brought urban diseases such as rainstorm and flood, urban heat island, etc., which largely threatens the safety of cities and residents, hinders the sustainable development of cities, and poses great challenges to the construction of urban resilience and the improvement of human welfare. Specific planning objectives or expectations do not frequently know about the criteria for ecosystem development [13]. The ability of various ecosystem services in Green Spaces depends on their unique setting and size [14]. Diverse types of UGS like road belt green spaces, public parks, wetlands, and private garden are tremendously unrelated [15]. Various vegetation communities and varieties reflect assorted social requirements and personal preferences that further impact eco-function value provisions [16]. In China, spatially dissimilar UGS are categorized into four major categories: protective green spaces, a public park, an attached green space, and a square green space by individual function and location across urban zones based on the Standard for Classification of UGS [17]. Landowners' preferences drive various social requirements and ecological value, and function-oriented design brings different UGS [18]. Different vegetation inclinations and preservation practices reproduce human-concerned design within various UGS [19, 20]. Our primary objective is to carry out a complete assessment of urban green space use at national scales based on big data analytics and considers the variances in the real use status of urban green space between peri-urban areas and intra-urban regions based on the BDA-UGSPD model. Luohe city and the Shali River area have been chosen as the study area because of their high number and considerable variety of UGS. The Shali river construction planning and development, an overall area of about 86 square kilometers, is a set of urban flood controls, the conversion of the old city, cultural tourism, ecological security as integrated projects. In the Shali River, a cross-strait formed 36 km in length, with an overall area of 669 million square meters of the banded public gardens, scenic bluegrass green. The Luohe was granted the Chinese Habitat Environment Prize model for 2014. It has been awarded the 4A national scenic places, national sports park, the national water preservation area, the

Ecologic Civilisation Education Base in Henan Province, and a civilized, beautiful area. The rest of the study is prearranged as follows. Section 2 discusses the related study on river water quality assessment. In section 3, the BDA-UGSPD model has been suggested for effective UGS implementation based on the Shali River region. In section 4, the result and discussion have been implemented. Finally, section 5 concludes the research paper.

2 LITERATURE REVIEW

Baohua Chen et al. [21] suggested differential gene expression analysis (DGEA) using high-throughput RNA-Seq data during spawning migration from alkalized lake to freshwater river. Firstly, the short RNA-Seq readings were combined into 44.318 contiguities and contained the reference sequences of the transcription. Differential analysis of gene expression found a total of 2575 genes having substantial differential expression (value = 0.1; log2 – fold – change > 2). Many distinct genes controlled the acid basis, excretion of nitrogen waste, sexual maturation and reproduction, and stress response [22]. These results give critical data for further analysis of Amur's sub-principal alkaline acclimation, adjustment, and spawning mechanisms. Zhang Min et al. [23] discussed the China Meteorological Assimilation Driving Datasets for the Soil and Water Assessment Tool (SWAT) model (CMADS 1.0). This research simulated Chao River Basin's non-point source (NPS) pollution in the upper reach of the Miyun Reservoir, which evaluated the nitrogen-phosphorus pollutant geographical and allocated patterns and the pollution contribution rates. The main results are as follows. A good application for the field of research is the CMADS V1.0 powered SWAT model. The calibration and validation periods simulated the rush, nitrogen, and phosphorous pollution, resulting in Nash Sutcliffe (Ens) coefficients at 0.51 ~ 0.78 and a coefficient of determination 0.73 ~ 0.88 complying with model standards of assessment. In the flood season, the overall pollution load of nitrogen (TN) and phosphorus (TP) is significant, with an average inflow of 60.62 and 75.15 percent, correspondingly, from both TP and TN to the reservoir. Mahdi Shojaei-Miandoragh et al. [24] deliberated the environmental-psychological analysis (EPA) for examining the Agriculturalists' resilience behavior in the face of water scarcity. The research was descriptive correlational, causal, and performed as a survey. Statistics were drawn from farmers in the Aji-Chay Basin in the east portion of Urmia Lake ($N = 417000$), of whom 384 have been designated with a random stratified sampling approach. The instrument was a questionnaire whose validity was confirmed by a team of experts. The dependability was established by an alpha test by Cronbach and a pilot study ($0.60 < \alpha < 0.90$). The results showed the causal structure of agriculturalists' behavior in resilience. The findings of the causal analysis further demonstrate the largest effects on farmer's resistance to water shortages of three variables: 'place connection,' 'environmental attitudes,' and 'environmental belief.' Understanding people's preferences and perspectives on urban landscape design scenarios, especially innovative sustainable development methods, will have a significant impact on future urban planning and public satisfaction [25]. According to the above survey, there are several problems in the effective implementation of urban green space. Therefore, this paper proposes the BDA-UGSPD algorithm. The next section briefly discusses the proposed model.

3 BIG DATA ANALYTICS-BASED URBAN GREEN SPACE PLANNING DESIGN (BDA-UGSPD)

Urbanism is a computational consideration of city systems and processes that decrease urban life to algorithmic and logical rules and processes while binding urban big data to deliver a more holistic and combined view or synoptic intelligence of the city. This is progressively being focussed on advancing, enhancing, and preserving the contribution of both smart cities and sustainable cities to sustainable development objectives. Furthermore, big data application in sustainable cities tends to deal mainly with the quality of life, economic growth, and governance while overlooking the more complex challenges and urgent issues related to sustainability [26]. It substantiates and highlights the great potential of big data analytics for facilitating such contribution by synthesizing, recognizing, distilling, and computing the main analytical and practical application of this technology concerning numerous urban systems and fields concerning operations, services, functions, designs, policies, and strategies.

Figure 1 Study area

Fig. 1 shows the study area. Luohe city has been chosen as the study area because of its huge number and a considerable variety of urban green spaces. Luohe region is located in central Henan province and is characterized by varied topography of plateau and hills in the west and lower riverine valleys in the east. The lands are designated for a potential district center with commercial, cultural uses and a new administrative center for Luohe Municipality. Urban Design Framework will provide detailed guidance for developing a sustainable new urban quarter with distinctive architectural and landscape characteristics. During urbanization, the population assembled into the ever-increasing cities and created artificial and impermeable surfaces (for example, asphalt, concretes) to substitute natural zones containing grassland, wetland, and forest. The proportion of urban green spaces did not continue with the urban growth of speed, which greatly influenced the urban environments and led to a steady decrease in life quality. Urban green space refers to urban land covered by vegetation. As a component of the urban landscapes, urban green space mapping must consider its physical possessions and social function, resembling to urban land use and land cover mapping. The article on the physical features of urban green space mainly includes studying vegetation types, like different trees, grass, and shrub species. The social functions of urban green space include the usages' examination of urban green space and their classification into the different artificial prearranged spaces for human use, like a theme park, municipal park, residential green space, and community park, green buffers.

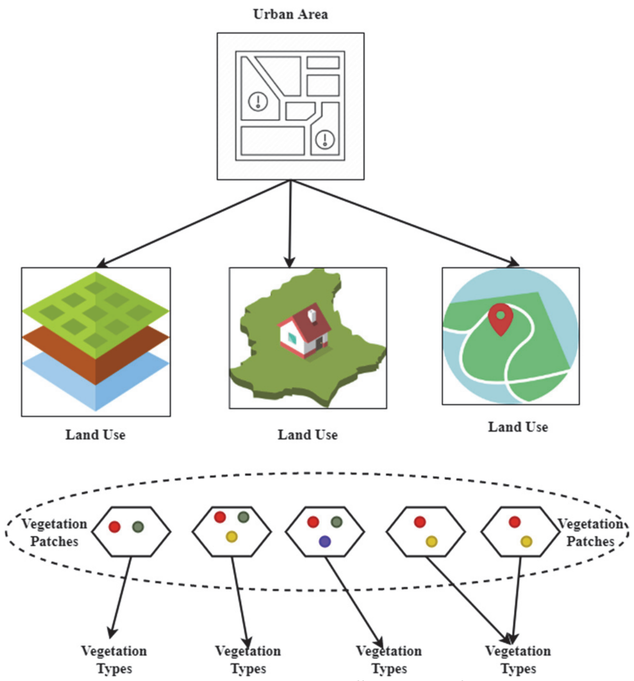

Figure 2 Vegetation types, patches with different social function, and urban land-use types Hierarchy

Fig. 2 shows the vegetation types, patches with different social function, and the urban land-use types form hierarchical structures. Urban green space consists of vegetation patches with different social roles related to urban land and distinct plant species. Thus, an urban land usage map may reflect the socio-economic activities of different urban areas according to this hierarchical structure and is the fundamental indicator to determine the social function of vegetation patch. For instance, the social role of vegetation patch inside a park is a national park, while a residential green area is the social function of vegetation patch, and green buffers are vegetation parks on the highways. In recent years, more emphasis was given to investigating how specific aspects of different social function kinds of urban green space might impact its social and ecological advantages, such as locations, vegetation structures, patch size, connectivity, etc. Fig. 3 shows the urban green space management system. Another issue concerning urban farmlands is the exclusiveness of urban farming. The system facilitates people who are willing to engage in urban farming with urban farmlands without successors. If there are urban farmlands whose farmer has passed away and its successor does not intend to continue farming, the urban green space management sector buys the utilization right (UR) of the farmland and manages the farmland as green open space. The urban green space management sector does not permanently manage the land and instead sells farmlands UR to new urban farming entities. This allows various urban residents to engage in urban farming, including residents and farmers inside/outside Luohe city and Shali River water utilization. This will enhance community food growing, agricultural business enlargement, and new entrepreneurial urban farming.

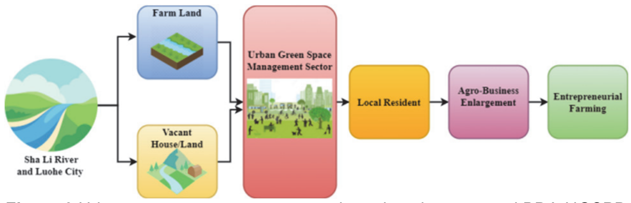

Figure 3 Urban green space management based on the proposed BDA-UGSPD model

As an important element of urban construction, lands, green spaces, and square land share unified spatial and temporal features with other land types. This study joined the development of the UGS model with the advancement of urban land-use [27]. The proposed BDA-UGSPD model incorporates the ANN algorithm and roulette's adaptive inertia competition process. An artificial neural network is a deep learning technique with self-organization, self-learning, and is self-adaptive. It can efficiently resolve the non-linear connection among land-use status information and spatial parameters, like location, terrain, and traffic. The adaptive inertia competition process based on roulette assortment is united with adjacent weights (the development capability of land use categories driven by external elements), inertia coefficients (the legacy of land use categories in the iterative progression), conversion costs (the land-use transformation or not), and roulette assortment (the possibility for transformation and distribution of every land-use types) to implement a circular iteration among land status and land demand to make the output values close to target values. This study uses the BDA-UGSPD model with the artificial neural network algorithm to determine the improvement likelihood of all land-use types in the research scope. The artificial neural network model utilized in this paper encompassed input layers with six neurons, hidden layers, and output layers with two neurons. Basically, the simulation progression implemented the intensity association of the interaction between driving elements and land categories, and the likelihood formulation can be articulated:

$$net_i(q,t) = \sum_j \omega_{ji} \cdot y_j(q,t) \tag{1}$$

$$Sigmoid\left(net_i(q,t)\right) = \frac{1}{1+e^{-net_i(q,t)}} \tag{2}$$

$$q(q,l,t) = \sum_i \omega_{i,l} \cdot Sigmoid\left(net_i(q,t)\right) \tag{3}$$

As inferred in Eq. (1) to Eq. (3) where $net_i(q, t)$ signifies the transmission signal received by neuron i,

$y_j(q, t)$ indicates the association function between training period t and grids q in input layer neurons j, ω_{ji} denotes the adaptive weights utilized for calibration in the training progression, and $Sigmoid(net_i(q, t))$ indicates correlation functions. Diverse neurons in output layers signify various land-use type; $q(q, l, t)$ indicates the occurrence likelihood of land types l in t period and grids q. $\omega_{i,l}$ is similar to ω_{ji} and is adaptive weights. The NN models of $\omega_{i,l}$ and ω_{ji} after proofreading with training, data can be utilized to compute the appropriateness likelihood of different land-use types. The adjacent effect is the same as the conventional model. The description of neighborhood expansion density of land types l in grids q is as follows.

$$\Omega_{q,l}^{t} = \frac{\sum_{M \cdot M} con\left(c_q^{t-1} = 1\right)}{M \cdot M - 1} \cdot \omega_l \tag{4}$$

As shown in Eq. (4) the $\sum_{M \cdot M} con\left(c_q^{t-1} = 1\right)$ signifies the overall number of grids when the iteration period of land-use types l is $t - 1$ in the $M \times M$ Moore windows. This research chooses the 3 × 3 Moore neighborhood models. ω_l denotes parameter weights. The inertia coefficients are based on the present land-use iterative adjustment to the preset demand conversion. The inertia coefficient is defined as follows.

$$Intertia_l^t = \begin{cases} Inertia_l^{t-1} \text{ if } \left|D_l^{t-1}\right| \le \left|D_l^{t-2}\right| \\ Inertia_l^{t-1} \cdot \dfrac{D_l^{t-2}}{D_l^{t-1}} \text{ if } D_l^{t-1} < D_l^{t-2} < 0 \\ Inertia_l^{t-1} \cdot \dfrac{D_l^{t-2}}{D_l^{t-1}} \text{ if } 0 < D_l^{t-2} < D_l^{t-1} \end{cases} \tag{5}$$

As discussed in Eq. (5) the $Intertia_l^t$ denotes the inertia coefficients of land-use types l when iteration period is t, and D_l^{t-1} is the variances between macro demand and land-use types l allocation when the period is $t - 1$. The overall likelihood of the unit engaged by a particular land use type can be articulated:

$$TQ_{q,l}^{t} = Q_{q,l} \cdot \Omega_{q,l}^{t} \cdot Intertia_l^t \cdot \left(1 - sc_{c \to l}\right) \tag{6}$$

As derived in Eq. (6) where $TQ_{q,l}^{t}$ specifies the combined likelihood of grids q from the first status to target types l at iteration period t, $Q_{q,l}$ denotes the likelihood of grids q appearing as the land-use types k, $\Omega_{q,l}^{t}$ indicates the adjacent effect of grids q appearing as the land-use types l in iteration, and $sc_{c \to l}$ denotes the cost of land-use types c to k alteration.

Fig. 4 shows the artificial neural network. These networks rival a biological NN and use a compact set of concepts from biological neural systems. Precisely, artificial neural network models show the electrical actions of the nervous and brain system. Processing components are linked to other processing components. Usually, the neurodes are organized in layers or vectors, with the output of one layer aiding as the input to the next layer and probably other layers.

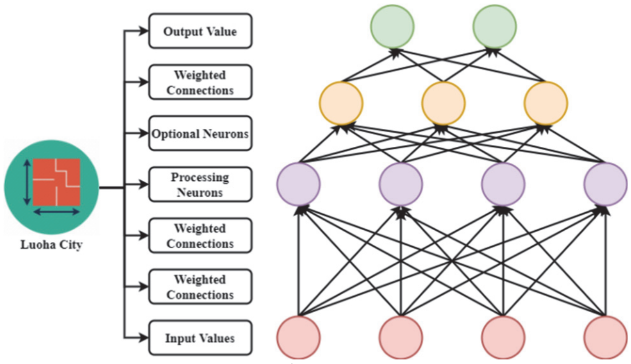

Figure 4 Artificial neural network

A neurode may be associated with every or a neurodes subset in the succeeding layers, with these connections pretending the brain's synaptic connections. Weighted data signals inflowing a neurode pretend the electrical excitation of a nerve cell and the conveyance of data within the brain or network. The input value to a processing component is multiplied by connection weights, which stimulates the brain's strengthening of the neural pathway. Through the adjustment of the connection strength or weight, learning is rivalled in artificial neural networks.

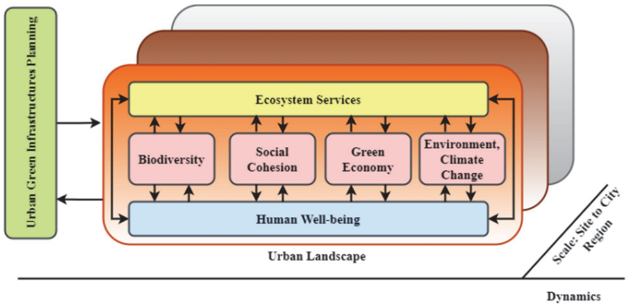

Figure 5 Urban landscapes and green infrastructure

Fig. 5 shows the urban landscapes and green infrastructure. The promotion of urban green infrastructure is designed to address significant urban environmental and social issues, including reducing its environmental and social impact, improving human health and prosperity, and adaptation to climate change. Various kinds of green places occur in urban areas, such as natural remains, marginal agricultural land, planned green spaces, and abandoned areas, in which successive vegetation has become developed. These green areas, and notably components like trees, may cover a considerable number of metropolitan areas. However, social and environmental justice concerns arise with their unequal distribution. Furthermore, GI planning challenges different governmental, institutional, and private property owners of urban green areas. Urban GI planning must consider urban transformation processes, particularly pressure on green areas from the growth of urban expansion and infills, whereas abandoned land may be an opportunity to create new biodiversity in densely constructed places. These issues are mostly addressed by the benefits of the urban green spaces via ecosystem solutions. Four of these areas are discussed further: green-gray inclusion, multifunctionality, connectedness, and social inclusion. GI's planning is a different planning technique based on these concepts in conjunction. The findings of a significant European study project show that urban GI planning concepts are applied in diverse ways. Green-gray integration and socially inclusive planning techniques provide room for future progress. Finally, urban GI has considerable potential to move towards more sustainable and resilient urban development paths. The suggested BDA-UGSPD model enhances the water quality assessment ratio, climate change adaptation ratio, decision-making ratio, land-use classification accuracy ratio, probability ratio and reduces the root mean square error rate compared to other popular models.

4 RESULTS AND DISCUSSION

Based on the experimental results of the BDA-UGSPD model, the water quality evaluation rate, climate change adaptation rate, decision rate, land use classification error rate, and probability ratio are reduced.

4.1 Water Quality Assessment Ratio

In managing the freshwater resource, cities play an important role, as they may influence both water quality and quantity via land-use change, contamination and overexploitation. Water and environmental management offer a multidisciplinary understanding of water resources and environmental problems. Water bodies are cultural, ecological, and economically significant ecosystems that offer many valuable services to humankind. Urban water management dynamically parallels urbanization. It ensures both the quantity and quality of water resources for future generations. This study considered the Shali River water quality assessment model. Centralized infrastructure currently addresses the symptoms of urban runoff, such as flood-prone heat islands, stream bank erosion, and poor water quality, rather than addressing the root causes. Fig. 6 shows the water quality evaluation ratios for the proposed BDA-UGSPD model.

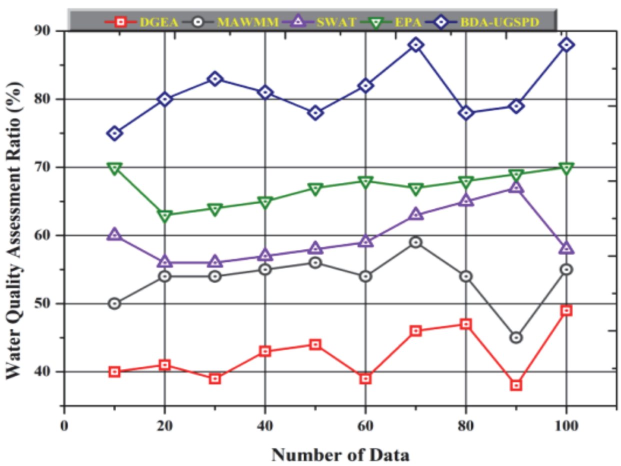

Figure 6 Water quality ashsessment ratio

4.2 Climate Change Adaptation Ratio

Due to significant regional differences in the impact of climate change, adaptation costs, and adaptability of different regions and countries, there are also significant differences in adaptation choices. China is a developing country with high vulnerability to climate change and faces higher risks of climate change. Different scenarios considered, such as rainfall, climate change, socio-economic elements, and human and natural effects on land use trends, have been analyzed. Luohe is located in the climate region (Climate Classification model) [28], and its elevation is 56 to 59 meters above sea-level. Luohe contains three districts, Shaoling, Yuanhui and Yancheng with a population of 720000 and 8000 ha of land. The UGS rate spreads 34%, and the per capita public green space is 11.8 sm. Unmanned Aerial Vehicles images have been accessible, which can be inferred to attain the numbers and spatial distribution of UGS in Luohe city. Attached with climate variation, the perceived extremes and storm frequencies are higher than forecasted. Extreme and frequent weather events, like heavy rainfall linked with climate change, can be expected to raise flooding risks in China cities and their associated ecosystems. Fig. 7 illustrates the climate change adaptation ratio.

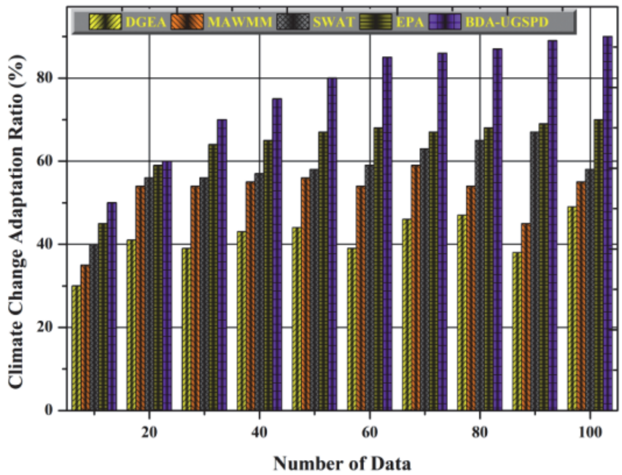

Figure 7 Climate change adaptation ratio

4.3 Decision-Making Ratio

Data accessibility limitations have meant that the conventional portrayal of the real usage status of urban green space has been restricted to the small-scale sampling survey, which cannot offer large-scale panoramic examinations. Sporadic findings cannot deliver a complete viewpoint for the public and decision-maker.

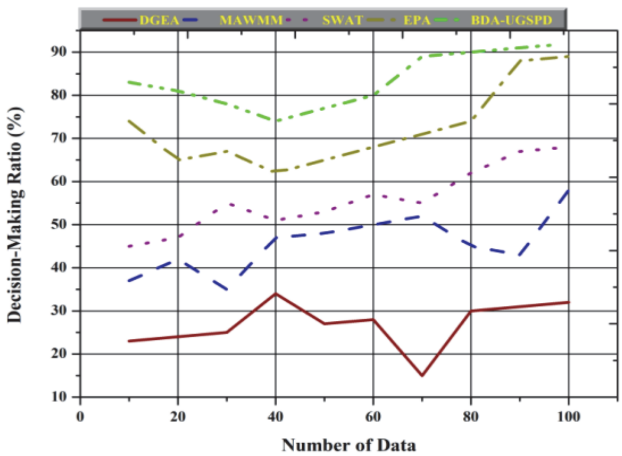

Figure 8 Decision-making ratio

The real use status of urban green space is thoroughly linked with human expectations and requirements. Our research delivers scientific data for the decision-maker and planner and would promote a complete understanding of the spatial patterns of urban green space development in every city in mainland China. The land-use change scenarios simulation models are efficient tools for simulating urban land-use trends. These simulation models can optimize the urban land-use layouts and help with decision-making. Fig. 8 shows the decision-making ratio.

4.4 Probability Ratio

The appropriateness likelihood of every land type in the research region can be determined. The dependency on the multi-phase information and the error propagation can be evaded, and the difficulty of different land-use categories under natural possessions and human intervention can be handled efficiently. The appropriateness probability map has been determined by training the artificial neural network model. The value is greater, the probability that every land use type be fallen higher. The suggested BDA-UGSPD model enhances the likelihood ratio when compared to popular approaches. Fig. 9 shows the probability ratio.

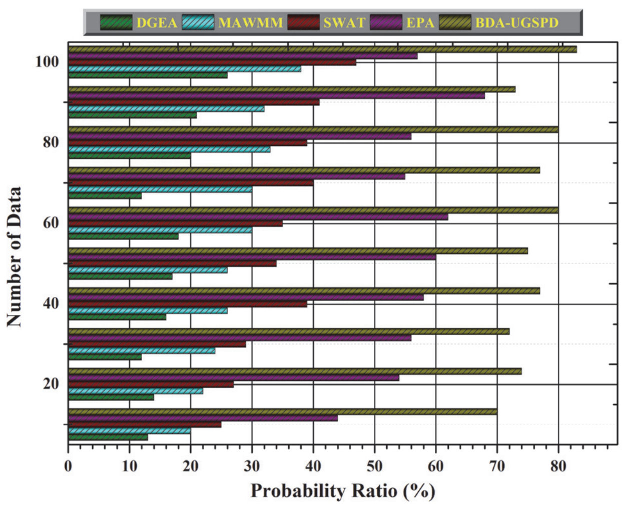

Figure 9 Probability ratio

4.5 Root Mean Square Error Rate

This study utilizes the RMSE of the likelihood of appropriateness occurrence modules and Kappa coefficients of the total model simulation accurateness verification index to assess the viability of the BDA-UGSPD model [29]. The mode of artificial neural network training samples comprises random and uniform sampling. This research has utilized uniform samplings. The Kappa coefficient of the Baseline Scenario and the Planning Guidance Scenarios has been considered. The simulation accuracy of the model is within the precision level. The suggested BDA-UGSPD model reduces the RMSE value compared to other existing models. Fig. 10 signifies the root mean square error rate.

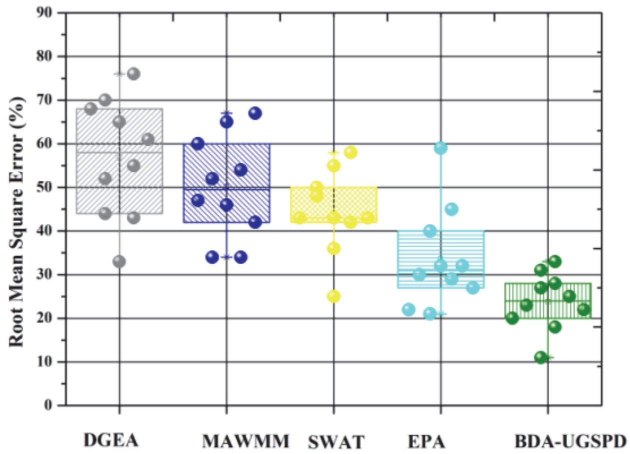

Figure 10 Root mean square error rate

4.6 Land-use Classification Accuracy Ratio

The data reproduce the variation of water area, rural residential lands, and forestry and agricultural lands. The urban construction land balance reproduces the altering pattern of the four reclassified land usages. Due to its intricacy, earlier studies have often not noticed the role of attached green space in urban spaces. In our system, every land type modification value and green space index restraint have been pivotal factors affecting the cost matrix's parameter setting and neighbourhood weights. Among these elements, the area change reflected the expansion and development capability of the land, and the green space rate of every land type reflected the complexity and the probability of land transformation. Based on the numerous planning incorporations of spatial planning and the flexible modifications of plots of nature, this research reclassified urban land accurately and compared the land simulation findings with the current planning. Fig. 11 shows the land-use classification accuracy ratio.

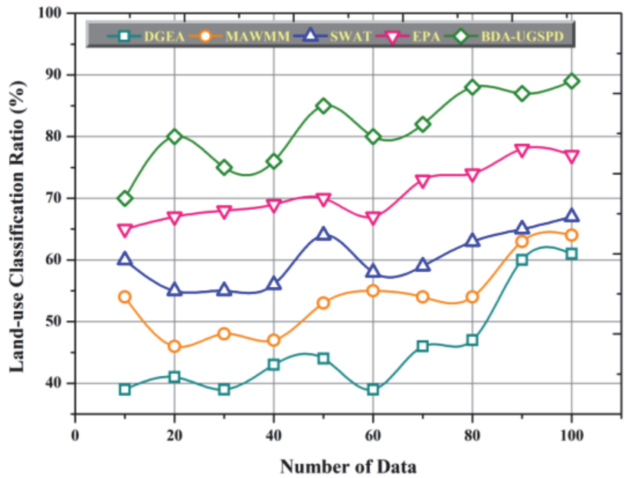

Figure 11 Land-use classification accuracy ratio

The suggested BDA-UGSPD model enhances the land-use classification accuracy ratio, probability ratio, decision-making ratio, climate change adaptation ratio, water quality assessment ratio and reduces the root mean square error ratio compared to other existing differential gene expression analyses (DGEA), Moving Average Weighted Markov Model (MAWMM), Soil and Water

Assessment Tool (SWAT) model, environmental-psychological analysis (EPA) methods.

5 CONCLUSION

In this study, a big data methodology has been applied to overcome environmental justice related to the provision of Luohe and Shali River urban green park spaces. The UGS appropriateness assessment technique is the main tool to determine appropriate UGS planning and construction locations. In this model, the likelihood of the occurrence has been calculated for land use according to the artificial neural network. The findings display that the BDA-UGSPD model, which inserts the parameters involving ecological space security, planning quantitative index, and openness of green park space, can realize urban land-use expansion simulation in long- and medium-term planning. Experimental results show that the BDA-UGSPD model improves 92.0% land use classification accuracy, 90.6% probability rate, 95.0% decision rate, climate change adaptation rate by 94.5%, 95.9% water quality assessment rate, and 9.7% lower RMSE compared with other existing methods. The limitation of this article is that it only selects Luohe as the research object, and more regions should be selected for analysis and research. The coordinated achievement of adaptation and development goals requires comprehensive consideration of multiple social development goals when formulating specific policies. The concept of climate capacity has a scientific and empirical basis, which can reflect the interactive relationship between human development and the natural environment. It can become an analytical tool for population resources and environmental economics to conduct climate change risk assessment and adaptation policy research.

Acknowledgements

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