Making decisions on the basis of data science in managing social and economic systems

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Abstract

Aim. To identify the prospects and possible areas of data science use in the decision-making process in the management of social and economic systems.

Objectives. To analyze existing approaches and promising directions of data science use; to analyze methods that allow to obtain real-time data for decision-making, to identify gaps and shortcomings; to briefly formulate conclusions relevant for practitioners and policy makers in the process of decision-making based on data science.

Methodology. The authors analyzed the scientific literature, applied methods of logical analysis and interpretation of data.

Results. In the course of the research, it was found that data science makes a significant contribution to the global transformation of society, allowing solving urgent problems of socio-economic development. Methods that facilitate the acquisition of real-time data increase the effectiveness of decisions in the management of social and economic systems. These methods were analyzed, their advantages and disadvantages were identified, and examples of their use were presented. The key data requirements were defined: confidentiality, ethics, and security. A range of new questions for future research in the context of the topic under consideration was proposed.

Conclusions. The results obtained contribute to the theoretical development of new approaches to the application of data science, as well as the practical use of best practices in cases of decision-making in the management of social and economic systems. These results can form the basis for the design and implementation of solutions by policy makers and practitioners.

Принятие решений на основе data science в управлении социальными и экономическими системами

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Аннотация

Цель. Определить перспективы и возможные сферы использования data science в процессе принятия решений при управлении социальными и экономическими системами.

Задачи. Проанализировать существующие подходы и перспективные направления использования data science; выполнить анализ методов, позволяющих получать данные в режиме реального времени для принятия решений, выявить пробелы и недостатки; кратко сформулировать выводы, актуальные для практиков и политиков в процессе принятия решений на основе data science.

Методология. Авторами проведен анализ научной литературы, применены методы логического анализа и интерпретации данных.

Результаты. В процессе исследования установлено, что data science вносит существенный вклад в глобальную трансформацию общества, позволяя решать актуальные проблемы социально-экономического развития. Методы, способствующие получению данных в режиме реального времени, повышают эффективность решений при управлении социальными и экономическими системами. Проведен анализ этих методов, выявлены их преимущества и недостатки, представлены примеры их использования. Определены ключевые требования к данным: конфиденциальность, этичность и безопасность. Предложен спектр новых вопросов для будущих исследований в контексте рассматриваемой тематики.

Выводы. Полученные результаты способствуют теоретическому развитию новых подходов применения data science, а также практическому использованию лучших практик в случаях принятия решений в процессе управления социальными и экономическими системами. Эти результаты могут служить основой при разработке и реализации решений политиками и практиками.

Ключевые слова: *data science, социальное и экономическое развитие, данные в реальном времени, глобальные проблемы, моральные и этические вопросы, новые технологии*

Data science has become a revolutionary means of business decision-making and addressing many of the challenges the world is facing today. In the modern world, the use of technology and innovation to deliver large volumes of data in a timely manner will open a new chapter of transformation in many fields inclusive of social and economic development. Data science helps organizations and policymakers make informed decisions that can enhance social and economic development, given the growing interconnectedness of the world today. The application of data science changed the way different challenges in business and social sphere are addressed.

Thus, modern data science is based upon the capability to integrate real-time data from multiple sources, such as social networks, sensor arrays and public databases, to reveal previously undetectable patterns, trends and relationships. Besides, it broadens our knowledge and contributes to the development of interventions that meet particular requirements in communities.

Another reason why the use of data sciences is crucial is that it offers solutions that have been validated by research [1]. Historically, conventional techniques of addressing social issues include guesswork and overlooking current statistics and information, which are likely to provide inferior results. Data science, however, involves the use of complex equations and statistical models to analyse current data to ensure that

action is taken based on the most up-to-date information.

The purpose of this paper is narrower and it is to discuss the application of data science in managing social and economic systems with the focus on social empowering via the use of real-time data. It will also showcase a range of data science computing methodologies used to tackle global challenges and their efficacy for further improvement. To achieve these objectives, the paper will present a plethora of case studies or real-life examples and a synthesis of currently available data science applications for social good and the potential to enhance the positive social impacts stemming from its usage.

The aims of this paper are to illustrate the use of data science in empowering the society, to examine the effects of real-time data on solving world challenges and offer the recommendation on the future advancement in this discipline [2]. Hence, through the illustration of the relevant case studies and examples in poverty alleviation, healthcare, and disaster response, the paper will provide a qualitative discussion of the advantages of using data analytics in real-life scenarios. The drawbacks and constraints of real-time data processing such as privacy and security concerns and the required data infrastructure are also analysed in the paper.

The third major benefit of data science is that it provides the necessary inputs for policy formulation to the politicians and its further implementation by practitioners. Data science thus offers substantive material to bring to bear on decision-making ensuring that policymakers affair decisions on facts, in most cases, rather than making assumptions or generalizations [3]. It also makes the designs of social and economic development programs more efficient while at the same time fulfilling the basic principles of transparency and accountability in docketing of resources. For example, in fighting poverty, data science can help identify target populations and measure how different plans will help reach those who are in need.

The involvement of data science in social empowerments has received more attention since the world faces various difficulties in power together. The analysis of how data science can solve these problems highlights numerous approaches and methods that show that this science is incredibly promising [4].

It is noteworthy that using predictive analytics and machine learning seriously improves the organization of patient care, highlights high-risk patients, optimizes key treatment strategies, and predicts epidemics of certain diseases. Another domain that has benefited from data science is the education sector. Research based on educational data can be useful in designing interventions that would effectively address inequities and barriers, thereby increasing students' educational achievements.

However, certain areas in the current literature remain under researched, which needs to be filled in the future studies. It is also found that there are no current studies closely related and explicitly linking data science applications between various domains of social networking and empowering programs. Despite many studies conducted regarding the efficiency of big data in various domains like healthcare, education, and disaster management, there is a lack of studies on how data science could be employed as a comprehensive solution to address complex global issues [5]. It is in an effort to fill this gap that this paper will seek to present a detailed discussion of data science solutions across various industries while highlighting how these technologies can jointly enhance the social cause.

Another important issue that must be discussed is the question as to the application of real-time data, and possible methods of its usage, with special reference to ethical and practical problems. There is understanding of the benefits of data science, yet concerns of problems such as data stewardship and security, as well as bias within algorithms. These issues remain unaddressed as the studies mainly concentrate on the beneficial effects of data utilization. In response to these ethical considerations, this paper explores the existing and future threats related to real-time data and provides the means to address them. In this way, it expects to foster the values corresponding to accountable data science with regard for individuals' privacy and proper treatment, in terms of both efficiency and fairness.

Additionally, the sustainable role of data science in the advancement of social justice is another crucial topic that has not been addressed fully. The current research focuses more on specific gains and quick returns with less consideration for the long-term outlook and effects and methods for creating data
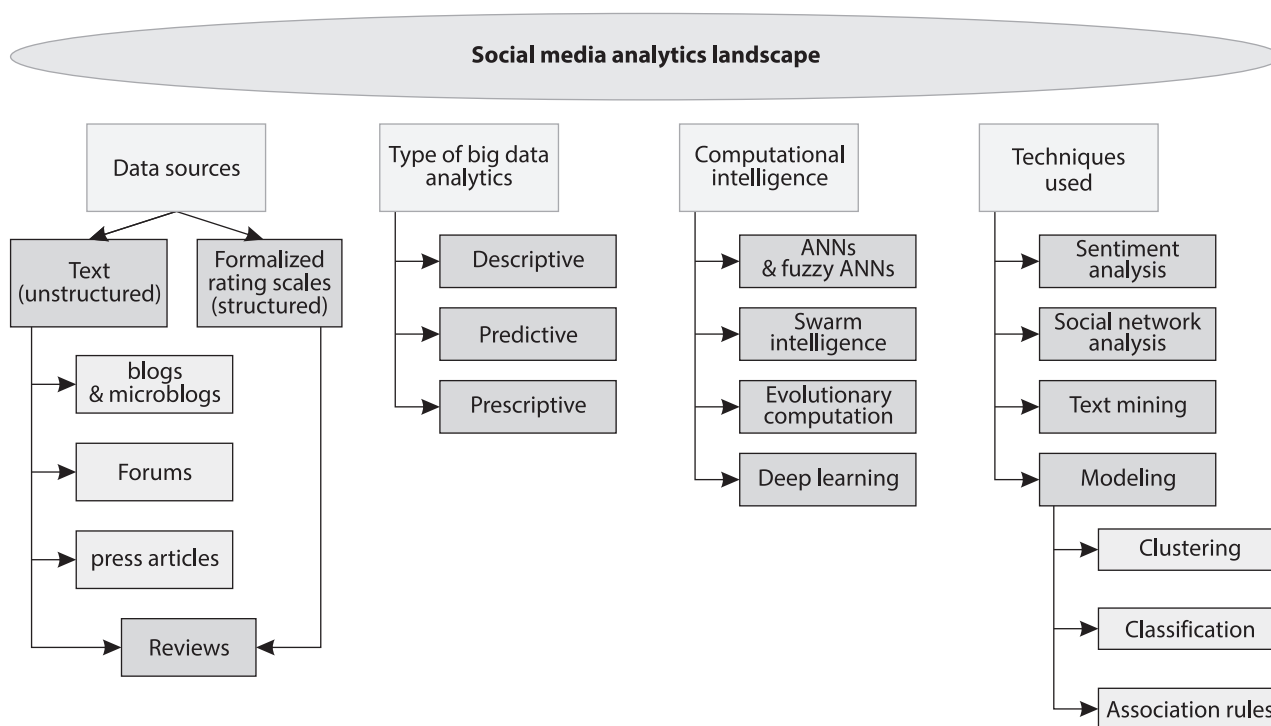
Fig. 1. Types of data sources
Рис. 1. Типы источников информации

Source: [2].

processing solutions. This paper fills this gap by assessing the outcomes of applications of data science in the long run and examining the possibility of expansion **[6]**. In this regard, it illuminates the possibility of actually creating sustainable data-driven interventions by sharing best practices and on how those interventions can be successfully scaled. The present research helped to reveal the progress achieved in this field and the shortcomings that exist. Despite the relatively great successes in using data science, there is a need to come up with an integrated data science approach, address some of the ethical issues as well as establish evaluations of the impacts in the future.

Data sources are crucial in the data science lifecycle as information acquisition lays the foundation for subsequent data exploration, analysis, and modelling. Some types of data sources are presented in figure 1.

Data science is a versatile concept that presupposes the use of various techniques and technologies aimed at data analysis and interpretation. Frankly speaking, it uses statistics, artificial intelligence and data mining to uncover business values from data assets. Common methods encompass regression, classification, clustering and

Natural Language Processing (NLP). Regression analysis deals with predictive models of gives continuous dependent variable and on independent variables, while classification divide data into pre-specified group. Clustering means finding out a pattern and grouping of similar points and NLP means getting a meaning out of text and getting to know the sentiment attached to it. Some of the tools that are employed in data science include programming languages like Python and R which provide sophisticated libraries and frameworks for data processing and modelling **[7]** some of which were analysed in the research.

For example, Python includes tools like Pandas, NumPy, and Scikit-Learn that can be used in data cleaning and analysis, as well as statistical analysis and machine learning. The SciKit-Learn library offers a variety of classification, regression, and clustering algorithms. R, another popular language, comes with its packages such as dplyr for data manipulation, ggplot2 for data visualization, caret and random Forest for high statistical analysis.

There are tools like Jupyter Notebook, which include the capability for exploration and interaction with the data and for creating

data visualizations that can be inspected, Apache Hadoop and Spark and other big data platforms are efficient for data management in large scale data, and Tableau and Power BI for representing complex information at a glance.

The results of the research show how these techniques' implementation can positively change community conditions and improve business operations. Data science and its application in empowering society are indeed significant [8]. Thus, data analysis becomes a beneficial component in decision-making processes since it can help pinpoint and rectify social issues.

The analysis of the data science utilization in managing social and economic systems helped to identify some of the effective methods and examples of their application, mainly in the social empowerment:

1. Multiple Linear Regression is a useful method for assessment of multiple endpoints and can be effectively employed for development of ready-made tools for risk assessment, establishing diagnosis or monitoring therapeutic efficacy in patient care etc. For instance, the method can help insurance companies to make decisions on charging the premium and predicting future medical expenses of individuals using such individual features as age, physical or family conditions and location.

The model is structured as follows:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_p x_p + \varepsilon,$$

where: y — dependent variable; x_1, x_2, ..., x_p — independent variables; β_0, β_1, β_2, ..., β_p — coefficients; ε — error term.

2. Simple Linear Regression can be used to evaluate trends and make estimates or forecasts. For example, in business it is possible to forecast sales in future months on the data received from company's operations for the past few years.

The model is structured as follows:

$$y = \beta_0 + \beta_1 x + \varepsilon,$$

where: y — dependent variable; x — independent variable; β_0 — intercept; β_1 — slope; ε — error term.

3. Logistic Regression extends the techniques of multiple regression to research situations in which the outcome variable is categorical and can be effectively used in the fields of medicine, education and social sciences.

The model is structured as follows:

$$\log(\text{odds}) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_p x_p,$$

where: $\log(\text{odds})$ — log of the odds of the event occurring; x_1, x_2, ..., x_p — independent variables; β_0, β_1, β_2, ..., β_p — coefficients.

For instance, in education it can help to assess students' performance on the basis of various factors such as grades, motivation, social and economic conditions; in medicine it can help to identify patients at high risk for certain diseases based on factors such as age, weight, and family history.

4. Pearson Correlation Coefficient is one of the ways of measuring a linear correlation to identify the strength and direction of the relationship between two variables.

Formula:

$$r = \sum \frac{(x - \bar{x})(y - \bar{y})}{\sqrt{\sum (x - \bar{x})^2 \times \sum (y - \bar{y})^2}},$$

where: r — Pearson correlation coefficient; x, y — data points; $\bar{x}, \bar{y}$ — means of x and y.

For instance, in healthcare it can be used to identify the relationships between various health outcomes and potential predictors like smoking and lung cancer; in finance it may help to figure out the risk and return of a portfolio in case the stocks are positively or negatively correlated; in social sciences it can be used to understand the relations between income inequality and social unrest.

5. Spearman's Rank Correlation Coefficient is effectively used in various fields due to its ability to measure the strength and direction of monotonic relationships between variables.

Formula:

$$\rho = 1 - \frac{6 \sum d^2}{n(n^2 - 1)},$$

where: ρ — Spearman's rank correlation coefficient; d — difference in ranks between corresponding values of x and y; n — number of data points.

6. Chi-Square Test is a powerful statistical tool that it is often used to determine whether or not there is a significant association between two or more categorical variables. It can be utilized in real-world scenarios in various spheres.

Formula:

$$\chi^2 = \sum \frac{(O - E)^2}{E},$$

where: χ^2 — chi-square statistic; O — observed frequency; E — expected frequency.

For instance, in business it may help to determine if there is a strong association between customers' age and their preferred products and using this information to develop marketing strategies to particular age groups; in healthcare the method is commonly used to evaluate the effectiveness of medical treatments.

Through the use of superior analytical tools and mechanization, social problems can be analysed in a deeper approach with the help of different machine learning techniques which in result will help in the invention of better interferences and policies [9]. Real-time data analysis helps in improving the rate at which response aid is provided and also helps in identifying areas that require more assistance.

Real-time data is the one that changes frequently and illustrates the situation that is currently taking place. They are wide ranging and evidence significant benefits across many fields.

Thus, in healthcare various types of integrating PPS, wearable biosensors and mobile health applications as well as other devices and solutions provide an opportunity to constantly monitor the health indicators and institute the relevant interventions on a real-time basis. The effectiveness of such systems proves the ability of data science to make work processes more effective and the quality of patient's health better [10]. In cases of natural disasters, the collected data from satellite images and other social media platforms enables effective and timely response to unmet needs which may be critical in saving lives and minimizing the effects of disasters [11]. In finance real-time data analytics are used to monitor market changes and make instant investment and risk management decisions.

Another area of great influence is the use of data science for poverty eradication. Computerized technologies have been used to facilitate better targeting of welfare programs as well as more accurate poverty estimates [12]. When information from household surveys, satellite imagery, and mobile-phone data are combined, it becomes easier to identify vulnerable individuals in need of help. With the integration of the data, resources concentrating on the services that minimize poverty are directed efficiently and effectively.

Real-time data has its advantages when used in organizations. It allows quick decisions, which are useful where conditions change rapidly or when decisions have to be made instantly. Furthermore, real-time data fosters openness and provides a means to assess effectiveness, enabling changes to be made when necessary.

However, as it has been seen, real-time data comes with its own set of issues. The very large amount of data could cause issues for various systems, and present large storage and computation needs. The protection of data is also a major issue here as the data gathered in real-time includes personal data of individuals. Moreover, real-time data may also contain a certain level of error or uncertainty, and hence requires validation before being used in decision-making process. Solving these problems requires having appropriate data management systems and meeting the privacy regulations while designing algorithms to meet the data storage and analysis requirements. Nevertheless, the benefits of real-time data in increasing organizational adaptability and thus decision making remain a key motivating factor behind the use of the system in the various fields hence the importance of the system in solving real world problems [13]. These concerns have revealed the versatility of data science when applied to global concerns and also the various results it has achieved in practice, positive and negative alike. The results of the research reflect how data science may be used to generate positive social impact, as well as potential challenges in practice, which are discussed in the subsequent sections of the paper [14].

Data science relies on access to various sources of information to capture and transform data patterns into usable evidence through the use of complex machine-learning techniques. It is worth noting that the number of the daily time spent on social networking globally has increased. Changes for the period from the year 2012 to 2024 are presented in figure 2.

It was noticed that Internet users spent around 60 minutes on average in 2012 which has grown up to approximately 140 minutes in 2024. These tools use past crime data to predict and deter crime, but they are built with and reproduce the prejudices in the data [15]. This has created apprehension for massively policed and overwatched black and nonwhite stakeholders. Hence the requirement for explainable and non-prejudiced algorithms
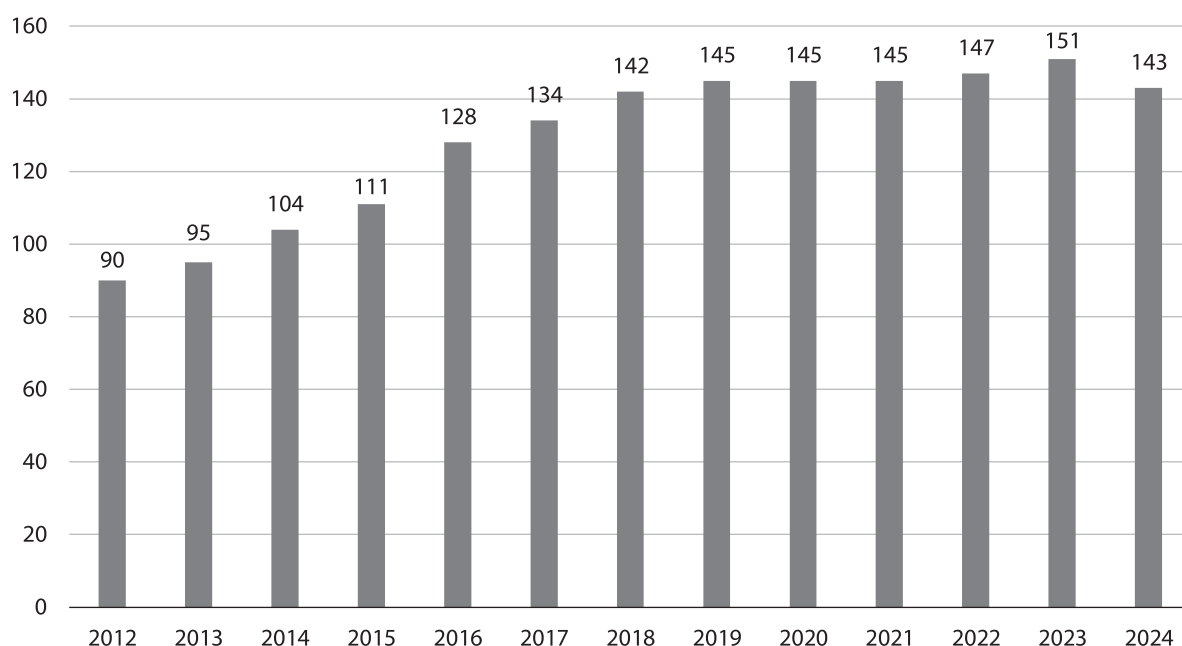
Fig. 2. Daily time spent on social networking by internet users worldwide from 2012 to 2024 (in minutes)
Рис. 2. Ежедневное время, проведенное в социальных сетях интернет-пользователями во всем мире
в период с 2012 по 2024 г. (в минутах)

Source: [1].

to eliminate such harms and guarantee that the pivoting to data-centric solutions does not widen injustices. At the same time, the integration of data science in social credit systems faces several challenges. They rely on the measurement of data flow to rate and rank people in behaviours, including monetary dealings and interactions. Thus, while designed to enhance social accountability they have elicited concern over privacy and abuse [16]. An important factor to consider is the fine line between sharing data for the common good of society and invasion of privacy of the persons involved. In general, data science integration into different fields demonstrated the possibility to become an agent of societal benefit. Across different sectors including healthcare, education, and poverty reduction, it has been established that big data can improve results while applying resources efficiently.

The future of data science in social empowerment is highly promising with regards to this paradigm shift and the new trends that are yet to emerge. Analysing today's trends in data science, it is possible to identify several important concepts that define the further development of this field and its potential applications. One of the emerging trends has been the incorporation of Artificial Intelligence and Machine Learning with data science. They allow them to apply higher-order analysis and predictive modelling improving the decision-making process.

There is a variety of advanced analytics and data science technologies in the market. The market share of various big data and business analytics software in 2019 in presented in figure 3.

MATLAB takes the largest share with 14,58 percent of the total shares, further goes Alteryx with at 10,82 percent of the total shares. HubSpot Analytics, Tibco Spotfire Datascience, and Stata each has a smaller portion. The remaining percentage is 58,32 is allocated to the 'Other' category. This figure gives an initial impression of the competitive environment of big data and business analytics industry. Automated computations through Artificial Intelligence can manage Big Data more efficiently and derive information that might otherwise be impossible [17]. This capability is very useful when it comes to product management, disease outbreak predictions, or devising an individualized treatment plan. It is expected that Artificial Intelligence and Machine Learning algorithms will progress and enhance these applications for more precision and real-time data insights. Another trend is the focus on ethical data use and the protection of data privacy.
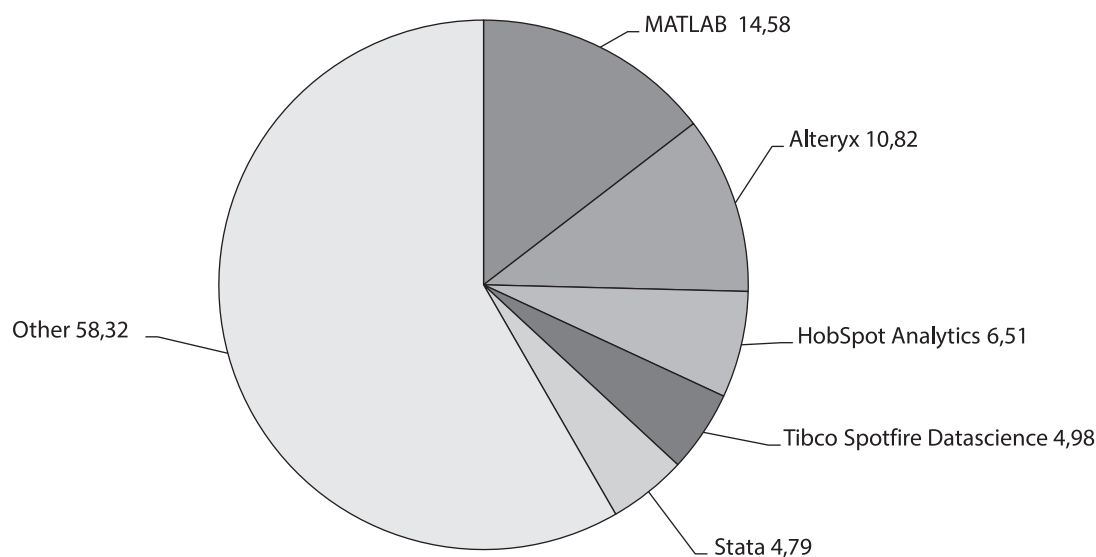
Fig. 3. Market share of advanced analytics and data science technologies
Рис. 3. Доля рынка передовой аналитики и технологий обработки данных

Source: created by the authors using [23].

As, more organizations start to adopt data science for operations and decision-making, there is a realization that several concerns such as data protection, permissions, and ethics in Machine Learning models need to be dealt with. The IoT devices produce a constant flow of real-time data which, when analysed with analysis tools, can be useful for different uses [18]. For instance, smart city initiatives employ IoT data for better traffic signal control, physical security, and resource utilization. The fusion of big data with IoT has the ability to help change how we solve major socio-political challenges with more clarity and precise solutions.

A study of outcomes of recent data science effort shows promising results as far as social issues and social emancipation are concerned. By analysing the different studies and applications, the study demonstrates that data science can have a distinctive positive impact in different fields and arenas. One result observed from these implementations is that the effectiveness and success of social programs was considerably enhanced in terms of precision and speed. For example, the system and technologies such as the predictive analytics and machine learning have made the models for targeting resources and interventions to be more accurate. For instance, in the treatment of diseases, technological tools have helped in early diagnosis, individualized treatment of the diseases and improved quality of the treatments hence improving

on the quality of the health since the use of resources has been optimized.

The authors analysed different social and economic development projects paying special attention to the beneficiaries of such projects. The results of the research are presented in figure 4.

The image depicts a bar graph based on the number of beneficiaries of different social development projects. Each of the bars corresponds to a project and its individual segments represent different beneficiaries. The chart also reveals the details of beneficiaries according to various projects, enabling one to evaluate the effectiveness of one project to the other.

In the same way, in education, various methods using big data and data science have been used to note early talents that are struggling in school and therefore, necessary action is taken, ensuring improvement of performances as well as low incidence of dropouts. It is equally important to note that these data science applications are evidence based and have measurable impacts [19]. For instance, in poverty alleviation programs, big data and real-time analysis has helped in the identification of the targeted beneficiaries to ensure that the needy are well catered for. This not only has improved the determinations of poverty figures but also has helped in improving the efficiency of the delivery of resources in poverty alleviation programs by cutting down on overhead costs. Furthermore,

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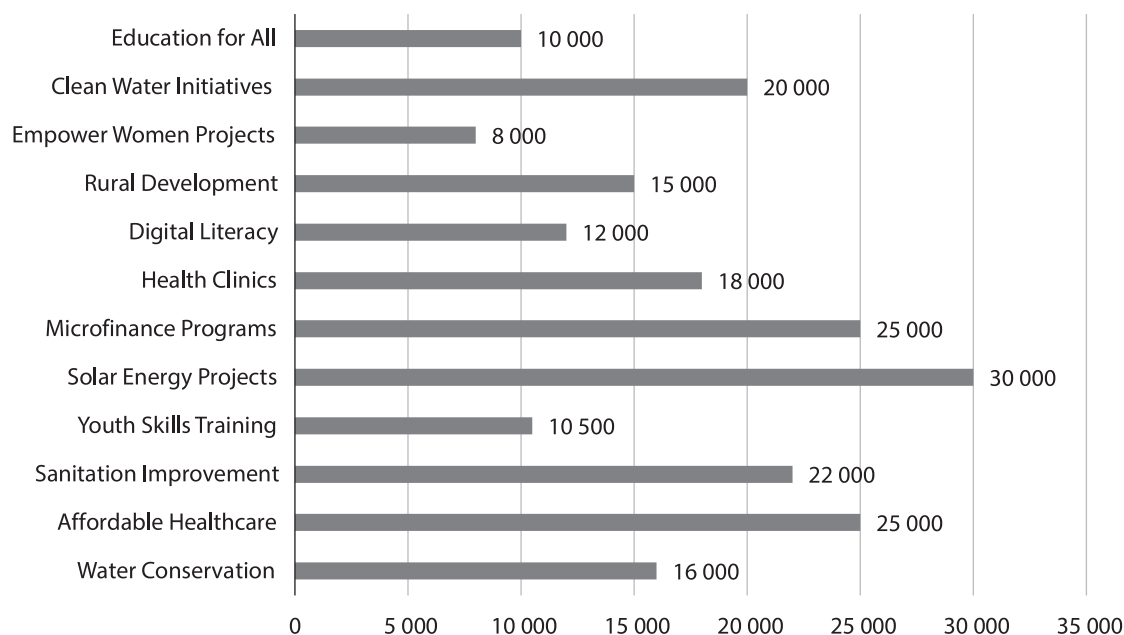
Fig. 4. Beneficiaries of different social and economic development projects
Рис. 4. Бенефициары различных проектов социально-экономического развития

Source: created by the authors.

data as an asset in systems design for cities has improved the population services such as transport and safety measures during calamities resulting in safer societies. Regarding equalization, the study reinforces the fact that data science is at the core of eradicating disparities and creating parity [20]. The use of data is meant for organizations to enhance policies and programmes that directly capture experiences of key population groups. The ability to understand big data and identify regularities is essential since it allows policymakers to come to the right decision in society's regard.

The technique may have some downsides, though. Data science may be hampered by privacy, ethics, and the digital gap [21]. Responsible data use and ensuring all relevant stakeholders benefit from data science are crucial to societal enfranchisement. Finally, data science may help empower society. By unravelling important approaches, problems, and assuring a more equitable approach, data science may create fairness and efficient solutions to global social issues. Data science has influenced social empowerment in many areas of life [22]. Data analytics in healthcare has improved results by personalising treatments and forecasting. Data science helps educators deliver learning content that meets students' needs best, enhancing attainment and learning achievement [23].

Discussion of data science solutions for social emancipation suggests a change from traditional global problem-solving. Recent findings show that data science, particularly real-time data analytics, has enhanced health, education, and poverty reduction efforts. Strategic data analysis has substantially improved resource use and help distribution to the poor. This increased health, education, and poverty reduction. This study emphasises the importance of data science in social program development and support. Analytics, machine learning, and predictive models help organisations make better decisions, distribute resources efficiently, and offer unique treatments. They improve service delivery and social interventions, which may help provide fair and equal solutions. Future work and policy will be affected in different ways. Data must be used ethically and policymakers and practitioners must address privacy, ethics, and access. Data science is a young field, thus research must enhance methods or find new uses. Better data analysis, more digital tools, and bias reduction should be the goals of future study. Emerging technologies like artificial intelligence and blockchain as have the capability to advance social power at a larger capacity. Five large programs were successfully implemented to improve society — the discussion confirms the potential of data science for social impact. Expert analytical

tools together with real-time data processing can be used to solve social problems affecting the globe. It is necessary to carry on with this process and employ these findings when addressing the mentioned challenges.

Modernization of cooperation between various fields, as well as further development of data analysis and related projects will help enhance the effectiveness of social activities and create a more just society.

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