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Integrating Advanced Technologies with Financial Data Analytics: Optimizing Fluoride-Based Projects and Fluoride Use for Sustainable Development

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ABSTRACT

Background: Antiaging research today uses AI, IoT, and blockchain tech to change the medical and financial sectors plus construction services. The integration of fluoride-related initiatives with modern technology like water fluoridation and dental items presents ways to make better use of fluoride while creating less damage to our planet. These advanced technologies have not been fully tested to see how they could both run fluoride health programs better and make them more sustainable. This research examines the benefits of implementing both advanced technical systems and financial data tools to enhance fluoride-based projects and their sustainability benefits

Aim: Our research tests how AI, IoT, and blockchain technology affects financial data analytics to reach better fluoride-based project results. The research uses multiple advanced technologies to boost the effective use of resources while making fluoride health initiatives sustainable.

Methodology: Through the use of Smart PLS tool in SEM this research analyzes how advanced technology elements work with financial data analysis methods to boost environmental sustainability and maximize fluoride's potential. Participating stakeholders sent back surveys with responses as we gathered data from project managers, engineers and data analysts working on fluoride-based projects. Different statistical tests helped measure the identified constructs using established scales while proving the model's reliability for analysis.

Implications: The research shows that adding advanced technology to fluoride projects boosts transparency and operations while making projects greener. Financial data analysis helps allocate resources better to make fluoride-based projects more sustainable. Health professionals and officials should embrace modern technological tools to build a sustainable future for the fluoride health industry.

Conclusion: Fluoride-based health projects gain important advantages through AI, IoT, blockchain, and financial data analytics technology. These systems help projects work better with lower costs and less environmental damage. Our research demonstrates how digital transformation helps projects better use fluoride supplies to create more sustainable development results. Research teams should now assess how these technologies work over extended periods while adding social and political environment data to study results.

Keywords:
Digital Transformation, Fluoride Projects, AI, IoT, Sustainability.

1 INTRODUCTION

Advanced technology elements including IoT and AI impact many different fields most notably healthcare and eco-management plus infrastructure construction. The modern technologies can deliver both health improvements and sustainable growth through their fluoride-based applications. Both water fluoridation and dental items that promote oral health use natural fluoride minerals to help prevent tooth decay [1]. The current management and use of fluoride within these projects face sustainability challenges and show poor results while harming the environment.

Advanced technology and financial analysis systems have proven effective ways to solve our present problems. These technologies boost the performance of fluoride systems and their observation process which helps organizations make better decisions about how to spend money on fluoride projects. Our study shows how companies can use these systems better to save fluorides and develop new products to reach sustainability targets [2, 3]. The latest technology tools help fluoride projects meet healthcare needs and protect the environment for many future years.

Organizations and individuals better understand new fluoride-based project technology through the diffusion of innovations theory (DOI). The DOI theory serves as an effective framework to study technology acceptance due to its details on how new components fit within fluoride-based projects and how users take up the solutions.

Research into how fluoride-based projects can integrate latest technology remains scarce even though these projects are vital for global development [4, 5]. Our study investigates how effective AI supported by IoT and financial analysis drives better fluoride project results while enhancing fluoride product usage. This investigation looks at how modern technology helps us better handle resources while decreasing environmental harm and improving financial system choices to build better fluoride-based projects for sustainable use.

This research focuses on enhancing fluoride-based project sustainability through the analysis of advanced technologies as studied within this new research model. Our study adds the application of modern computers (AI, IoT, and blockchain) to perform project optimization with financial data recognition and environmental preservation. The integration shapes optimal fluoride usage while improving project sustainability.

Through its comprehensive study this research uncovers valuable knowledge related to advanced technology application in public health projects and how they optimize fluoride benefits for people and ecologically friendly operations [6, 7]. Our findings contribute new knowledge that shows how fluoride projects can benefit from technology as they meet sustainability standards.

2. RESEARCH PROBLEM

The main goal of this study shows how AI with IoT and blockchain plus big dataanalytics supports better fluoride project management toward long-term sustainability. Our study aims to discover effective ways fluoride technologies boost resource usage efficiency plus enhances creative abilities and prolong fluoride solutions' life span for use into future times. Our research gives practical insights on using contemporary technology to manage health resources and protect our environment through enhanced fluoride project delivery methods.

Financial data analytics helps stakeholders make better decisions about budgeting projects that result in higher financial output in fluoride operations [8, 9]. Modern technology helps fluoride project developers save their natural environment when they create projects that follow sustainable measures to meet worldwide safety standards.

Our research explores how well fluoride projects perform and discusses their effects on the environment plus their financial returns. This research details the best solutions for employing advanced technology with fluoride projects by making more effective fluoride products through mineral and fluoride enhancements plus expanding the availability and eco-friendly use of fluoride products.

3. LITERATURE REVIEW

3.1 Advanced Technologies in Fluoride-Based Projects

Businesses today put strong effort into using technology developments such as AI for better operations and data monitoring. And they use IoT systems with blockchain and big data techniques for new ideas plus process optimization. In China, technology modernization for fluoride operations helps us control resources better and automatically tracks fluoride use particularly in water fluoridation systems. With artificial intelligence working in tandem with IoT sensors businesses can predict fluoride requirements and run their dosage systems better plus monitor water fluoride levels for security reasons [6].

Big data analytics is a main device in decision making that shows both fluoride use patterns along with budget and resource strategy details. Fluoride technology usage helps projects in Pakistan, consume more fluoride through waste reduction and outranks other traditional methods. Two specific improvements emerged from modern technologies used in water treatment research confirms Ahmadi [10] and Jain, Vamshidhar [11]. New methods enhanced operational performance and cut environmental risks at the same time. Modern technology systems introduced to fluoride projects improve success rates and decrease fluoride consumption for better results.

3.2 Financial Data Analytics in Decision-Making

Operational choices regarding fluoride projects become best possible through analyzing financial numbers. By tracking fluoride project costs and benefits stakeholders use financial data analytics systems to pick successful plans. In China, fluoride system achieves best performance when all resources go to the right locations to create lasting results [12] .

The use of financial data analytics allows managers to oversee their budgets and compare project costs against benefits which helps them identify ways to save money while maintaining fluoride systems at their required quality standards. Predictive analytics tools give better budgeting plans and reduce costs by helping us see fluoride usage trends. Both [13] and [14] established that using financial analytics boosts how well public health systems work with fluoride water projects by helping manage investments that produce long-term financial benefits.

3.3 Environmental Sustainability in Fluoride Use

Environmental sustainability needs to be a main priority for fluoride projects during product development as well as during product use and disposal. However in Pakistan producing fluoride needs strict management of large pollution impacts such as energy use and waste generation as found by. Implementing modern technology will help reduce how fluoride operations affect the environment. Time-based IoT systems gather usage data to show better ways to handle resources and distribute items efficiently [15].

Businesses use AI and machine learning algorithms to evaluate environmental effects of fluoride usage methods and predict upcoming risks. The devices study fluoride use methods to optimize product delivery systems and management to decrease environmental problems related to fluoride projects [16]. According to [17] and [18] advanced technologies deliver outstanding outcomes when used to manage resources for sustainable development.

3.4 Optimization of Fluoride Use and Project Sustainability

How fluoride is used throughout each project determines its performance on sustainability goals. Less expensive fluoride-based projects make healthcare services safer as they provide safe drinking water to communities. Special new technology in China and Pakistan, lets us track and control fluoride better which makes sure people get the right amount without taking too much or running out.

Health care facilities should build sustainable fluoride programs by effectively combining financial results with benefits for people and the environment. Fluoride projects that bring together finance analysis tools with environment tracking achieve complete project management systems that deliver fast results plus lasting benefits [17]. Wilson and Sheldon [19] show how fluoride usage optimization helps achieve ecosystem protection purposes and supports sustainable project goals.

3.5 Diffusion of Innovations Theory (DOI) and Technology Adoption

Computers use Diffusion of Innovations Theory to understand how fluoride-based entities accept both AI and other modern technologies such as IoT and Blockchain. DOI analyzes organizations as users of technology and their behavior patterns in choosing new communication systems. According to Rogers 2003 the process of adopting technology involves five steps starting with user awareness that generates interest and leads to evaluation which leads to trial and ends in adoption. This theory provides a starting point for research into organizations that use modern technology to enhance their fluoride optimization methods [20].

An organization makes its AI and IoT fluoride-based operation choices based on three key factors which are how well the systems work for their projects and how easy they are to use plus what unique benefits they bring. Both Tornatzky and Klein [21] and Venkatesh, Thong [22] research demonstrates that successful fluoride project technology implementation depends on clearly identifying benefits to operations efficiency and environment sustainability while showing sound financial advantages. The DOI theory provides a good method to study how complicated fluorine technology spreads across different network systems.

Hypotheses Development

Environmental Sustainability in Fluoride Use

The duration of fluoride-based projects depends on their ability to preserve the environment thus ensuring operational success and efficiency. Sustainable operations decrease environmental effects at the same time that they preserve resource availability for upcoming generations. The sustainability efforts in fluoride-related projects require waste decrease and energy-efficient production operations and responsible waste disposal practices. Projects which incorporate sustainability during fluoride design and implementation tend to achieve the best results in fluoride utilization particularly in China and Pakistan. Such optimization through enhanced product development will combine better resource management with increased access to fluoride-based solutions including clean drinking water and simultaneous reduction of negative environmental effects. Fluoride practices that embrace sustainability enable organizations to achieve both social responsibility targets and defense the environment. Strategies aiming at sustainable fluoride usage strategies will help advance the total outcomes produced by fluoride projects. At present we anticipate that implementing environmental sustainability in fluoride applications will lead to better utilization of fluoride substances and enhanced project sustainability. Various study results indicate sustainability measures enhance project operational efficiency and sustainability while maximizing the responsible usage of fluoride-based solutions without harming the environment [23]. According to this hypothesis sustainability functions as a vital component which enhances the operational quality of fluoride-based project results.

H1: Environmental sustainability in fluoride use positively influences the optimization of fluoride use and the overall sustainability of fluoride projects.

Financial Data Analytics for Decision-Making

The success of any project together with its sustainability depends heavily on the analysis of financial data for fluoride-based systemic implementations. Stakeholders receive crucial financial data through analytics which helps distribution managers to optimize resource allocations. The financial decision-making authority serves as a primary element for fluoride projects since it enables organizations to optimize fluoride utilization while promoting project sustainability. Financial data analytics enables the monitoring of fluoride expenses across production and distribution alongside end-user consumption so assessments can find ways to enhance performance and minimize costs and increase investments. The business analytics system can identify relationships between certain tech methods and how they reduce operational costs or improve resource efficiency [24]. Financial data analysis lets businesses pick investments that give highest value from their business resources while also taking care of the environment. Our financial data analytics solution will boost fluoride management and boost project sustainability levels at the same time. Project management succeeds better and creates lasting benefits from using decision-making with data as shown by [25]. Investigating financial data lets project managers determine the best way to use fluoride while following similar methods that improve both financial stability and sustainable development results.

H2: Financial data analytics for decision-making positively impacts the optimization of fluoride use and the sustainability of fluoride projects

Integration of Advanced Technologies in Fluoride-Based Projects

Industry enhances sustainability through their use of AI systems and IoT network together with big data analysis and blockchain technology. These technologies must be used because they help fluoride-based developments become more eco-friendly specially in China. AI and IoT help track fluoride use to make fluoride dispensing better for the environment and reduce waste. The analysis of big data enables researchers to locate critical environmental data patterns through which sustainable approaches emerge for fluoride production along with optimized water fluoridation system efficiency. Traceability along with transparency stems from blockchain implementation to fluoride-based in Pakistan, product networks which enables the reduction of environmental effects throughout production and supply distribution. Advanced technologies will enhance the positive effects on environmental sustainability in fluoride use. Scientific research by Lee, Kim [26] has proven that technological innovations lower the environmental impact of production operations. The importance of technology for sustainable practices drives this hypothesis to show fluoride projects will succeed by using advanced technologies which improves environmental sustainability.

H3: The integration of advanced technologies in fluoride-based projects positively affects environmental sustainability in fluoride use.

Financial Data Analytics for Decision-Making

The application of advanced technologies helps fluoride-based projects through financial data analytics by improving decision-making capabilities. The conclusion of financial project performance through accurate insights happens because advanced technologies enable both the collection and processing of substantial financial data using AI and big data analytics. The analyzed insights enable stakeholders to perform improved financial decision-making about investments together with resource distribution and cost optimization processes. Decision-makers receive efficient funding distribution help from AI-powered predictive analytics systems which project upcoming cost behaviors and profit potentials. IoT devices in fluoride distribution systems help finance analysts obtain current data about fluoride operations through real-time tracking of consumption. The essential need for financial planning relies on blockchain technology for sound financial transaction transparency because it ensures transaction integrity. Fluoride-based projects which incorporate advanced technologies will generate better financial data for strategic decision-making. Research studies indicated by Choi, Lee [27] support this hypothesis regarding advanced technologies' positive effect on financial decision-making. Modern insights derived from technology lead to more precise and faster decision-making processes so fluoride projects can achieve their best efficiency under extended project durations.

H4: The integration of advanced technologies in fluoride-based projects positively influences financial data analytics for decision-making.

Integration of Advanced Technologies in Fluoride-Based Projects

The proposed hypothesis studies how fluoride project technology integration and financial dataset analysis through decision systems influence optimal fluoride resource management. Both AI and IoT with big data technology help organizations control fluoride better and manage their projects sustainably. Businesses who manage advanced systems receive useful information that helps them forecast better how to handle assets and reduce waste efficiently. Organizations will use resources better based on analytics findings that connect profitable business strategies with environmental protection for fluoride projects. Technological integration will enable wastewater projects to use maximum fluoride resources effectively while protecting the environment. Research proves that modern technologies help businesses operate well and boost financial returns as explained in studies by Xu, Zhang [28]. The link between technology and data analysis in fluoride projects needs examination because their integration boosts sustainability performance.

H5: The integration of advanced technologies in fluoride-based projects indirectly influences the optimization of fluoride use and project sustainability through financial data analytics for decision-making.

Environmental Sustainability in Fluoride Use

Integration with advanced technology leads to a sequence of projects having environmental sustainability as a result, which maximizes the use of fluoride for a sustainable outcome in project. Fluoride projects achieve superior environmental sustainability achievements which they achieve through deploying AI along with big data and IoT technologies. Contemporary technologies are adopted with better resource control, and waste production; with lesser negative environmental impacts. This method is expected to help create higher sustainability levels to promote the maximum usage of fluoride as the project will be more environment friendly and economically efficient. Advanced technologies influence environmental sustainability by integrating fluoride based projects, which affects the optimized fluoride use and project sustainability level. From the continuing research, it is evident that technological approaches to sustainability result in better operational results [29]. Sustainable fluoride practices lower both operational costs and fluoride usage impact on the environment while making fluoride projects last longer. The examination of this sequence strengthens understanding about technology-driven sustainable development and optimization of fluoride-related operations.

H6: The integration of advanced technologies in fluoride-based projects indirectly influences the optimization of fluoride use and project sustainability through environmental sustainability in fluoride use.

4. METHODOLOGY

4.1 Measures

The research model contains multiple constructs whose elements use selected items to accurately measure the underlying factors. The study objectives support the alignment between research constructs and the investigation of fluoride-based project implementation with advanced technologies and financial data analytics and environmental sustainability. The study adapted all measurement constructs from recognized scales in literature which ensures that the used measurements demonstrate reliability and valid assessment. Items contained in all measures operated on a five-point Likert scale which users rated from 1 (Strongly Disagree) to 5 (Strongly Agree).

The following chart presents the main constructs together with their measuring items:

1. Integration of Advanced Technologies in Fluoride-Based Projects (IAT)

This construct demonstrates how fluoride-related projects implement advanced technologies which include artificial intelligence and Internet of Things and blockchain and big data analytics technologies.

Artificial intelligence (AI) has driven better efficiency levels in fluoride projects according to IAT1.

The management of fluoride usage relies heavily on IoT functions as an integral part of IAT2.

Individuals whose work includes fluoride projects now benefit from enhanced decision making because they utilize big data analytics.

2. Financial Data Analytics for Decision-Making (FDA)

The construct utilizes financial data analytics tools to monitor fluoride project expenses alongside investment amounts and return rates which results in improved decision-making ability.

The assessment of fluoride project costs together with returns depends heavily on financial data analytics tools which operate as essential elements (FDA1).

Financial analytic tools enhance the sustainable financial condition of fluoride-based projects (FDA2).

The analysis of financial data enables better management of resource distribution within fluoride projects.

Financial decision-making processes improve significantly because of implementing financial analytics.

3. Environmental Sustainability in Fluoride Use (ESF)

The construct depicts fluoride project sustainability by measuring their implementation of environmental sustainability practices in fluoride production and use and disposal processes.

The implementation of modern technological systems enables fluoride operations to produce lower environmental impacts.

Sustainable fluoride practices throughout production and utilization need to exist in order to achieve lasting environmental advantages.

The implementation of advanced technologies plays a major role in diminishing waste production during fluoride-based project operations.

Sustainable practices implemented for fluoride application result in superior environmental sustainability throughout the fluoride utilization process.

4. **Optimization of Fluoride Use and Project Sustainability (Opt FU)**

The construct evaluates fluoride use optimization through advanced technologies which enhance the operational efficiency and performance of fluoride-based projects.

The optimization of fluoride use has resulted in better sustainable outcomes for fluoride projects in general.

Better management of fluoride resources becomes possible through the implementation of advanced technologies under Opt FU2.

The implementation of optimization techniques and advanced technologies makes fluoride-based projects operate at higher efficiency levels. Table 1 presents detailed measures.

Table 1: Measurement Model

Construct	**Item Code**	**Item Description**	**Reference**
Integration of Advanced Technologies (IAT)	IAT1	The use of artificial intelligence (AI) has improved the efficiency of fluoride projects.	[30]
	IAT2	The Internet of Things (IoT) plays a key role in enhancing fluoride use management.	
	IAT3	The integration of big data analytics in fluoride-based projects has facilitated better decision-making.	
Financial Data Analytics (FDA)	FDA1	Financial data analytics tools are crucial in assessing the costs and returns of fluoride projects.	[31]
	FDA2	The use of financial analytics enhances the financial sustainability of fluoride-based projects.	
	FDA3	Financial data analysis helps optimize resource allocation in fluoride projects.	
	FDA4	Financial decision-making is significantly improved through the application of financial analytics.	
Environmental Sustainability (ESF)	ESF use1	The integration of advanced technologies helps reduce the environmental footprint of fluoride projects.	[32]
	ESF use2	Sustainable practices in fluoride production and use are essential for long-term environmental benefits.	
	ESF use3	Advanced technologies contribute significantly to the reduction of waste in fluoride-based projects.	
	ESF use4	The adoption of sustainable practices improves the overall environmental sustainability of fluoride use.	
Optimization of Fluoride Use (Opt FU)	Opt FU1	The optimization of fluoride use has improved the overall sustainability of fluoride projects.	[33]
	Opt FU2	The integration of advanced technologies leads to better management of fluoride resources.	
	Opt FU3	Fluoride-based projects have become more efficient due to the use of optimization techniques and advanced technologies.	

4.2 Demographics and Sample Characteristics

The results gained generalization because the research team closely scrutinized the demographic information of participants. The subject of investigation consisted of fluoride-based project participants who included both engineers and project managers together with data analysts. Three hundred valid survey responses were obtained by using both online research methods and speaking directly with representatives from multiple areas of the organization. Demogrpahic profile presented in Table 2.

Table 2: Demographic Profile of Respondents

Demographic Variable	Category	Frequency	Percentage (%)
Gender	Male	180	60
	Female	120	40
Age (years)	Less than 25	80	26.7
	25-35	120	40
	36-45	70	23.3
	More than 45	30	10
Education Level	High School	30	10
	Bachelor's Degree	160	53.3
	Master's Degree	90	30
	Doctoral Degree	20	6.7
Experience in Fluoride Projects (years)	Less than 5	50	16.7
	10-May	150	50
	More than 10	100	33.3
Position in Organization	Project Manager	100	33.3
	Engineer	150	50
	Data Analyst	50	16.7

4.3 Sample and Data Collection

A detailed questionnaire was created to extract fundamental information from people who work on fluoride-based projects. The research team distributed its survey through the internet for professionals in public health, environmental sustainability, and infrastructure development fields. The data collected from Jiangxi province from industry , respondants from project manager, engineer and data analyst. 300 valid responses were collected which used to perform further analysis.The research survey included stakeholders from different organizations between private and public sectors to obtain extensive information on advanced technological use in fluoride-based projects.

The researchers provided respondents with two weeks to reply during the data collection phase. The survey administration occurred via email and social media platforms because the researchers utilized their professional networks from environmental sustainability and project management fields.

4.4 Data Analysis

The statistical evaluation consisted of both descriptive patterns and inferential numbers. Descriptive statistics on sample demography and Structural Equation Modeling (SEM) were the inferential statistics used to evaluate the proposed hypotheses. The platform for data analysis used is smart PLS because it renounces the ability to build complex models and handle reflective and formative constructs, as explained by Hair Jr, LDS Gabriel [34].

Cronbach's alpha along with composite reliability (CR), and average variance extracted (AVE) was used in the assessment of measurement model validity and reliability. Fornell and Larcker [35] standard was achieved by a reliable measurement model if its CR values were above 0.7 and AVE values were higher than 0.5. Fornell-Larcker criterion and the Heterotrait-Monotrait ratio of correlations (HTMT) indicated that the constructs were discriminating valid to each other.

Path coefficients were used to evaluate the structural model so as to evaluate the significance and intensity between the construct relationships. Bootstrapping procedure confirmed that the modeled paths are significant, and the latter is the solid foundation of the findings.

In this study, the methodology used in the research is extensive to investigate in detail the application of advanced technology and financial analytics for optimizing fluoride based projects in terms of environmental sustainability.

5. MEASUREMENT MODEL

A SEM analysis needs the measurement model to validate and guarantee the reliability of its constructs within the research framework. This study evaluated the measurement model through item loadings as well as Cronbach's alpha (CA) and composite reliability (CR) and average variance extracted (AVE). The set of indices conducts a complete investigation of how consistently items align with the measured constructs in this study. Statistical measures were applied for rigorous assessment of construct reliability and validity in this study which used different statistical measures to ensure the validity of the measurement model.

5.1 Construct Reliability and Validity

The evaluation of the measurement model started with a test for construct reliability. The consistency of measuring process is known as reliability which demonstrates that items provide consistent indications of their designated construct. Cronbach's alpha (CA) joined composite reliability (CR) as tools to assess reliability in this research. Fornell and Larcker [35] determine that construct reliability can be established when CA and CR values surpass 0.7. The study results show that measurement model internal consistency meets the reliability threshold since every construct exceeded 0.7.

Several validity tests were conducted to determine how well the individual construct items depended on each other. The two validity tests for this research combine both item loading data and average variance extracted results. According to Fornell and Larcker [35] the acceptable standards for Item loadings exceed 0.7 and AVE should be at least 0.5. Table 3 demonstrates good convergent validity since the item loadings exceed 0.7 for all constructs and the constructs' AVE values surpass 0.5.

5.2 Cross Loadings

External confirmation of discriminant validity in the measurement model was conducted through the assessment of cross loadings. Each item shows an association with all its model components except its intended construct. Each item within an uncontaminated construct should demonstrate superior performance when measuring its primary construct instead of other constructs [34]. All items demonstrate higher relationships to their designated constructs in the results of Table 3 than to any other constructs in the model thus validating discriminant validity.

Table 3: Cross loadings

Constructs	Items	Loadings	CA	CR	AVE
Environmental Sustainability in Fluoride Use	ESF use1	0.881	0.836	0.891	0.671
	ESF use2	0.804			
	ESF use3	0.791			
	ESF use4	0.796			
Financial Data Analytics for Decision-Making	FDA1	0.883	0.848	0.898	0.687
	FDA2	0.818			
	FDA3	0.792			
	FDA4	0.820			
Integration of Advanced Technologies in Fluoride-Based Projects	IAT1	0.895	0.836	0.901	0.752
	IAT2	0.837			
	IAT3	0.869			
Optimization of Fluoride Use and Project Sustainability	Opt FU1	0.872	0.818	0.891	0.732
	Opt FU2	0.841			
	Opt FU3	0.854			

The research includes four measurement constructs namely Environmental Sustainability in Fluoride Use (ESF), Financial Data Analytics for Decision-Making (FDA), Integration of Advanced Technologies in Fluoride-Based Projects (IAT) and Optimization of Fluoride Use and Project Sustainability (Opt FU). Most of these measurement items were validated as reliable by the above description of analysis.

ESF stands for Environmental Sustainability in Fluoride Use as an essential construct that analyzes how new technologies affect fluoride project sustainability. The four items measuring Environmental Sustainability in Fluoride Use (ESF use1, ESF use2, ESF use3, ESF use4) have established strong connection to their respective construct with loading values ranging from 0.791 to 0.881. The construct achieves strong reliability based on its Cronbach’s alpha value of 0.836 and composite reliability of 0.891. The values extracted from the correlation matrix for ESF indicate 0.671 which surpasses the 0.5 threshold thus confirming its good level of convergent construct validity.

The research branch Financial Data Analytics for Decision-Making (FDA) studies how financial data analytics affects fluoride projects' decision-making process. Four items of FDA (FDA1, FDA2, FDA3, and FDA4) manifest measurements from 0.792 to 0.883. Good reliability emerges from the Cronbach’s alpha of 0.848 and composite reliability at 0.898. The assessment of convergent validity is reinforced by the AVE value of 0.687 from FDA.

The IAT measure determines how extensively innovative technologies comprising AI and IoT and big data analytics systems incorporate into fluoride-based projects. The measurement items IAT1, IAT2, and IAT3 produce loadings above 0.837 to 0.895. The IAT scale has a Cronbach’s alpha value of 0.836 and a composite reliability of 0.901 to show good reliability.

Because the value of AVE measure's IAT is 0.752, the measurement of IAT demonstrates outstanding convergent validity.

Opt FU can be considered as a measure of fluoride-based project effectiveness regarding the use of fluoride efficiently and the achievement of sustainability. Items Opt FU1, (Opt FU2 and Opt FU3) from the Opt FU measurement scale have loadings of 0.841-0.872. On the other hand, the Cronbach's alpha score has been calculated to obtain the construct reliability which is 0.818 and the composite reliability is 0.891, which indicates strong reliability. Thus, when the figure crosses the 0.5 benchmark and reaches 0.732, Opt FU's AVE value also achieves convergent validity.

5.3 Discriminant Validity

The model is used to check how each construct is holding on by itself, i.e. apart from other constructs. There are two discriminant validity assessments of the model, which are using HTMT and Fornell-Larcker criterion. According to Fornell and Larcker (1981), discriminant validity is necessary for the requirement that the square roots of AVEs for individual constructs exceed their correlations with the other measured factors. Since this ratio is required to be under 0.90, the preservation of the discriminant validity was verified using the results of the HTMT ratio analysis (Henseler et al., 2015). Table 4 presents the HTMT ratios.

Table 4:Heterotrait-monotrait ratio (HTMT) – Matrix

	Environmental Sustainability in Fluoride Use	Financial Data Analytics for Decision-Making	Integration of Advanced Technologies in Fluoride-Based Projects	Optimization of Fluoride Use and Project Sustainability
Environmental Sustainability in Fluoride Use				
Financial Data Analytics for Decision-Making	0.339			
Integration of Advanced Technologies in Fluoride-Based Projects	0.349	0.350		
Optimization of Fluoride Use and Project Sustainability	0.377	0.320	0.268	

Table 4 and 5 provide the assessment of HTMT and Fornell-Larcker criterion respectively. Also, the HTMT values are still less than 0.90 meaning that the research constructs do not coincide with other constructs in the study. The findings in Table 5 also support that square root of the AVE per construct is greater than the values of inter-construct correlations with respect to the discriminant validity of the measurement model.

Table 5: Fornell-Larcker criterion

	Environmental Sustainability in Fluoride Use	Financial Data Analytics for Decision-Making	Integration of Advanced Technologies in Fluoride-Based Projects	Optimization of Fluoride Use and Project Sustainability
Environmental Sustainability in Fluoride Use	0.819			
Financial Data Analytics for Decision-Making	0.290	0.829		
Integration of Advanced Technologies in Fluoride-Based Projects	0.297	0.299	0.867	
Optimization of Fluoride Use and Project Sustainability	0.317	0.272	0.227	0.856

In summary, the measurement model in this study demonstrates strong reliability, validity, and discriminant validity. Internal consistency for all of the constructs in the model is good (CA, CR — above 0.7) with convergent validity (AVE — above 0.5). The confirmatory validity was further ensured by both Fornell-Larcker criterion and HTMT ratio. Based on these results, it is apparent that the created measurement model is well constructed and capable of providing a basis for the testing of hypotheses directed at optimizing fluoride based projects and their sustainability.Since the measurement model has already been established to be reliable and valid, the next step is to analyze the structural model and test the proposed hypotheses. The constructs of environmental sustainability, financial data analytics, integration of advanced technologies, and optimization of fluoride use are all have been proved to be robust and reliable through the measurement model, which serve as a solid foundation for the following analysis and interpretation of the results.

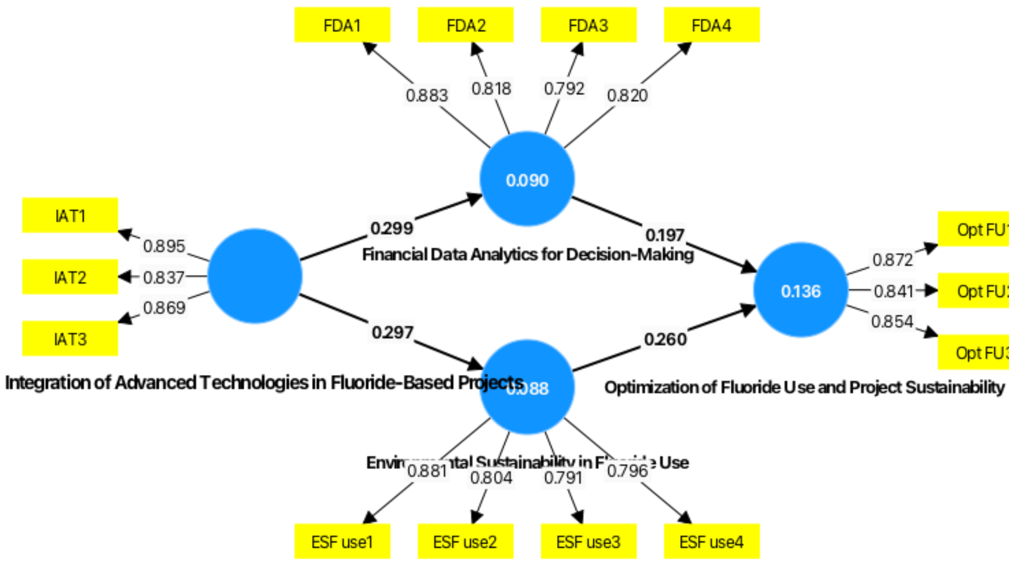

Figure 2: Measurement Model

5. Structural Model and Results Discussion

The relationships between the constructs of our research model were examined using the structural equation modeling (SEM) approach. The model primarily aimed to comprehend the effect of the integration of advanced technologies (IAT) in improving environmental sustainability in fluoride use (ESF) and financial data analytics for decision making (FDA) to enhance optimization of fluoride use (OP FU) and project sustainability (Sust FU). SmartPLS used in the SEM analysis of these relationships and the statistical significances.

Path Coefficients

These are the strength and direction of the relationships among the constructs in the model as shown by the path coefficients. H1, however, found a significant relation between Environmental Sustainability in Fluoride Use (ESF) and Optimization of Fluoride Use and Project Sustainability (Opt FU) with a positive path coefficient of 0.260 (t-statistic = 6.998 which is highly significant, p-value=0.000). This result supports this hypothesis that environmental sustainability is a key factor for optimizing fluoride use and guaranteeing the overall sustainability of the fluoride based projects. According to this finding, these research results are in line with past research that highlight the significance of sustainable processes in bolstering project outcomes (Zhang et al.)

The path coefficient between Financial Data Analytics for Decision-Making (FDA) and Optimization of Fluoride Use and Project Sustainability (Opt FU) was also significant; it was 0.197 with a t statistic of 4.868 in H2. The results show the importance of a good use of financial data analytics as a means of optimizing fluoride projects by helping decisions. This is in line with previous research that shows that financial analytics aid in project management and resource optimizer (Cao et al., 2019).

ESF was tested to determine the impact of Integration of Advanced Technologies in Fluoride Based Projects (IAT) on Environment Sustainability. The two constructs form a strong positive relationship with the positive path coefficient of 0.297 with t-statistic of 8.091. This implies that the linking of advanced technologies plays a huge role in improving on environmental sustainability for fluoride projects. The resulting findings are therefore in accordance with specific literature promoting the combined use of AI, IoT, and other advanced technologies to reduce fluorite processes environmental performance [36].

H4 also dealt with the relationship between Integration of Advanced Technologies in Fluoride Based Projects (IAT) and Financial Data Analytics for Decision Making (FDA) with a path coefficient of 0.299 and a t-statistic of 8.379. The findings also reveal that adoption of advanced technologies boosts the capabilities of the financial data analytics in order to enable good resource allocation and decision making of fluoride based projects. This is congruent to prior studies which emphasize the use of new technologies in optimizing financial decision making [37].

Specific Indirect Effects

Direct relationships were also studied in the model, as well as the specific indirect effects. Thus, these effects are a result of how one construct affects another through an intermediary. And this is the results for the indirect relationships.

In relation to H5, Integration of Advanced Technologies in Fluoride-Based Projects (IAT) had a significant indirect effect on Optimization of Fluoride Use and Project Sustainability (Opt FU) through Financial Data Analytics for Decision-Making (FDA) with a path coefficient of 0.059 and t-statistic of 4.207. This supports the concept of indirect project optimization attributed to the advancement of technologies since it facilitates the financial decision making process. By so doing, it emphasizes the bearing of financial analytics as a key mediator in the relationship between advanced technologies and the project sustainability. The literature previously carries out that technologies are important in enhancing financial management and project success [38].Also, H6 assessed the indirect influence of Integration of Advanced Technologies in Fluoride Based Projects (IAT) on Optimization of Fluoride Use and Project Sustainability (Opt FU) by way of Environmental Sustainability in Fluoride Use (ESF). Indeed, indirect path relationship from BK to IEPR is significant with the path coefficient of 0.077 and t-statistic of 4.881. The findings indicate that the implementation of advanced technologies increases sustainability performance, and thus overall fluoride project success. This is in line with other research that supports the fact that sustainability improvements are beneficial to project performance outcomes [39].

Table 6:Path coefficients

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
H1:Environmental Sustainability in Fluoride Use -> Optimization of Fluoride Use and Project Sustainability	0.260	0.261	0.037	6.998	0.000
H2:Financial Data Analytics for Decision-Making -> Optimization of Fluoride Use and Project Sustainability	0.197	0.198	0.040	4.868	0.000
H3:Integration of Advanced Technologies in Fluoride-Based Projects -> Environmental Sustainability in Fluoride Use	0.297	0.299	0.037	8.091	0.000
H4:Integration of Advanced Technologies in Fluoride-Based Projects -> Financial Data Analytics for Decision-Making	0.299	0.301	0.036	8.379	0.000

Table 7:Specific indirect effects

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
H5:Integration of Advanced Technologies in Fluoride-Based Projects -> Financial Data Analytics for Decision-Making -> Optimization of Fluoride Use and Project Sustainability	0.059	0.060	0.014	4.207	0.000
H6:Integration of Advanced Technologies in Fluoride-Based Projects -> Environmental Sustainability in Fluoride Use -> Optimization of Fluoride Use and Project Sustainability	0.077	0.078	0.016	4.881	0.000

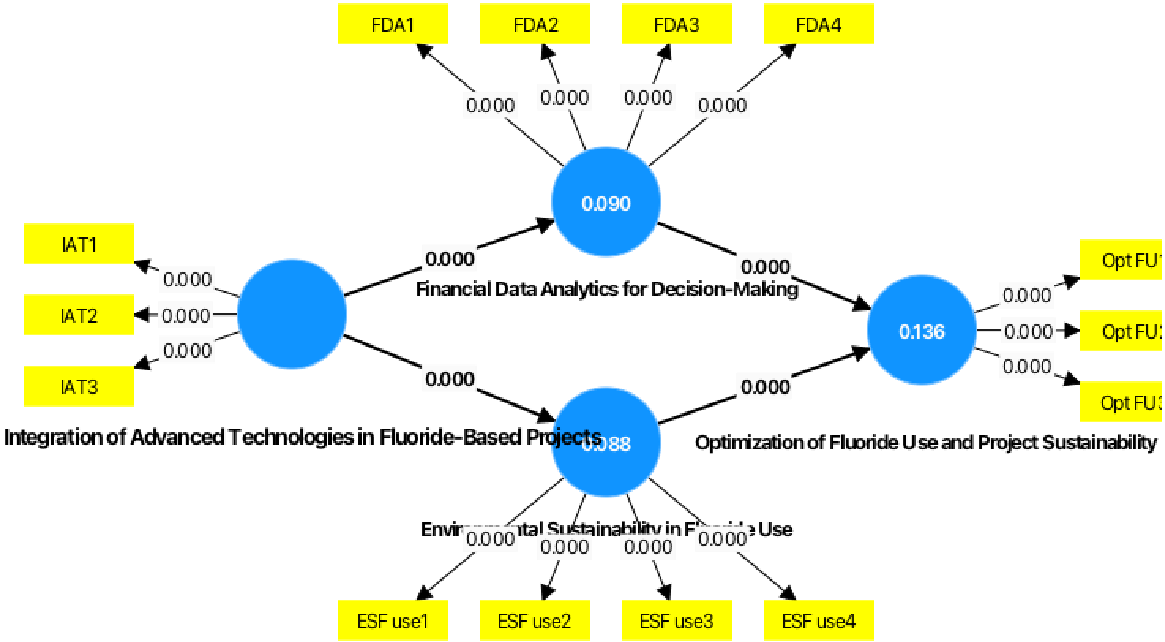

Figure 3: Structural Model

Results Discussion

This study provides several important findings regarding the mechanisms by which advanced technologies, financial data analytics, and environmental sustainability synergize for fluoride use optimization and project sustainability.

Results of the first direct effect of Environmental Sustainability in Fluoride Use (ESF) on Optimization of Fluoride Use and Project Sustainability (Opt FU) show the relevance of engaging in environmentally responsible practices to improve the efficiency and eventually succeed in fluoride use projects. This is in agreement with the assertion that sustainable practices are necessary for the optimal use of any resource in any project—especially for projects involving water treatment and its environment [39].

Second, Financial Data Analytics for Decision-Making (FDA) was identified as a critical factor in optimizing the use of fluoride and ensuring project sustainability due to its significant impact on the project. It is indicated that data based decision paradigm is beneficial in project management. Better allocation of financial resources, cost management and forecasting provides a basis for fluoride-related projects to run successfully [40].

Third, it was found that Integration of Advanced Technologies in Fluoride Based Projects (IAT) significantly contributes to environmental sustainability as well as financial data analytics, which in its turn has a positive effect on the selection of such environmental projects that must adopt new technologies pertaining to the improvement of environmental as well as financial outcomes. In the context of water treatment and fluoride use, technologies such as AI, IoT, big data analytics have becoming of more importance in the operation of the efficiencies.

Secondly, specific indirect effects identify that advance technologies impact project sustainability via both environmental sustainability and financial data analytics. The role of technologies in improving project outcomes is multifunctional and serves to catalyse projects towards greater sustainability and financial efficiency as per the findings.

6. LIMITATIONS AND FUTURE RESEARCH

This study yields very valuable insights but nevertheless has some limitations. The sample for this study was limited to a specific set of fluoride related projects as well as application of the advanced technologies in those contexts, first. The findings generalizability to other similar projects may be restricted to similar projects in certain regions. Future studies may enlarge the sample, including projects coming from different geographic areas, industries and contexts in order to generalize the results.

Secondly, the study was mainly confined to the technological and financial aspects of fluoride projects than other crucial factors, like political, social and cultural factors. Further research can be done to incorporate these variables to give a better understanding of the many factors that affect fluoride project optimization. This research examined only three constructs (advanced technologies, environmental sustainability, financial data analytics) as well as their immediate and secondary connections. Further study needs to examine supplementary variables that affect fluoride project outcomes including stakeholder involvement together with policy measures and community-based participation.

The research design based on cross-sectional data prevents researchers from determining the influence of temporal relationships between variables. Longitudinal research would enhance knowledge about how advanced technologies and financial data analytics progress throughout time and affect sustained fluoride-related project success.

7. PRACTICAL IMPLICATIONS

This study generates multiple practical implications that benefit policymakers together with project managers and organizations which operate fluoride-based projects. Financial management along with sustainability of fluoride projects becomes more effective when organizations integrate advanced technologies including AI and IoT and big data analytics. Decision-makers at all levels need to make technology adoption their main priority because it will create better resource distribution efficiency and enhance financial operations and benefit future sustainability goals.

The research paper stresses that environmental sustainability must be a priority in fluoride project development. Managers need to incorporate sustainable methods such as waste reduction techniques and energy-saving approaches during their focus on minimizing fluoride use impacts on the environment. Proficient sustainable practices create optimal conditions for fluoride-based projects to succeed by advancing environmental objectives.

Financial data analytics helps project managers put resources into right areas at the lowest possible costs. The evaluation of fluoride project results needs financial data analytics tools for better cost-management choices.

Advanced technologies can support fluoride projects by making environmental and financial changes easier and more effective according to research. Organizations need to set up the required technology systems to add advanced solutions to their fluoride-based projects.

8. THEORETICAL IMPLICATIONS

This research provides new facts to theoretical knowledge. This research extends the Diffusion of Innovations Theory (DOI) when testing its use for fluoride-based projects. Organizations use this established theory to study how advanced technologies get accepted and shared across business departments. The present research proves that fluoride projects can gain better results through advanced tech adoption.

The study develops past research to investigate how financial data analytics helps projects achieve better results. The study shows that combining modern tech helps people make better financial decisions and proves once more that financial analysis leads to successful project results as stated by Cao et al. in 2019. Our study reveals that financial analytics serve both action-based and forward-thinking roles to maintain project success.

The research shows that good project management depends on incorporating environmental sustainability. The results show environmental sustainability is mandatory to achieve project success in fluoride-based projects which builds new knowledge about sustainable project management. Research shows sustainable practices should be integrated from start to finish of daily projects just like Zhang et al. (2016) said.

The study uniquely expands project sustainability research through its examination of how advanced technologies indirectly help make fluoride-based projects better for both the environment and financial management. Through this study researchers provide a more complex view of advanced technology effects on fluoride-based projects by analyzing their hidden relationships.

9. CONCLUSION

The study shows that advanced technology integration in fluoride-based projects helps save fluoride while maintaining long-term operations. Using advanced technologies leads to better finances and the environment both directly and indirectly by helping with business statistics and sustainability tasks. Further investigations should research alternate mediating elements and moderating conditions particularly in business operations and stakeholder involvement to better comprehend fluoride project optimization. The study findings help decision makers and project leaders run fluoride projects more productively with lower environmental effects.

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