

THE RECOVERY OF LOOTED ANTIQUITIES IN EGYPT: EMPIRICAL EVIDENCE AND ANALYSIS

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INTRODUCTION

The concept of international cooperation is at the heart of international litigation and its implications for international mutual legal assistance, extraditions, and improved information sharing. The concept also extends to international negotiations, mechanism designs, and streamlining of legal criminal procedures across nations and via respective UN bodies. In this concern, prevention of illicit trade of cultural property constitutes a pivot of international cooperation among countries. This is due to the fact that Illicit trade of cultural property is a global and damaging phenomenon.¹

Fighting this crime requires specific knowledge and experience of international legal tools, including their practical implementation. Most importantly, in order to cooperate efficiently on this matter, all actors involved in mitigating the illicit trafficking of cultural property must be well-prepared. Any loss of time only serves to favour the smugglers while undermining cultural heritage, science, and hope.²

Besides prevention of illicit trade of cultural property, the recovery of looted antiquities is a fundamental necessity for the protection of cultural heritage.³ Toward this end, this Study proposes a conceptual framework that explains the recovery of looted antiquities in Egypt in terms of country-level international cooperation, country-level sustainable development, and country-level innovation. The data sample for the Study covers all publicly

¹ Janet K. Hawley, *The International Illicit Trade in Cultural Heritage: Can Museum Professionals Help Stop It?*, in STRATEGIES FOR SAVING OUR CULTURAL HERITAGE 228, 228 (Vasilike Argyropoulos et al. eds., 2007).

² ZEYNEP BOZ, FIGHTING THE ILLICIT TRAFFICKING OF CULTURAL PROPERTY 14, 14 (Julie Wickenden ed., UNESCO 2023).

³ See generally INTERPOL, ASSESSING CRIMES AGAINST CULTURAL PROPERTY 2020: SURVEY OF INTERPOL MEMBER COUNTRIES 6 (Sept. 2021).

available data reported by the Egyptian government on the recovery of looted antiquities. The Study adheres to the traditional scientific paradigm via which a parsimonious model of recovery output is specified and estimated where international cooperation, sustainable development, and innovation are exogenous variables. The Study in this fashion contributes to the contemporary literature by documenting empirical evidence as to the impact of international cooperation, sustainable development, and innovation on the recovery of looted antiquities in Egypt.

In view of the preceding, the Study advances the following research questions:

RQ1: What is the impact of country-level sustainable development on the recovery of looted antiquities in Egypt?

RQ2: What is the impact of country-level innovation on the recovery of looted antiquities in Egypt?

RQ3: What is the impact of country-level international cooperation on the recovery of looted antiquities in Egypt?

The rest of the Study proceeds in accordance with three sections: (1) the hypothetical development section relates the endogenous variable of the recovery of looted antiquities to each of the exogenous variables; (2) the empirical study section specifies, estimates, and tests the model; and (3) the recommendations section concludes the Study.

I. HYPOTHETICAL DEVELOPMENT

This section relates the Study variable of the recovery of looted antiquities to the exogenous variables of international cooperation, sustainable development, and innovation.

A. *The Recovery of Looted Antiquities and International Cooperation*

H1: The impact of international cooperation on the recovery of looted antiquities in Egypt is positive.

International cooperation is a pivotal aspect in the recovery of looted antiquities in Egypt. International mutual legal assistance and cooperation to recover looted antiquities grew as a great challenge facing Egypt when preserving its cultural heritage. The recovery of looted antiquities arises in response to illicit trafficking of cultural heritage, which introduces a host of international legal difficulties.⁴ The illicit trafficking of cultural heritage and other antiquities across international borders continues to be a problem for worldwide law enforcement attempts to lessen the trafficking of such property despite increasingly active enforcement measures to prevent theft.⁵

Antiquities theft is thought to be a multi-billion-dollar, transnational criminal enterprise.⁶ The relationship between the illicit trade in antiquities and money laundering, and even terrorist financing, can hardly be overstated. The money gained from the sale of looted antiquities can fund a terror organization or terror attack that may lead to an international crisis of cultural racketeering.⁷ In this concern, international cooperation is a significant tool to all the public prosecutions working on that field and it usually works positively with others to repatriate the looted

⁴ See generally Emilio Granell et al., *Transcription of Spanish Historical Handwritten Documents with Deep Neural Networks*, 4(1) J. IMAGING 1, 1-2 (2018) (discussing how the use of Handwritten Text Recognition (HTR) systems to verify text in ancient historical text are scarce or unavailable given the nature and age of such documents and relevant applicable lexical and language models).

⁵ Patty Gerstenblith, *Controlling the International Market in Antiquities: Reducing the Harm, Preserving the Past*, 8 CHI. J. INT'L L. 169, 169-70 (2007).

⁶ See generally JIRI TOMAN, *THE PROTECTION OF CULTURAL PROPERTY IN THE EVENT OF ARMED CONFLICT* (Dartmouth Publ'g Co. 1996) (Discussing the provisions of the Hague Convention on May 14, 1954 for the protection of cultural property in the event of armed conflict after the destruction of numerous historical monuments during the second world war).

⁷ Randa Alaa El-Din Fouad, *Addressing Challenges of Illicit Cultural Heritage Trafficking in Post-2011 Egypt*, 5(1) INT'L ACAD. J. FAC. TOURISM & HOTEL MGMT. 149, 151 (2019).

antiquities from the country of destination. Toward this end, the Egyptian Public Prosecution Office pushes the fruitful international cooperation to move on through many mechanisms that usually help the counterpart prosecutions get all the evidence and all the proof to affirm the ownership of the looted antiquities through the international mechanisms and with the collaboration of the internal entities all working under the Prime Minister's decree.⁸

The Prosecutor General issued decree no 975 /2020 on May 30, 2020 to establish the International Cooperation, Judgements' Enforcements, and Prisoners' Care Office for the enforcement of sentences.⁹ This highlights the major role of the Egyptian Public Prosecution Office's role on accelerating the procedures with other countries through digital communication and fastening the diplomatic channels procedures that usually take many months and usually fail to reach the convenient place that provides the proper mutual legal assistance.¹⁰

Looting of antiquities or artifacts is the direct outcome of illicit excavations and plundering of museums and archaeological sites. Since 2011, there was a dramatic increase in the scale and

⁸ Those internal entities include the ministry of terrorism and antiquities, the ministry of foreign affairs, the ministry of justice, the interior ministry, the ministry of international cooperation, the national security authority, the secretary general of antiquities, the administrative control authority, and the legal advisor for the Supreme Council of Antiquities. For a brief overview on a few of the relevant entities, see *The Ministry of Tourism and Antiquities*, The Egyptian Arabic Republic, <https://mota.gov.eg/ar> [<https://perma.cc/7RXX-MEZK>]; *Ministry of Foreign Affairs*, WIKIPEDIA, [https://en.wikipedia.org/wiki/Ministry_of_Foreign_Affairs_\(Egypt\)](https://en.wikipedia.org/wiki/Ministry_of_Foreign_Affairs_(Egypt)) [<https://perma.cc/5HPR-TTYK>]; *Supreme Council of Antiquities*, WIKIPEDIA, https://en.wikipedia.org/wiki/Supreme_Council_of_Antiquities [<https://perma.cc/Y8DB-2596>].

Editor's note: The relevant decree from the Prime Minister the entities are working under is no 1306 /2016. *Copy on File with Author*.

⁹ See Hamada Alsawy, *Decision no 975/2020 – On the Scope of Mandate of the International Cooperation, Judgements' Enforcement, and Prisoners' Care Dept.*, EGYPT PROSECUTOR GEN. OFF. (May 30, 2020), https://drive.google.com/file/d/12xFIfP4q17i3JgZ8lsXYvqydq1_ca4nX/view?usp=sharing [<https://perma.cc/L9NW-9G7X>].

¹⁰ See Baizura Kamal, *International Cooperation: Mutual Legal Assistance and Extradition*, SIXTH REGIONAL SEMINAR ON GOOD GOVERNANCE FOR SOUTHEAST ASIAN COUNTRIES 82, 82-95 (2012) (discussing how mutual legal assistance is the formal process by which sovereign states can exercise coercive powers to obtain evidence admissible for a criminal trial).

organization of smuggling artifacts.¹¹ The worldwide markets are flooded with several Egyptian master pieces, especially after the 2011 revolution onward.¹²

Prior to the Arab Spring, few looting stories had appeared in the media, but, following the Egyptian Revolution in January 2011, anecdotal reports of systematic looting began to spread.¹³ With many sites lacking any police protection since 2009 and most police being withdrawn from tourism in late January 2011, unarmed local guards could do little against armed looters at well-known sites such as Abusir, Giza, Dashur, Lisht, Abydos and Karnak or at less visited sites such as el Hibeh, Buto and Tell ed-Dab'a.¹⁴ It is reported that civilians occasionally risked their lives driving away would-be looters. Such looting stories have continued unabated since early 2011.¹⁵

From an archaeological perspective, when a site is destroyed, the context of all material culture from that site is lost and a piece of our history vanishes forever. Site looting also represents a lucrative business for crime cartels, with the proceeds from looted materials (estimated at billions of dollars) funding terrorism and insurgency.¹⁶ Until we can grasp the full extent of the damage done to Egypt's archaeological heritage, the total cost of these losses and the long-term global impact cannot be understood. "Only by comprehending the root causes of large-scale looting in Egypt can we begin to propose plausible solutions to stem the problem."¹⁷

¹¹ See SIMON MACKENZIE ET AL., *TRAFFICKING CULTURE: NEW DIRECTIONS IN RESEARCHING THE GLOBAL MARKET IN ILLICIT ANTIQUITIES* (Routledge 2020) (discussing how research linked an observable increase in looting in 2011 to economic recession).

¹² See generally Monica Hanna, *Documenting Looting Activities in Post-2011 Egypt*, in *COUNTERING ILLICIT TRAFFIC IN CULTURAL GOODS: THE GLOBAL CHALLENGE OF PROTECTING THE WORLD'S HERITAGE* 47, 47-63 (Akzent-Dolmetscherteam et al. trans., France Desmaris ed. 2015).

¹³ See generally Amr Osman & Marwa Abdel Samei, *The Media and the Making of the 2011 Egyptian Revolution*, 2(1) *GLOB. MEDIA J. (GERMAN EDITION)* 1, 11 (2012).

¹⁴ See Sarah Parcak et al., *Satellite Evidence of Archaeological Site Looting in Egypt: 2002-2013*, in 90(349) *ANTIQUITY* 188, 189 (Robert Witcher ed., Cambridge Univ. Press 2016).

¹⁵ See generally Katharyn Hanson, *Ancient Artefacts and Modern Conflict: A Case Study of Looting and Instability in Iraq*, in *CULTURAL HERITAGE, ETHICS, AND THE MILITARY* 113, 113-14 (Peter G. Stone ed., 2011).

¹⁶ See generally Vanessa Hanson, *Looted Antiquities: Economic Opportunity for Terrorists*, *DOMINICAN SCHOLAR: SENIOR THESES* 2 (2015).

¹⁷ Parcak et al., *supra* note 14, at 190.

“The evidence derived or taken from devices, equipment, media, electronic supports, information systems, software, or any means of information technology shall have the same value and force of criminal evidence where the technical conditions set out in the executive regulations of this Law are met.”¹⁸

The international treaties and conventions still have regulation and binding enforcement according to the Egyptian judicial system, and the empirical study proves that the antiquities that have been looted through the 2011 revolution should be repatriated to Egypt through the implementation of the 1954 Convention for the Protection of Cultural Property in the Event of Armed Conflict, the 1970 Convention on the Means of Prohibiting and Preventing the Illicit Import, Export and Transfer of Ownership of Cultural Property, and, finally, the United Nations Convention against Transnational Organized Crime (“UNTOC”).

All of these tools are considered an international constitution for all countries that joined and ratified these treaties and become binding for all of them, and that arrange obligations for the repatriation of the smuggled antiquities.¹⁹ After the United Nations Educational, Scientific, and Cultural Organization (“UNESCO”) Convention was adopted in 1970, many museums took more aggressive positions to ensure that the art they acquired came through legal channels.²⁰ “Specific references to the UNESCO Convention and provenance research began appearing in the policy manuals and press releases of major associations and organizations.”²¹

¹⁸ MOHAMED CHAWKI, *Article (11): Digital Evidence, in ANTI-CYBER AND INFORMATION TECHNOLOGY CRIMES LAW “EGYPT” LAW NO. 175 OF 2018: “UNOFFICIAL TRANSLATION”* 10 (2020), <https://cybercrime-fr.org/wp-content/uploads/2020/04/Egyptian-cybercrime-law-.pdf> [<https://perma.cc/ZD4T-UQFX>]; see also Mohamed Hassan Mekkawi, *The Challenges of Digital Evidence Usage in Deepfake Crimes Era*, 3(2) J. L. & EMERGING TECHS., 175, 182 (2023), <https://jolets.org/ojs/index.php/jolets/article/view/123/66> [<https://perma.cc/HR6L-TK74>] (“Digital evidence is considered evidence of a technical nature because it is intangible, that is, it is not physical or matierl evidence, as it is a group of electric or magnetic fields.”).

¹⁹ BOZ, *supra* note 2, at 38.

²⁰ See generally Erik Nemeth, *Cultural Security: The Evolving Role of Art in International Security*, 19(1) TERRORISM & POL. VIOLENCE 19, 19-20 (2007).

²¹ Carol A. Roehrenbeck, *Repatriation of Cultural Property—Who Owns the Past? An Introduction to Approaches and to Selected Statutory Instruments*, 38 INT’L J. LEGAL INFO. 185, 198 (2010).

The Egyptian Public Prosecution Office is working in the restitution and repatriation of the looted cultural property items through legal instruments and international conventions that are binding for all countries and partner organizations.²² For example, the UNESCO Fight Illicit Trafficking 1970 Convention required States Parties should undertake appropriate measures to seize and return any cultural property stolen and imported.²³

The Egyptian Public Prosecution Office is represented by the Director of the department and some of the chief prosecutors in the conference of the parties to the United Nations conventions against transnational organized crime in the issuance of the 10\7

²² Mark V. Vlastic, *Stolen Antiquities, War Crimes and Asset Recovery: Protecting Cultural Heritage as a Common Good of Humanity and the Challenges for Global Criminal Justice*, in *PROTECTING CULTURAL HERITAGE AS A COMMON GOOD OF HUMANITY: A CHALLENGE FOR CRIMINAL JUSTICE* 143 (2014).

²³ *Convention on the Means of Prohibiting and Preventing the Illicit Import, Export, and Transfer of Ownership of Cultural Property*, (Nov. 14, 1970), <https://en.unesco.org/about-us/legal-affairs/convention-means-prohibiting-and-preventing-illicit-import-export-and> [<https://perma.cc/GG56-U4KG>].

(“Article 7[:] The States Parties to this Convention undertake: (a) To take the necessary measures, consistent with national legislation, to prevent museums and similar institutions within their territories from acquiring cultural property originating in another State Party which has been illegally exported after entry into force of this Convention, in the States concerned. Whenever possible, to inform a State of origin Party to this Convention of an offer of such cultural property illegally removed from that State after the entry into force of this Convention in both States; (b) (i) to prohibit the import of cultural property stolen from a museum or a religious or secular public monument or similar institution in another State Party to this Convention after the entry into force of this Convention for the States concerned, provided that such property is documented as appertaining to the inventory of that institution; (ii) at the request of the State Party of origin, to take appropriate steps to recover and return any such cultural property imported after the entry into force of this Convention in both States concerned, provided, however, that the requesting State shall pay just compensation to an innocent purchaser or to a person who has valid title to that property. Requests for recovery and return shall be made through diplomatic offices. The requesting Party shall furnish, at its expense, the documentation and other evidence necessary to establish its claim for recovery and return. The Parties shall impose no customs duties or other charges upon cultural property returned pursuant to this Article. All expenses incident to the return and delivery of the cultural property shall be borne by the requesting Party.”).

resolution upon Combating transnational organized crime against cultural property,²⁴ that states:

[s]tates parties to strengthen and facilitate international cooperation, in accordance with domestic law and consistent with their obligations under relevant international law, with regard to trafficking in cultural property and other crimes targeting cultural property, including through extradition, mutual legal assistance, the identification, seizure and confiscation of trafficked, illicitly exported or imported, stolen, looted, illicitly excavated or illicitly traded cultural property and the return or restitution of such cultural property, as well as the investigation and prosecution of these crimes and the recovery of their proceeds, and to make effective use of the Convention as a legal basis for such international cooperation, in applicable cases[.]²⁵

In light of the above, it can be concluded that Egypt's efforts to augment its international cooperation are expected to be replicated positively in the recovery of looted antiquities through legal channels.

²⁴ See The Conference of the Parties to the United Nations Convention Against Transnational Organized Crime, *Resolution 10/7: Combating Transnational Organized Crime Against Cultural Property*, (May 5, 2023), https://www.unodc.org/documents/treaties/UNTOC/COP/SESSION_10/Resolutions/Resolution_10_7_-_English.pdf [<https://perma.cc/3XCK-BL79>]; INT'L CRIM. CT., FINANCIAL INVESTIGATIONS AND RECOVERY OF ASSETS 12-13 (2017).

²⁵ The Conference of the Parties to the United Nations Convention Against Transnational Organized Crime, *Resolution 10/7: Combating Transnational Organized Crime Against Cultural Property*, (May 5, 2023), https://www.unodc.org/documents/treaties/UNTOC/COP/SESSION_10/Resolutions/Resolution_10_7_-_English.pdf [<https://perma.cc/VAV9-RRJX>].

B. The Recovery of Looted Antiquities and Sustainable Development

H2: The impact of country-level sustainable development on the recovery of looted antiquities in Egypt is positive.

Egypt's sustainable development goals ("SDGs") are critical in the recovery of looted antiquities.²⁶ In general, SDGs are a set of 17 goals adopted by all United Nations Member States in 2015.²⁷ The SDGs are a call to action to end poverty, protect the planet, and ensure prosperity for all.²⁸ Indeed, illicit trafficking of antiquities is a major problem that undermines the SDGs. The trade in illicit antiquities is a multi-billion-dollar industry that fuels conflict, corruption, and organized crime.²⁹ Trade in illicit antiquities also deprives countries of their cultural heritage, which is essential for economic development and social cohesion.³⁰

The SDGs that are most affected by illicit trafficking of antiquities include:

- *Goal 1 - No poverty*: Illicit trafficking of antiquities can contribute to poverty in several ways. First, it can deprive countries of the economic benefits of tourism. Second, it can

²⁶ See generally *Our Work on the Sustainable Development Goals in Egypt*, U.N. EGYPT, <https://egypt.un.org/en/sdgs> [<https://perma.cc/SG8W-QQDX>] (last visited May 9, 2024).

²⁷ *Id.*

²⁸ See Mohamed Ben Ellefi et al., *Cultural Heritage Resources Profiling: Ontology-based Approach*, in WWW '18 COMPANION: THE 2018 WEB CONFERENCE COMPANION 1489, 1489-90 (Apr. 2018).

²⁹ See generally Vanda Felbab-Brown, *The Threat of Illicit Economies and the Complex Relations with State and Society*, in ORGANIZED CRIME AND ILLICIT TRADE: HOW TO RESPOND TO THIS STRATEGIC CHALLENGE IN OLD AND NEW DOMAINS 2 (Virginia Comolli ed., Springer Nature 2018).

³⁰ See generally Francesca Nocca, *The Role of Cultural Heritage in Sustainable Development: Multidimensional Indicators as Decision-Making Tool*, 9(10) SUSTAINABILITY 1 (Oct. 19, 2017) (discussing indicators that are able to support the relationship between cultural heritage conservation/regeneration and sustainable development).

lead to the loss of jobs in the cultural sector. Third, it can increase the cost of security and law enforcement.³¹

- *Goal 2 - Zero hunger*: Illicit trafficking of antiquities can contribute to hunger in many ways. First, it can deprive countries of the resources they need to invest in agriculture. Second, it can lead to the loss of land and water resources. Third, it can increase the cost of food imports.³²
- *Goal 4 - Quality Education*: Illicit trafficking of antiquities can undermine the quality of education in several ways. First, it can deprive countries of the resources they need to invest in education. Second, it can lead to the loss of cultural artifacts that are used in education. Third, it can increase the cost of textbooks and other educational materials.³³
- *Goal 5 - Gender Equality*: Illicit trafficking of antiquities can contribute to gender inequality in a number of ways. First, it can lead to the exploitation of women and girls in the workforce. Second, it can increase the risk of violence against women and girls. Third, it can deprive women and girls of the opportunity to participate in decision-making.³⁴
- *Goal 10 - Reduced Inequalities*: Illicit trafficking of antiquities can contribute to inequality in a number of ways. First, it can lead to the concentration of wealth in the hands of a few individuals. Second, it can increase the cost of living for the poor. Third, it can deprive the poor of access to education, healthcare, and other essential services.³⁵

³¹ See generally Donna Yates, *The Global Traffic in Looted Cultural Objects*, OXFORD RSCH. ENCYCLOPEDIA OF CRIMINOLOGY AND CRIM. JUST. 1, 1-12 (Dec. 2016), <https://traffickingculture.org/app/uploads/2016/10/Global-Traffic-in-Looted-Cultural-Objects-Oxford-Research-Encyclopedia-of-Criminology.pdf> [<https://perma.cc/2B42-P964>].

³² See ALBERT MUMMA, *Framework for Legislation on Immovable Cultural Heritage in Africa*, in CULTURAL HERITAGE AND THE LAW: PROTECTING IMMOVABLE HERITAGE IN ENGLISH-SPEAKING COUNTRIES OF SUB-SAHARAN AFRICA 97 (2008), https://www.iccrom.org/sites/default/files/publications/2019-11/iccrom_ics08_culturalheritageandlaw_en.pdf [<https://perma.cc/JHD4-ZGFK>].

³³ Gerstenblith, *supra* note 5, at 367.

³⁴ U.N. OFF. ON DRUGS AND CRIME, GENDER BRIEF FOR UNODC STAFF: MAINSTREAMING GENDER IN ORGANIZED CRIME & ILLICIT TRAFFICKING PROJECTS 14 (2020).

³⁵ Audrey Azoulay, *International Day against Illicit Trafficking in Cultural Property*, UNESCO (Nov. 14, 2020), <https://www.unesco.org/en/days/against-illicit-trafficking> [<https://perma.cc/B5BG-JL4L>].

There are a number of things that can be done to address the problem of illicit trafficking of antiquities. These include:

- *Strengthening Law Enforcement*: Governments need to strengthen law enforcement efforts to combat the illicit trafficking of antiquities. This includes increasing the number of law enforcement officers who are trained in investigating and prosecuting cases of illicit trafficking.
- *Improving Border Controls*: Governments need to improve border controls to prevent the illegal movement of antiquities. This includes increasing the number of customs officials who are trained in identifying and inspecting antiquities.
- *Raising Awareness*: Governments and civil society need to raise awareness of the problem of illicit trafficking of antiquities. This includes educating the public about the importance of cultural heritage and the dangers of buying illicit antiquities.
- *Promoting Responsible Tourism*: Governments and tourism operators need to promote responsible tourism. This includes educating tourists about the importance of cultural heritage and the dangers of buying illicit antiquities.

The illicit trafficking of antiquities is a serious problem that undermines the SDGs. By taking action to address this problem, we can help to protect our cultural heritage, promote economic development, and reduce poverty and inequality.

There are several SDGs directly affected, mainly SDG 16 (Peace, Justice and Strong Institutions) and SDG 8 (Decent Work and Economic Growth), but it affects a general array of goals such as poverty reduction, decent employment, and economic growth (SDGs 1, 2, 3, 4, and 5), deprives governments of revenue and therefore hinders public investment (SDGs 9 and 17), and in turn makes organized crime and terrorist groups increasingly powerful, undermining the objectives of peace and stability (SDG 16).³⁶

³⁶ See generally Diane F. Frey, *Economic Growth, Full Employment and Decent Work: The Means and Ends in SDG 8*, 21 INT'L J. HUM. RTS. 1164 (Aug. 1, 2017) (discussing SDG 8 from two perspectives).

Furthermore, in order to achieve these objectives, natural resources are plundered (SDGs 6, 14, and 15), supply chains are abused, and consumers are exposed to counterfeit, and in some cases harmful products (SDG 12). It should also be borne in mind that cultural objects are a unique testimony to the evolution and identity of peoples and that the importance of protecting them is more significant because they are irreplaceable. They are a vital educational resource that reveals the rich and complex story of humanity, made of many peoples, ideas, and faiths.³⁷

In view of the preceding, whereas looting antiquities is a major problem that undermines SDG 16, improved country-level SDG performance is expected to enhance the recovery of looted antiquities through legal channels.³⁸

C. The Recovery of Looted Antiquities and Innovation

H3: The impact of country-level innovation on the recovery of looted antiquities is positive in Egypt.

The amount of time and paperwork typically needed for legal procedures is considerable. Toward this end, it is argued that the standard and consistent use of information technology through international cooperation decreases the amount of time and paperwork needed for legal procedures and increases the level of legal efficiency. Moreover, the Egyptian public prosecution has recently started to rely on digital evidence and advanced data analytics to complement national efforts in the recovery of looted antiquities.³⁹ For instance, the recovery of looted antiquities may benefit from Artificial Intelligence (AI) technologies in several ways via the recognition of the symbiotic relationship between technology and humanity. One such use of AI is deepfakes.

³⁷ Francisco Jose Rufián Fernández & Isber Sabrine, *Illicit Trafficking of Antiquities and Its Consequences on the SDGs*, in PEACE, JUSTICE AND STRONG INSTITUTIONS - ENCYCLOPEDIA OF THE UN SUSTAINABLE DEVELOPMENT GOALS 1, 7 (W. Leal Filho et al. eds., Springer Int'l Publ'g 2020).

³⁸ Neil Brodie & Colin Renfrew, *Looting and the World's Archaeological Heritage: The Inadequate Response*, 34 ANN. REV. ANTHROPOLOGY 343, 343-61 (2005).

³⁹ See *Public Prosecution Launches Digital Transformation Strategy to Consolidate Transparency, Combat Corruption*, AHRAM ONLINE (Oct. 9, 2021), <https://english.ahram.org.eg/News/426580.aspx> [<https://perma.cc/BX2C-3RS2>].

The use of AI for deepfakes is arguably one of the most controversial topics because it raises ethical issues. “Deepfakes are images or recordings that have been convincingly altered and manipulated to misrepresent someone as doing or saying something that they did not actually do or say.”⁴⁰ Furthermore, a machine could be developed and used to track and discover stolen objects in large online auction houses to detect the exact instance of objects on an image by using convolutional neural networks (“CNNs”), like the example provided in Figure 1 below.⁴¹

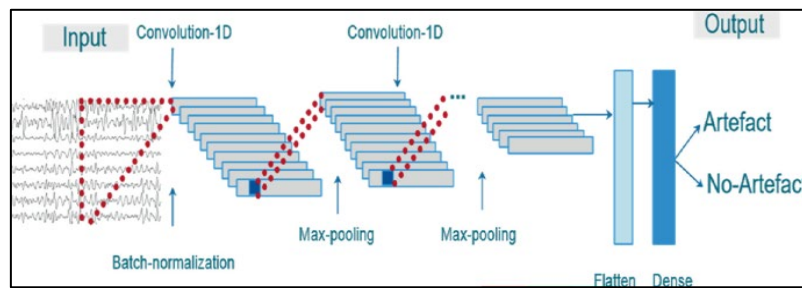


Figure 1: Framework for AI-Based Detection of Illicit Trafficking in Antiquities through CNN technology

Moreover, the following technologies are typically employed in the recovery of looted antiquities and the prevention of illicit trafficking:

Monitoring Satellite Imagery: AI algorithms can analyze high-resolution satellite imagery to identify changes in archaeological sites and detect any unauthorized excavations.⁴² By comparing images over

⁴⁰ Chidera Okolie, *Artificial Intelligence-Altered Videos (Deepfakes), Image-Based Sexual Abuse, and Data Privacy Concerns*, 25(2) J. INT'L WOMEN'S STUD. 1, 1 (2023).

⁴¹ Thomas Winterbottom et al., *A Deep Learning Approach to Fight Illicit Trafficking of Antiquities using Artefact Instance Classification*, 12 SCI. REPS. 13468, 1-2 (2022); see also Amal Boudaya et al., *A Convolutional Neural Network for Artifacts Detection in EEG Data*, in PROCEEDINGS OF INTERNATIONAL CONFERENCE ON INFORMATION TECHNOLOGY AND APPLICATIONS 3, 8 (Abrar Ullah et al. eds., Springer Nature Singapore 2022).

⁴² Deodato Tapete & Francesca Cigna, *Detection of Archaeological Looting from Space: Methods, Achievements and Challenges*, 11(20) REMOTE SENSING 1, 2 (2019).

time, AI can help identify signs of looting or illicit activities.

Digital Image Recognition: AI can be trained to recognize and match images of stolen or looted artifacts against databases of known cultural objects. This can assist law enforcement agencies, museums, and auction houses in identifying and recovering illicitly trafficked antiquities, and that may be done through different techniques like web crawling as it will be shown in the paper, and they will be used by retrieving raw data from the internet and the dark web.⁴³

It will collect textual and visual information about heritage artefacts connected with illicit traffic activities for further analysis. Once datasets are stored, the AI algorithms will be deployed and will analyze the new dataset to discover possible illegal activities.

The AI machine⁴⁴ will scan well-known web applications, such as ecommerce platforms (i.e., online auctions), auction-houses websites, social networks (i.e., Facebook) and additional websites that have been pinpointed as relevant by domain experts during the user requirements data collection.⁴⁵

Natural Language Processing: AI techniques such as natural language processing (“NLP”) can be used to analyze vast amounts of textual data from online sources, auction records, and social media platforms.⁴⁶ By monitoring conversations and detecting suspicious keywords or discussions related to the illicit trade in

⁴³ D. Abate et al., *Significance. Stop Illicit Heritage Trafficking with Artificial Intelligence*, in XLIII THE INT’L ARCHIVES OF THE PHOTOGRAMMETRY, REMOTE SENSING & SPATIAL INFO. SCIS. 729, 732 (2022).

⁴⁴ See generally J.L. Wolf et al., *Optimal Crawling Strategies for Web Search Engines*, in WWW ‘02: PROCEEDINGS OF THE 11TH INT’L CONF. ON WORLD WIDE WEB 137 (2002).

⁴⁵ *Id.* at 730.

⁴⁶ See generally Tim Ken Mackey et al., *Big Data, Natural Language Processing, and Deep Learning to Detect and Characterize Illicit COVID-19 Product Sales: Infoveillance Study on Twitter and Instagram*, 6(3) JMIR PUB. HEALTH & SURVEILLANCE 1, 1 (2020).

antiquities, AI can help identify potential traffickers and illegal activities.

Network Analysis: AI algorithms can analyze complex networks of individuals, organizations, and transactions involved in the illicit trade.⁴⁷ By examining patterns, connections, and financial flows, AI can identify key players, smuggling routes, and money laundering activities associated with the trade in antiquities and that can occur through many new techniques like geofence warrants and that what we will talk about as following:

Geofence: is a digital boundary that encloses or delimits a physical space.⁴⁸ Electronic communication equipment can be found on either side of this area's border thanks to sensors there.⁴⁹ Geofences can be used for a variety of purposes, such as detecting the smugglers and looters in such specific place.⁵⁰

According to the Egypt Criminal Procedure Code, such a warrant could be issued from the prosecutor or

⁴⁷ Ioannis Mademlis et al., *The Invisible Arms Race: Digital Trends in Illicit Goods Trafficking and AI-Enabled Responses*, AUTHOREA PREPRINTS 1, 2 (2023), <https://www.techrxiv.org/users/693487/articles/683136-the-invisible-arms-race-digital-trends-in-illicit-goods-trafficking-and-ai-enabled-responses> [https://perma.cc/ZZT3-9JT4].

⁴⁸ Mia Stevens & Ella Atkins, *Geofence Definition and Deconfliction for UAS Traffic Management*, 22(9) IEEE TRANSACTIONS ON INTELLIGENT TRANSP. SYS. 5880, 5881 (2020).

⁴⁹ See generally Astrit Hulaj et al., *Internet of Things Application for Green Border Surveillance, Based on Edge Detection Techniques*, 11(2) INT'L J. INTELLIGENT SYS. & APPLICATIONS ENG'G 702 (2023).

⁵⁰ See Ronald J. Rychlak, *Geofence Warrants: The New Boundaries*, 93 MISS. L.J. 957, 959 (2024) ("[I]f law enforcement agencies are investigating a crime but have no witnesses, geofence data can provide valuable information about a suspect's movements and whereabouts.").

magistrate and the search warrant shall be justified,⁵¹ similar to the same requirement in the United States.⁵² The serious issue is whether the typical warrant is justified with sufficient probable cause merely based upon the existence of an event, typically a crime, at a particular location at a given time. If the warrant limits the search in terms of time and geography,⁵³ the answer should be yes.⁵⁴

Provenance Research: AI can assist in researching the provenance of antiquities by analyzing historical records, archives, and databases. By cross-referencing various sources of information, AI can help trace the ownership history of artifacts and identify any gaps or suspicious activities that may indicate illicit trafficking.

Social Media Monitoring: AI can be used to monitor social media platforms for the sale and promotion of illicitly trafficked antiquities. By analyzing posts, images, and user interactions, AI can identify sellers, buyers, and online communities involved in the trade, facilitating investigations and enforcement actions.

⁵¹ Article 90 at the Egyptian criminal procedure law stipulates that “[t]he investigating magistrate shall move to any scene whenever deemed necessary to establish the condition of places, items and persons, to prove the physical existence of a crime and to establish all situations that need to be established.” EGYPT CRIM PRO. art. 90. Article 91 for the same law stipulates “[s]earching places of residence is deemed part of an investigation process and shall not be resorted to unless by virtue of a warrant issued by the investigating magistrate on the grounds of an accusation made against a person residing in the place of residence that needs to be searched for the commission of a crime or misdemeanor or for participating in the commission thereof or if presumptions are found proving that said person is in possession of items relevant to the crime. The investigating magistrate may search any place and may seize documents, arms and everything that might have been used in the commission of the crime, that may have resulted from the commission of the crime or on which the crime has been committed and everything that may be useful in the revelation of the truth. In all cases, the search warrant shall be justified.” *Id.* at art. 91.

⁵² See U.S. CONST. amend IV.; see also Frank Chambers, *An Ongoing Seizure: The Struggle to Uniformly Protect Fourth Amendment Interests from Unreasonable Searches of Legally Seized Digital Data*, 61 HOUSTON L. REV. 153, 155 (2023).

⁵³ Warrants should be limited in time, location, and scope. See *In the Matter of the Search Warrant Application for Geofence Location Data Stored at Google Concerning an Arson Investigation*, 497 F. Supp. 3d 345, 363 (N.D. Ill. 2020).

⁵⁴ *Id.*

Predictive Analytics: By analyzing historical data on illicit trafficking patterns and archaeological site vulnerabilities, AI can help predict potential hotspots for future looting and unlawful excavations. This information can guide the allocation of resources and enforcement efforts to prevent such activities.

Based on the above discussion, the impact of country-level innovation score and application of modern AI technologies on the recovery of looted antiquities is expected to be positive.

II. EMPIRICAL ANALYSIS

A. *Data Sample*

The study sample employed in the analysis is all data made available and reported by the Egyptian government on the recovery of looted antiquities. In this respect, data available on the subject are exhausted in terms of the number of recovered looted antiquities per annum for the ten-year period from 2011 to 2021. Data on SDG, Globalization, and Innovation are retrieved from authoritative UN indices.

B. *Empirical Model and Specification*

This study explains the recovery of looted antiquities in Egypt in terms of three government level exogenous variables. Specifically, the study estimates the output of recovery of looted antiquities in terms of (1) Egypt's sustainable development, measured as the SDG index, (2) Egypt's level of international cooperation, measured as the globalization index, and (3) Egypt's level of innovation, measured as the UN innovation index. The estimation is carried out according to the functional form:

FF: the level output of recovery of looted antiquities = f (sustainable development, international cooperation, and innovation)

It follows that, the collective impact of all exogenous variables other than sustainable development, international cooperation, and innovation is assumed to cancel out and so reduce to an expected value of zero. This is in accordance with the Gauss-Markov data generating process where the error term in the model specification

is assumed to have an expected value of zero and a constant variance.⁵⁵ In this concern, the functional form of the multiple regression relationship leads to the following linear specification form:

$$SF: Recovery(i) = b0 + b1*SDG(i) + b2*Glob.(i) + b3*Innov.(i) + e(i)$$

Where: Recovery is the level output of recovery of looted antiquities measured as the number of recovered antiquities in year i ; (i) is a year index from 2011 to 2021; $b1$, $b2$, and $b3$ are parameter estimates for the rates for change (the derivatives) pertaining to the change in the level output of recovery of looted antiquities stimulated by a corresponding change in the respective exogenous variables; $b0$ is an intercept term that the level output of looted antiquities reduces to whenever any of the exogenous variables or the respective parameter estimates take the value of zero; SDG is the exogenous variable of sustainable development measured on a continuous basis; Glob. is the exogenous variable of international cooperation measured on a continuous basis; Innov. is the exogenous variable of innovation measured on a continuous basis; and e is an independently and identically distributed Gauss-Markov error term such that $e \sim N(0, K)$.

C. Descriptive statistics

As per the descriptive statistics summary shown in Appendix 1, the mean value of recovered antiquities over the study period is 309 pieces. The mean values for Egypt's SDG, Globalization, and Innovation are respectively 66.53, 61.45, and 27.02. The minimum number of 16 recovered antiquities took place in 2013 and the maximum number of 574 took place in 2021. This indicates that the trend in recovered antiquities is positive over the study period. For SDG, the trend is both positive and persistent with a minimum score of 64.69 at the beginning of the study period in 2011 and a maximum score of 68.47 at the end of period in 2021. The trends for Egypt's Globalization and Innovation scores, however, are both

⁵⁵ See Roger Larocca, *Reconciling Conflicting Gauss-Markov Conditions in the Classical Linear Regression Model*, 13 POL. ANALYSIS 188 (2005) (discussing conflicting accounts of Gauss-Markov conditions).

negative or deteriorating. For Globalization, the minimum score of 90 took place in 2011 and the maximum score of 92 took place in the subsequent year. After 2012, Egypt's Globalization score kept dropping persistently until reaching 91 in 2021. For Innovation, the minimum score of 25.1 took place at the end of the study period, and the maximum score of 30 took place in 2014.

D. Regression Output

As per the regression output summary shown in Appendix 2, a parameter estimate of 121.26 is reported with respect to the impact of SDG on the recovery of looted antiquities holding both Globalization and Innovation constant. That parameter estimate is statistically significant at the 5% significance level, which indicates that the impact of SDG on the study variable is both positive and well-pronounced. This relationship is visualized in the line fit plot in Appendix 3. The parameter estimates for Globalization and Innovation, however, are both negative and statistically insignificant at the 5% percent significance level. This can be explained given the fact that, though the trend in the study variable is upward, the trends in Globalization and Innovation are both downward. These relationships are visualized in line fit plots in Appendices 4 and 5. Throughout, the model has an explanatory power of 69.8 %, which is statistically significant at the 10% type-I error.

Since SDG is shown to be the only exogenous variable that contributes toward significantly explaining the recovery of looted antiquities, this study concludes this empirical analysis by estimating the following model specification where the study variable is only explained in terms of SDG:

$$\text{Recovery } (i) = b_0 + b_1 * \text{SDG } (i) + e (i)$$

As per the regression output shown in appendix 6, the model has an explanatory power of 58.12%, which is statistically significant at the 5% level. Moreover, the impact of SDG on the recovery of looted antiquities in Egypt is estimated as 148.1, which is strongly significant at traditional levels. This may be interpreted along the lines that a unit improvement in the sustainable development score translates into the recovery of about 148 pieces of looted antiquities in Egypt.

CONCLUSION AND RECOMMENDATIONS

This study specifies linearly that Egypt's ability to recover the looted antiquities depends on its levels of sustainable development, innovation, and international cooperation. The study adhered to a quantitative design, which accommodates hypothesis testing at conventional significance levels and produces research outcomes deductively. The findings of this study show that only the impact of sustainable development on the recovery of looted antiquities tends to replicate the hypothetical prediction in Egypt. The study shows that that respective impacts of international cooperation and innovation are insignificant due to the deteriorating performance of Egypt on both UN Globalization and Innovation indices. Throughout, the study is limited by the quantitative design, and the scant data reported by the Egyptian government on the subject. In this respect, data reported by the Egyptian government on the recovery of looted antiquities cover a brief ten-year period from 2011 to 2021.

Furthermore, the study supports that the recovery of looted antiquities by the Egyptian government can be greatly enhanced with improved country-level international cooperation and innovation. This is non-trivial given the deteriorating Egyptian performance on both international cooperation and innovation over the course of the study period. With respect to innovation, this study further concludes by recommending a framework for AI-Based recovery of looted antiquities and detection of Illicit trafficking. This framework consists of the following by Data Collection and Preprocessing through Collect a large dataset of images of antiques, including both legal and illicit ones, Label the images to indicate whether they are illicit or legal, preferably with the help of experts in the field and preprocess the images to standardize their size, resolution, and format, and remove any artifacts or noise.

A. AI Methods for Detection:

1) Image Preprocessing:

- Apply various image preprocessing techniques, such as image denoising, histogram equalization, or contrast

enhancement, to improve image quality and enhance features.

- Perform object detection or segmentation algorithms to localize and extract the antique objects from the images.
- Normalize the images to ensure consistency in lighting conditions, color spaces, or orientations for effective feature extraction.

2) Machine Learning:

- Train a machine learning model, such as a convolutional neural network (“CNN”), using the labeled dataset of antique images.
- Utilize transfer learning techniques by leveraging pre-trained models on large-scale image datasets, such as ImageNet, to improve performance.
- Fine-tune the model on the specific task of detecting illicit antiquities using the collected dataset.
- Explore different machine learning algorithms, such as support vector machines (“SVM”) or random forests, to compare their performance.

3) Deep Learning:

- Utilize deep learning techniques, such as convolutional neural networks (“CNNs”), to extract meaningful features from the antique images.
- Design and train a deep learning model, such as a deep CNN or a variant like a Faster R-CNN or YOLO, to identify and localize illicit antiquities within images.
- Enhance the model’s performance through data augmentation techniques, such as rotation, scaling, and flipping, to increase the diversity of training samples.
- Employ techniques like transfer learning by fine-tuning pre-trained models, such as VGG, ResNet, or EfficientNet, to improve detection accuracy.

B. Outputs and Alerts:

- Implement a decision-making system to analyze the outputs of the AI models and generate alerts or reports based on their findings.
- The system can generate alerts in real-time, highlighting suspicious artifacts or transactions that require further investigation.
- It can identify high-risk individuals or locations based on patterns and historical data, providing insights to law enforcement agencies.
- Utilize visualization techniques, such as network graphs or heatmaps, to depict trafficking networks and their connections.
- Generate comprehensive reports outlining potential illegal activities, including details of the artifacts, involved parties, and potential routes.

C. Evaluation and Iteration:

- Continuously evaluate the performance of the AI models by comparing their outputs with expert annotations or ground truth data.
- Collect feedback from domain experts to refine and improve the AI algorithms and detection capabilities.
- Incorporate user feedback and lessons learned to update and enhance the framework iteratively.

When extracting features from an image, there are several types of features that can be calculated. Here's a summary of the commonly used features:

1. Color Features:

- *Mean Color Value:* The average intensity or color value of the image or specific regions.
- *Color Histograms:* Histograms of color channels (e.g., RGB, HSV, LAB) representing the distribution of color values.
- *Color Moments:* Statistical moments such as mean, variance, skewness, and kurtosis of color channels.

2. Shape Features:

- *Area*: The size or area of objects or regions in the image.
- *Perimeter*: The boundary length or perimeter of objects.
- *Eccentricity*: The measure of elongation or roundness of objects.
- *Compactness*: The measure of shape complexity or compactness.
- *Convex Hull*: The convex polygon enclosing objects.
- *Centroid*: The center of mass or centroid of objects.

3. Texture Features:

- *First-order Texture Features*: Statistical measures such as mean, variance, skewness, and kurtosis of pixel intensities.
- *Gray-Level Co-occurrence Matrix ("GLCM")*: Captures spatial relationships between gray levels.
- *Gabor Features*: Capture orientation and frequency information using Gabor filters.
- *Local Binary Patterns ("LBP")*: Describes the local texture patterns using binary codes.
- *Haralick Features*: Texture features derived from the GLCM, including contrast, dissimilarity, homogeneity, energy, and correlation.

4. Frequency Domain Features:

- *Fourier Transform*: Extracts features from the magnitude or phase spectrum of the image.
- *Power Spectrum*: Represents the power distribution across different frequency components.
- *Wavelet Transform*: Decomposes the image using wavelet transforms to capture frequency and spatial information.

5. Edge Features:

- *Edge Detection*: Detects and extracts the edges in the image using techniques like Canny edge detection.
- *Gradient Features*: Computes gradient magnitude and orientation as features.

6. Histogram Features:

- *Histogram of Oriented Gradients (“HOG”)*: Captures gradient information in different image regions.
- *Color Histograms*: Histograms of color channels in different color spaces, such as RGB, HSV, LAB, etc.
- *Local Histograms*: Histograms computed for local image regions or patches.

7. Texture Features:

- *Local Binary Patterns (“LBP”)*: Describes the texture patterns using binary codes computed from local neighborhoods.
- *Gray-Level Run Length Matrix (“GLRLM”)*: Describes the distribution of consecutive pixels with the same gray level.
- *Tamura Features*: Describes texture properties like coarseness, contrast, and directionality.
- *Local Phase Quantization (“LPQ”)*: Captures phase information in local image neighborhoods.

8. Structural Features:

- *Scale-Invariant Feature Transform (SIFT)*: Detects and describes keypoints that are invariant to scale and rotation.
- *Speeded-Up Robust Features (SURF)*: Similar to SIFT, detects keypoints invariant to scale, rotation, and affine transformations.
- *Oriented FAST and Rotated BRIEF (ORB)*: A fast and efficient method for detecting and describing keypoints.
- *Scale-Space Extrema (DoG, Hessian)*: Detects salient image features at multiple scales.

9. Deep Learning Features:

- *Convolutional Neural Network (CNN) Features*: Extract features from pre-trained CNN models such as VGG, ResNet, or Inception.
- *Deep Features*: Features extracted from deeper layers of a pre-trained CNN, capturing more abstract information.

10. Motion Features:

- Optical Flow: Computes the apparent motion of pixels between consecutive frames.
- Motion History Images (MHI): Represents the motion history over a sequence of frames.

11. Statistical Features:

- Statistical Moments: Higher-order statistical moments such as skewness, kurtosis, and higher-order central moments.
- Statistical Texture Measures: Measures like entropy, uniformity, and co-occurrence matrix-based features.

For more details, we explain some of these features in Figure 2, 3, and 4.

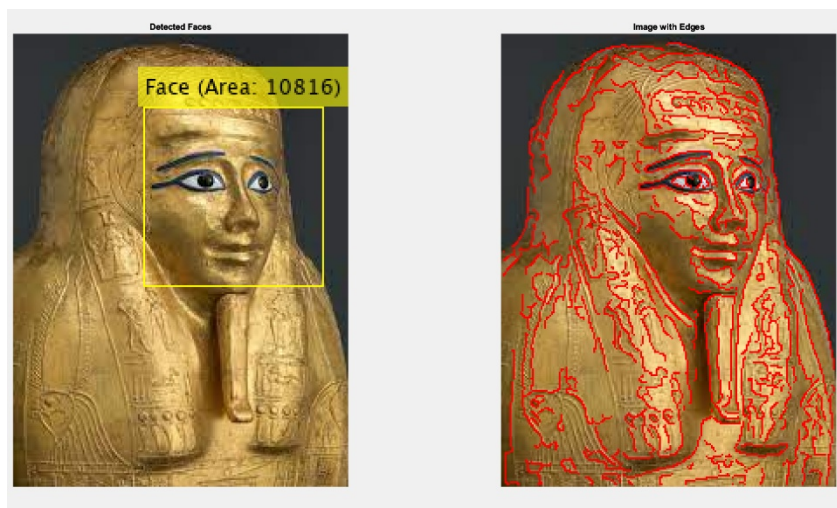


Figure 2: Faces Recognized, Edges Detected: Insights into Image Structure.

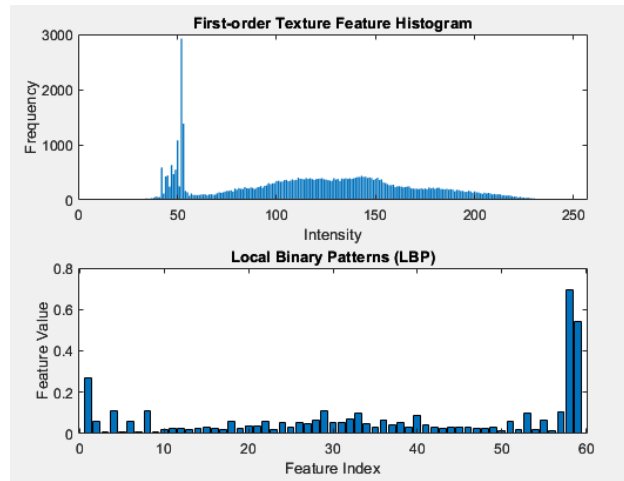


Figure 3: Texture Unveiled: First Order & LBP Features Revealing Image Patterns.



Figure 4: GLCM Unleashed: Revealing Image Patterns with Powerful Texture Features.

I worked on that figure with the help of the Bioengineering Lab in Louisville university, U.S. to get some online photos from the different newspapers and just do a infographic image for the mechanism of how the AI deep learning machine will work on detecting the illicit trafficking in antiquities by taking the following module and this idea may be a core for the Egyptian institution to work on a huge data base that will help in the future in detecting any illegal trade in cultural heritage in Egypt as it considered as a national wealth.

The following figure will show how can science suggest a framework for AI-Based detection of Illicit trafficking in antiquities.

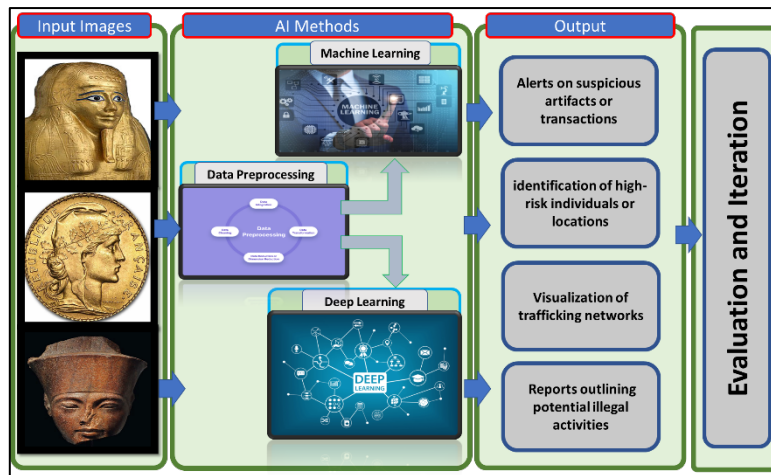


Figure 5: Framework for AI-Based Detection of Illicit Trafficking in Antiquities

As a remark, it's important to note that while AI can be a valuable tool in the recovery of looted antiquities, and prevention of illicit trafficking in antiquities, it is not a standalone solution. It should be complemented by effective legal frameworks, international collaboration, on-the-ground enforcement, and public awareness campaigns to address the complex issues surrounding the trade in cultural heritage. Moreover, Archeologists and the professors in the international universities who are interested in

cultural heritage should spread awareness to their students and among governmental institutions for the repatriation of the looted antiquities to its origin as it considered as part of identity and a fundamental right for nations.

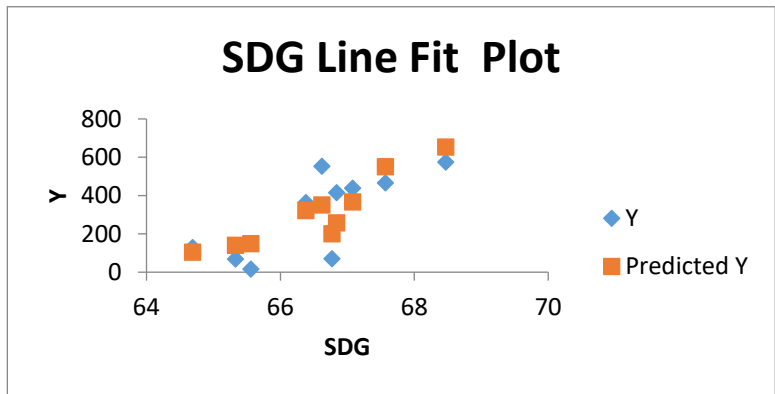
Appendix 1: Descriptive Statistics

<i>Descriptive Stat</i>	<i>Innov</i>	<i>SDG</i>	<i>Glob</i>	<i>Antiquities</i>
Mean	27.02	66.531	91.451	309.1
Standard Error	0.53496	0.351165	0.186294	68.23284481
Median	27.1	66.695	91.5	389
Mode	26	N/A	91.83	N/A
Standard Deviation	1.69168	1.11048	0.589113	215.7712008
Sample Variance	2.86178	1.233166	0.347054	46557.21111
Kurtosis	-0.38417	-0.05351	4.095019	-1.86409365
Skewness	0.25713	-0.02737	-1.88089	-0.25380071
Range	5.5	3.78	2	558
Minimum	24.5	64.69	90	16
Maximum	30	68.47	92	574
Sum	270.2	665.31	914.51	3091
Count	10	10	10	10
Largest (1)	30	68.47	92	574
Smallest (1)	24.5	64.69	90	16
Confidence Level (95.0%)	1.21015	0.794389	0.421426	154.3534186

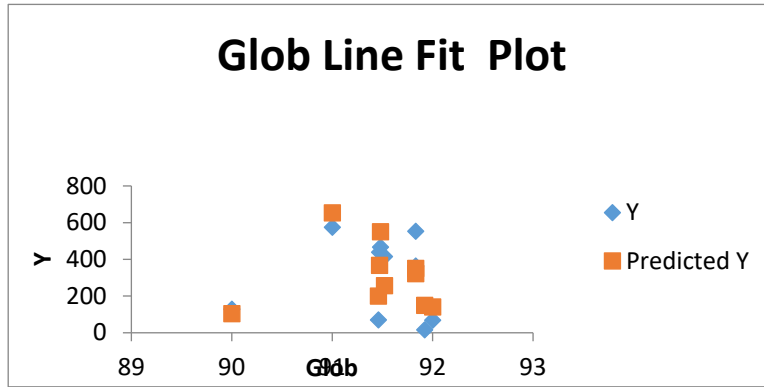
Appendix 2: Regression Full

SUMMARY OUTPUT								
<i>Regression Statistics</i>								
Multiple R	0.835474657							
R Square	0.698017903							
Adjusted R Square	0.547026854							
Standard Error	145.2210948							
Observations	10							
<i>ANOVA</i>								
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>			
Regression	3	292479.9018	97493.3	4.622909	0.05294485			
Residual	6	126534.9982	21089.17					
Total	9	419014.9						
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	-2506.70316	8234.070266	-0.30443	0.771082	-22654.747	17641.34	-22654.7	17641.34
SDG	121.2626426	48.24306055	2.513577	0.045682	3.216126	239.3092	3.216126	239.3092
Glob	-43.7611896	82.9980006	-0.52726	0.616934	-246.84998	159.3276	-246.85	159.3276
Innov	-46.2589624	31.63767502	-1.46215	0.194018	-123.67356	31.15564	-123.674	31.15564

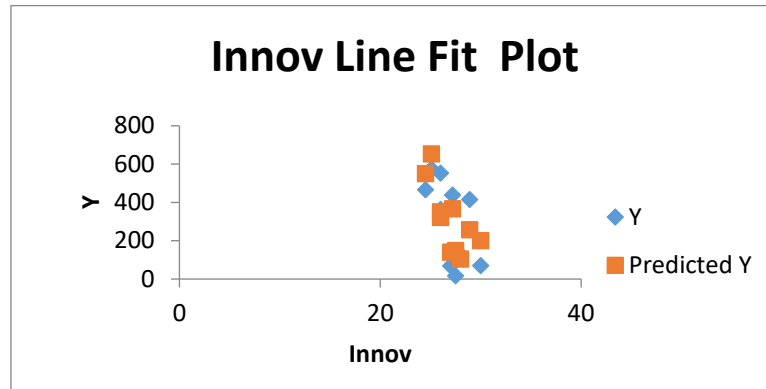
Appendix 3: SDG Line Fit Plot



Appendix 4: Glob Line Fit Plot



Appendix 5: Innov Line Fit Plot



Appendix 6: Regression SDG

SUMMARY OUTPUT								
<i>Regression Statistics</i>								
Multiple R	0.76241573							
R Square	0.58127775							
Adjusted R Square	0.52893747							
Standard Error	148.092396							
Observations	10							
<i>ANOVA</i>								
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>			
Regression	1	243564.039	243564	11.10574	0.01034543			
Residual	8	175450.861	21931.36					
Total	9	419014.9						
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	-9546.85444	2957.871493	-3.22761	0.0121	-16367.718	-2725.99	-16367.7	-2725.99055
SDG	148.140783	44.45297291	3.332528	0.010345	45.6320438	250.6495	45.63204	250.6495225