Marine Spatial Planning Connects Digital Technology, Excavation Equipment with Artificial Intelligence, Internet of Things for Underwater Heritage Investigation

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Research article

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Abstract

Background

Underwater cultural heritage (UCH) as a time capsule had accumulated marine ecological biological resources for centuries since sinking until discovery, forming an ecosystem wildly involves multifaceted fields.

Problem

The convention on the United Nations Educational, Scientific, and Cultural Organization (UNESCO), coastal states claim UCH jurisdiction in situ protection. However, foreign countries demand UCH sovereignty to evolve an international political event. Consequently, underwater archaeology preservation and exploitation become a diplomatic intrigue although no human lives beneath the sea.

Purpose

The purpose of paper attempts to identify significant issues about UCH providing standard operating procedures (SOP), One-Stop service for a comprehensive investigation, and finds a way for international UCH disputes.

Method

The research collected relevant UCH issues from six participants' brainstorming, statistical analysis, and the Chi-Squared test.

Results

Results showed 13 issues about UCH with no significant difference but conversion into seven groups with a significant difference.

Finding & Contribution

The top three groups, marine spatial planning (MSP), Digital Technology, Excavation Equipment were identified and contributed to better UCH investigation. The finding transnational, regional level regimes, community collaborative governance offers UCH better preservation.

Suggestion

Finally, suggestion MSP activating idle assets construct UCH research center through digital technology with excavation equipment and link artificial intelligence (AI), internet of things (IoT) to improve UCH investigation, and international collaboration.

1. Introduction
When misfortune led to the wrecking vessels, the result was a type of accidental time capsule, many thousands of objects came to rest in one location, undisturbed for centuries (Pearson, 2019). Underwater Cultural Heritage (UCH) management and maritime archaeology yield interdisciplinary framework, information communication technologies to build intelligent systems and applications. Underwater archaeological sites submerged settlements and shipwrecks are not accessible due to marine environment and depth (Malliri, Siountri, Skondras, Vergados, & Anagnostopoulos, 2019). UCH sites widely spread from ruins in coastlines to deep, documentation, and preservation is obligation and dictated by international treaties such as the Convention on the Protection of the UCH to encourage the non-destructive techniques and survey methods of objects recovery (Skarlatos & Agrafiotis, 2020). Virtual reality (VR) and augmented reality (AR) technologies have advanced in unreachable environments. An integrated interactive framework for exploring the underwater shipwrecks in situ via AR, or remotely via VR (Nomikou et al., 2020). The survey can be carried out by scuba divers, underwater remotely operated vehicle (ROV) or autonomous underwater vehicle (AUV). The UCH analysis from views of history, archaeology, environment, geology, biology along with data recording is useful for three-dimension (3D) reconstruction and mapping. A robotic solution for the UCH inspection, documentation, and monitoring systems of the underwater environment through the Artificial Intelligence (AI) realization platform (Ricca et al., 2020). The Internet of Things (IoT) has the potential capacity to be integrated into any complex system. Due to sensing technologies development, wireless sensors network is considered as key technologies, and IoT is emerging as an important technology for monitoring systems (Tokognon, Gao, Tian, & Yan, 2017).

Anyone discovers suspected UCH shall terminate any activities immediately, maintain the completeness of the site, and promptly report competent authority the discovery (Ministry of Culture, 2015). Under legal regulation of the Coastal Zone Management Act and UCH, competent authority should identify stakeholders and arrange a public hearing to prohibit any harmful action and proposes plans of heritage site protection. The underwater investigation leads to tensions and conflicts between scientific archaeological research and regulations resources available to protect and manage UCH (Nilsson, Hansson, & Sjöström, 2020). Marine spatial planning (MSP) is an integral part of comprehensive integration with innovative transition and often focuses on achieving specific objectives, related to important strategic priorities (J.S. Jones, Lieberknecht, & Qiu, 2016). Despite legal provisions in developed countries exerted monumental efforts to preserve shipwrecks and UCH, unfortunately, underwater archaeological sites are constantly endangered daily due to human activities and natural environmental stress (Kupusović, Dominković-Alavanja, & Marohnić, 2019). The advances communication field, up-coming 5G, and cloud technologies will make the idea fully applicable, contributing to the enhancement of the coastal and the underwater archaeological remains (Malliri et al., 2019).

Despite digital technology VR, AR, 3D, IoT, AI associates with equipment ROV, UAV assistance to investigate archaeological sites. The UCH wildly involves multifaceted expertise and has accumulated marine ecological biological resources for decades naturally forming an ecosystem. The shipwreck habitats in the conservation area and accumulated biological resources as artificial reefs. Where commercial fishing detects a significant signal location (Scotland, 2015). In situ preservation conflicts
UCH excavation, coastal country establishing diplomatic project performs sovereignty and jurisdiction to treat foreign states UCH claim as an international political event. The paper attempts to identify significant issues of the UCH investigation providing SOP, One-Stop service for a comprehensive investigation, and finds a way for international UCH disputes. The research collected relevant UCH issues from six participants brainstorming, statistical analysis, and the Chi-Squared test. Results showed 13 issues with no significant difference and conversion into seven groups with a significant difference. The top three groups, MSP, Digital Technology, Excavation Equipment were identified and contributed to better UCH investigation. The finding transnational, regional level regimes, and community collaborative governance offer UCH better preservation are similar to J. Martin (2019) view. Finally, suggestion MSP activating idle assets construct UCH research center through digital technology with excavation equipment and link AI, IoT to improve UCH investigation and international collaboration.

2. Methods

The UCH total six members were majoring in the Master Degree course “Underwater Cultural Heritage (UCH) Investigation” weekly three hours from Feb till Jun 2017 at the Institute of Marine Affairs and Resource Management, National Taiwan Ocean University (NTOU). In the last class, research requested each member brainstorming to write down three important topics about the UCH investigation for data collection. Each member cast 10 votes preference resulting in a total of 60 votes. Grouping a total of 18 topics into 13 issues further gathered 13 issues into seven groups for conducting statistical summary and the Chi-Squared test whether the seven group results showed a significant difference from the UCH investigation. As a result, showing UCH investigation involves multifaceted issues, competent agents are consistent with Kyvelou & Ierapetritis (2020) view, relevant authorities ensure harmonization and integration of interests into multifaceted and competitive MSP procedure to manage conflicting sea uses and creates synergies (Kyvelou & Ierapetritis, 2020). Therefore, the research produces the general standard operating procedures (SOP) and collaboration forming a One-Stop service for UCH investigation.

3. Result

3.1 Data Collection

The 18 topics of UCH were collected from each member writing down three topics multiplied by a total of six members brainstorming. These topics widely covered historical record data, restoration, preservation, material technology analysis components of heritage through an advanced facility. Database of human resources about expert authentication, financial budget, corporate social responsibility (CSR) fundraising is an alternative approach. A global trend trans-boundary needs an integrated ecosystem with digital technology, AI, IoT. The research categorized 18 topics into 13 issues indicating no significant difference and identified the top three issues first MSP, second MPA, third Digital Technology as Fig. 2.
Research conducting 13 issues the Chi-Square test was based on the degree of freedom (DF) 12, Chi-Square value 3.70 less than critical value 21.026, and the CHIDIST(3.70,12) P-Value 0.99 greater than significant interval 0.05 indicated no significant difference from UCH. The result was consistent with the top three issues, first MSP, second MPA, and third Digital Technology 3D, VR, AR from 13 issues as Table 2. This illustration MSP, MPA, Digital Technology are important issues for UCH investigation and are supported by previous studies. Such as MSP under a place-based approach creates better chances for UCH since MSP is assumed the key procedure to tackle competition among sea users and mitigating pressure on the marine environment (Papageorgiou, 2019). A different regional or national tool complying with the principle of in situ preservation is related to MPA establishment (Noon, 2020). Technological developments, social awareness, many coastal regions promoting coral reef assets in different planned with hundreds of wildlife marine reserves and MPA (Bideci & Cater, 2019). Digital technologies are intensively used for tangible and intangible cultural heritage. Interactive digital applications become parts of museum exhibitions, VR, and AR. The 3D reconstructions of cultural sites, virtual presentations, and traditions offer the users travel to the past (Rizvic, Okanovic, & Boskovic, 2020).
Table 1
The primary data of six members majored in the course “Underwater Culture Heritage (UCH) Investigation and Preservation” from Feb to June 2017 at the Institute of Marine Affairs and Resource Management from National Taiwan Ocean University (NTOU). Research requested each member to write down three topics about UCH total collection 18 topics and gathered similar topics into 13 issues
Table 2
Observation topic, issue, vote, and Chi-Squared results at 13 issues of UCH. Research requested each member to write down 3 topics about UCH, a total of six members multiplied by each one 3 topics made 18 topics and further categorized into 13 issues. Each member casting 10 votes preference among 13 issues multiplied by 6 members made a total of 60 votes. The degree of freedom (DF) 12, Chi-Squared value 3.70 was less than the critical value of 21.026. The P-Value 0.99 was greater than the significant interval alpha 0.05 to show no
significant difference among 13 issues.

Table 3  
The summary of 13 issues. The measure of central tendency “Mean” 4.615, “Median” 4.00, “Mode” 4, “Maximum” 7, “Minimum” 3, “Range” 4 what illustrate 13 issues were no central tendency. The measure of dispersion “Standard Deviation (SD)” 1.192, “Variance” 1.423 indicated no significant difference is consistent with the Chi-Squared test results.

3.2 Top Three Groups. MSP, Digital Technology, Excavation Equipment

Research assembled 13 issues into seven groups with a significant difference as Table 4. The top three groups’ first MSP, second Digital Technology, third Excavation equipment at the same equal observation total 13 votes, are consistent with the top three issues MSP, MPA, Digital Technology, and supported by previous studies. For instance, MSP-related challenges safeguarding UCH sites, sustainable tourism management, and joint scientific research programs require transboundary cooperation (Kupusović et al., 2019). Digital technologies allow users to receive archaeological, historical, biological information, and
the augmented diving through an underwater tablet provides geological localization multimedia for the divers to visit the underwater archaeological site (F. Bruno et al., 2019). Conducting underwater survey clearance operations, the scuba diving, training, technical survey, excavation, demolition, emergency medical, geographic information system (GIS), ROV and AOV equipment are needed (Demining, 2016).

Table 4
The Chi-Squared test of seven groups were significantly different. The critical criteria 0.05, DF 6, Chi-Squared value 12.80 was greater than the critical value 12.592. The CHIDIST (X2, DF) P-Value 0.046 was less than significant interval alpha 0.05 and showed seven groups a significant difference. Identifying the top three groups MSP, Digital Technology, Excavation Equipment at the equal importance observation at 13

3.3 SOP and One-Stop

As a result, UCH wildly involves interdisciplinary diverse issues of material, technique, assessment, expertise, fields, trans-cross sectors in conflicts with one another. Creating a general SOP formulates various fields at convenient operation and assessment. The daily products fully tested the revised workflow to make sure SOP worked right. The updated daily product SOP is working great, quicker, and
easier to complete workflow (Sowers, Wagner, Wilkins, & Baechler, 2020). The mapping team is working on developing SOP but relevant points require the operator to extend themselves, check function, detailed and user friendly (White, Wilkins, & Meyers, 2020). However, various documents, qualifications, criteria, and procedures for UCH investigation are complex. Therefore, research further establishes a One-Stop service to coordinate all relevant agencies’ collaboration for enhancing efficiency and comprehensive investigation. A one-stop service creates the opportunity to promote cultural heritage by integrating communities into the development process (Nur Mobi & Majumder, 2019).

3.4 International Politics

Maritime archaeological research the potential for interpreted public access to submerged cultural resources as a way of preserving wrecks in situ and also availing the public. The potential for UCH to be used as a political tool in disputes over national sovereignty (Campbell 2015) (Pearson, 2019). When foreign countries claim UCH ownership resulting in international laws competes with coastal states jurisdiction of UCH in inland water with sovereignty. International disputes impact on international organization, national legislation, adoption of solutions, principles, and policies. The most common issues of judicial procedure and alternative dispute resolution, the best appropriate solutions, and protective measures should adopt to minimize the arising disputes and safeguard not only interests but culture as well (Kesisoglou, 2019). The principle of in situ preservation, the convention on UNESCO, competent agencies organize experts of international law, political relations, foreign policy, and legal framework. Encouraging an international legal instrument regulates the protection of underwater archaeological sites to coordinate cooperation among states (Cheng, 2017). A system elaborates for the protection of World Heritage sites in areas beyond national jurisdiction and requires collaboration between UNESCO and the relevant competent international organizations and States Parties (Laffoley, Freestone, & Ecosystems, 2017).

4. Discussion

Cultural property disputes always caused international discussion, countries, and international organizations to deal with the protection of the relevant right. The continuous change and evolution raised several conflicts and led to cases resolution in various ways as well as cases still pending (Kesisoglou, 2019). The strategic alliance of synergy integrates transboundary resources to UCH preservation in the ecological area. Any kinds of heritage activities for marine inspection should be based on the principle of UNESCO in situ (Scotland, 2015). Article 12 of the Coastal Zone Management Act, Taiwan, important shoreland, or UCH zone shall be designated as first-grade coastal conservation zone (AGENCY, 2015).

4.1 Top Three Groups

The management tools MSP coordinate users conflicts with a specific time, zone, area delimitation for coexistence. AI detect anomalies and generate alarms in the VR environment. IoT for remote monitoring by a wireless sensor network (WSN) and UAV allows inspecting the critical structural damage (Bacco et
al., 2020). The research categorized 13 UCH issues converting into seven groups with a significant difference and identified the top three groups MSP, Digital Technology, Excavation Equipment at equal importance for analysis.

### 4.1.1 MSP

Activating idle asset establishes a research center of underwater heritage and incubation of training for marine archaeological education. MSP an emerging multidisciplinary process seeks to prevent conflicts among maritime activities, promoting environmental conservation and economic development (Noon, 2020). The first group “Training in Education & Promotion” combines issues “Census and Condition Evaluation”, “Propaganda, Education & Training” of Table 2. Substantial research is present in the cultural heritage of training and education, the evidence of long-term learning could benefit from studies as opposed to the short-term entertaining aspect (Čosović & Brkić, 2020). The accidental destruction of wrecks caused by deep-sea trawlers, cable-laying, drill for oil, and another resource exploitation is other significant contributors to the destruction of underwater heritage (Pearson, 2019). Preventing any intrusive action collects comprehensive data for analysis and governmental agents strengthens patrol in the scene to connect local association of fishery, in association with NGO (Non-Governmental Organization) volunteer, and implements precautionary measures to alleviate the adverse effect. The second group “MSP” combines issues “Marine Protected Area (MPA)”, “Marine Spatial Planning (MSP)”, “Restoration and Preservation”. Any heritage activity for marine inspection should be based on the principle of in situ preservation on UNESCO (Scotland, 2015). MSP adapts to gradual change at the underwater archaeological shipwreck. More connection with more values deeply researches underwater heritage and builds incubation center in marine heritage. The inspiration for investigations, collaborations, directions of research improves UCH management through scientific, governmental, industrial cooperation, and new participants of underwater archaeology (Nilsson et al., 2020). The fourth group “International Politics, Political, and Law” is the same issue “International Politics, Political and Law”. International adopted policies may challenge or contradict preexisting domestic policies, institutions, and interests. Domestic governments increasingly face the pressure to follow policy developments of international or supranational levels (Maags & Trifu, 2019). The fifth group “Human Resources Database” is the same eighth issue “Human Resource Deployment”. The supervision and management of cultural heritage areas require human resources as experts in preservation (Djukardi, Rachmi, & Sumiarni, 2020). Each project needs a collaborative network through digital technology and strategic participation from partners in complementary with comprehensive integration. The sixth group Financial Budget & CSR Funding combines issues “Corporate Social Responsibility (CSR)”, “Financial Budget & Funding”. Fundraising or patronage from CSR is an alternative approach.

**Example**

UCH Ecotourism. Crete island, Greece
UCH stands an interesting opportunity for touristic development. Underwater archaeological shipwreck or sunken city are considerably fascinating for the public, a sense of mystery surrounds them (Bruno et al., 2017). Searching for mythical sites becomes a tourist attraction and the process of acculturization on consumption has created and is creating a new heritage such as the Atlantis Hotel on Paradise Island, in Bahamas (Melotti, 2017). Novel interdisciplinary research combining ecological, environmental, and archaeological perspectives is devoted to changing the way submerged landscapes are treated and protected (Nilsson et al., 2020). MSP is a process of managing human activities in the marine and coastal environment to achieve sustainable development goals (Pyć, 2019) and is a managed tool for UCH in preservation (Harvey, Kelble, & Schwing, 2017). Crete island, Greece the coastal and marine landscape in zoning is a discrete unit in MSP. The Crete island exploitation is significant and continues to increase related to identify marine landscape typologies and emerged based on marine spatial visibility. (Tsilimigkas, Rempis, & Derdemezi, 2020). UCH shipwrecks, sunken cities, relics, and other remains have been popular tourist destinations. Artificial reef areas a wide range of wrecks (ships, aircraft, tanks, cars) and thematic parks (monuments, archeologic parks) have become diving locations and provided tourists with new knowledge about the underwater environment (Bideci & Cater, 2019).

4.1.2 Digital Technology VR, AR, AI, IoT

The third group “Digital Technology” integrates issues “Digital Technology 3D, VR, AR” and “AI, Internet of Thing (IoT)”. Excavation in conflicts with in situ preservation coexists sustainability through digital technology integration. IoT has brought interworking capabilities, a great impact on sensor networks for the remote monitoring of structures (Barsocchi, Cassara, Mavilia, & Pellegrini, 2018). Sensors data processing, acceleration data environmental parameters opening to the techniques provide complex aggregate information, alarms, or actuation without direct human intervention (Bacco et al., 2020). VR efficiently applied to underwater archaeological sites the most accessible to the general public without any constraint by distance, depth, or time (Barbieri et al., 2019). VR protects “living fossils” intangible cultural heritage, a special cultural carrier to achieve the sustainable development of making innovative and characteristic heritage (Li, 2020). The VR technologies allow the general public to explore the archaeological remains outside of the submerged environment such as sunken “Villa con ingresso a protiro” dated around the II century AD, located in the MPA - Underwater Park of Baiae (Naples) (Barbieri et al., 2019). AR and VR developing applications in the public enjoy the reconstructions of the underwater sites by experiencing a virtual dive (Ricca et al., 2020). The VISAS project (http://visas-project.eu) aims to ameliorate the sustainable exploitation of UCH through the technology approaches including an innovative virtual tour of submerged archaeological sites (Bruno et al., 2017).

Example

Archaeological Site of Cala Minnola (Levanzo Island, Italy)

The underwater archaeological site of Cala Minnola focused on virtual scene development for visualization exploitation and allowed users to live a recreational, educational experience by receiving archaeological and biological information about the submerged exhibits (Bruno et al., 2017). Developing
effective models capable of quantifying degradation phenomena in UCH by AI methods applied to environmental parameters and multi-sensors images acquired periodically on underwater (Ricca et al., 2020). Local native characteristic integrates digital innovation, AI, machine learning with powerful function of the sensor. Innovative virtual exploration applied the underwater archaeological site of Cala Minnola (Levanzo Island, Italy) to preserve the shipwreck remains and educational exploitation of the submerged archaeological sites (F. Bruno et al., 2019). Cala Minneola publicly presented on 6th November 2016 at exhibition "Mirabilia Maris. Treasures from the seas of Sicily" (Bruno et al., 2017). Virtual environments assisting engineers and divers perform subsea inspections. Using virtual images of damage captures under various simulated levels of underwater visibility. Virtual data creating an efficient, safe, and informed underwater inspection campaign for a wide range of built infrastructure, potentially leading to better monitoring, inspection, and lifetime performance of underwater structures using AI techniques (O'Byrne, Ghosh, Schoefs, Pakrashi, & Engineering, 2020). Mobile computing provides tools for running AR in real-time visualizing and interacting with UCH. Using a waterproof case smartphone hybrid markers and inertial sensors localize the diver site. The application was experimentally evaluated at an underwater archeological site in Italy in Baiae with ten expert divers was performed and significantly enhances user experience in underwater archeological sites. (Čejka, Zsiros, & Liarokapis, 2020). Computer technologies enable researchers to acquire accurate models of different environmental aspects and 3D printing technology is possible to reproduce artifacts (Erič, Guček Puhar, Jaklič, & Solina, 2018).

4.1.3 Excavation Equipment ROV, AOV, 3D

VR gives the UAV operator a quick look of the explored site with the vehicle correctly placed in the virtual scene in real-time (Bacco et al., 2020). Investigating underwater heritage, expert divers need advanced technology with apparatus, equipment to detect archeological site. Training inexperienced archaeologists are one of the most challenging tasks as well as underwater excavation dredging. Using immersive VR techniques focus on excavating underwater while following established archaeological methods and techniques (Kouřil, Liarokapis, & applications, 2018). Artificial visual documentation cannot replace authentic values of underwater tangible heritage. AR technology contributes to intangible property protection, maintaining the memory and information of underwater archaeology (Malliri et al., 2019). The seventh group “Excavation Equipment” combines issues “Museum Exhibition”, “Excavation Equipments ROV, UAV”. Developing a complex platform uses digital bathymetric data from ROV, topographic terrestrial photogrammetry data from unmanned drones to synthesize 3D digital images of specific areas (Nomikou et al., 2020). The excavation will damage the habitant ecosystem and biodiversity loss. The fundamental principle in situ preservation, excavation should be under strict assessment. The computer vision photogrammetry technology is automated systems for interpretation of the visual world as a part of AI rather than cartography (MAUS, JAFFKE, & HASKELL, 2017). The preserved artifacts remain in the watery environment alternative methods for preservation should be developed and supported by technology such as automatic measurement, control of microbiological changes, and AI (Erič et al., 2018). The patterns of cracks in the structural components monitored by UAV. The operator interacts with real-time data retrieved from a wireless sensor network (WSN) employing the VR environment (Bacco et al., 2020).
Example

UCH 3D Australia’s continental shelf Barrow Island

The 3D and VR enrich remote inspection providing a reconstruction of monitored sites with the location of the sensors. An interactive virtual scenario of the underwater site to the general public, based on the combined use of optical and acoustic technologies provides a digital 3D reconstruction of underwater scenarios (F Bruno et al., 2019). Bacco et al. (2020) suggestion monitoring system integrates environmental and mechanical data acquired through IoT with the images and UAV information collection to build a 3D reconstruction of structures, showing the position of the deployed sensor, allowing the operator dynamically to interact with the real-time readings from IoT. The 3D reconstruction focuses on the integration of data captured by acoustic and optical systems to obtain a complete representation. The underwater site inspection aims to identify the location of archaeological remains and classify important priority from an archaeological view (F Bruno et al., 2019). Once the survey activities ended, optical and acoustic data are merged to create a multiresolution textured 3D model of the underwater archaeological site and surrounding seabed (F Bruno et al., 2019). The UCH of Australia beginning some 65,000 years ago, using 3D seismic datasets cover vast areas of Australia’s continental shelf regions proximal to Barrow Island. The 3D seismic bathymetry revealed a highly complex and mature coastal landscape preserved at depths of 70–75 m (O’Leary, Paumard, & Ward, 2020).

4.2 SOP and One-Stop

Technologies protect UCH against conditions of degradation, deformation, or destruction. The mission of any museum implements new concepts of preservation and presentation for educational purposes (Erič et al., 2018). Any adverse effects might arise from activities incidentally affecting UCH. The 2001 UNESCO Convention on the Protection of the UCH stipulates in-situ preservation must be conducted before engaging in activities to prevent incidental damage (Aps, Lees, Herkül, Roio, & Tõnismaa, 2020). Trawlers can pull wrecks apart and drag objects for kilometers along the seabed, specific to the underwater environment, particularly common in shallow seabeds and the high volume of fishing activity (Pearson, 2019). New methods of underwater archaeological assets and sites in situ protection provide additional guidelines for operators, restorers, archaeologists, conservation scientists, geologists in the UCH (Ricca & La Russa, 2020). Sowers et al. (2020) claim written SOP are pretty straightforward to the tools and the latest version developed an SOP to ensure importing data and using a profile. Nur Mobi & Majumder (2019) view a one-stop service is an effective policy to decrease hassles and significantly reduces anxiety arising from administrative complications. The research indicating UCH investigation and preservation involves multifaceted issues and competent agents. Based on in situ preservation principles create general SOP for UCH investigation and preservation. Research generates the general SOP for UCH investigation, preservation, and gathers agents’ involvement in UCH for collaboration forming a One-Stop service.

(1)One-Stop.
1. Any possible heritage identification by official authorities in the public transparent Competent authority establishes ONE-STOP service for convenient application access and implements enforcement or creating agent institution in the legal framework.

2. The main functions indicator would be simple and A measurable table in specific characteristics with a score on the list and evaluates heritage value accumulation on the The total scores indicate a different level of valuation at 100, 90, 80, 70, 60, 50, 40, 30, 20, 10 and 0 respectively.

3. Each authentication of potential heritage is evaluated by the official The total score offers monitor performance and an estimated schedule in progress on the public website.

(2) Report

1. Generally, fishing vessels, expert divers, or official patrol show great probability than general people to find the possible UCH and reports ONE-STOP service for authentication immediately.

2. An incentive mechanism for discovering UCH, no one reports heritage site even finds it because of no benefit for himself/herself/themselves.

(iii) The reporting system provides open website development of update tracing function.

(3) Authority Implementation

1. Once received a report from One-Stop service, authority establishes a team of projects immediately.

2. Comprehensive data collection of heritage in situ preservation, authority prohibits any intrusive action in the scene.

(4) Analyze Authentication

1. A total score below 70, the central government hands over to the local government in the arrangement at a regular visit written report.

2. The score above 70, arrangement regularly visits the scene to collect data, comparative analysis, and comprehensive integration through technology.

3. Keep going data collection, accumulation, integration, and analysis if the prospect of archeological site report demonstrates a potential value.

(5) Project Team

1. The team members should widely cover diverse aspects from the professor in academic theory, associates with a practical expert, stakeholder, and local community resident participation.

2. Technical network connection crossing trans-boundary establishes functional subdivision for each team as an alternative.

3. Depending on adaptability to real demand, implements effective movement, and carry out adaptive management for dealing with change.

(6) Monitor and Feedback Mechanism
1. Precautionary measure implementation.
2. List item, progress schedule for monitoring performance.
3. Feedback amendment and adjust modification on direction and speed.

### 4.3 International Politics

Since no one lives beneath the sea, leaders do not find opportunities for political gains from archaeological sites. Until politicians in Canada, Russia, and China used shipwrecks on the seafloor to project sovereignty into new maritime territories. The politicized abuse of science puts the world on a path toward conflict (Campbell, 2015). Kesisoglou (2019) view cultural objects have the international character, due to continuous activity in art and antiquities are the guardians of cultural property, not only financial, moral interests of the parties involved but also learn to incorporate predecessors’ culture. The cultural Political extends understanding of diverse possibilities of managing warship wrecks and UCH to examine diversity and efficacy of alternative approaches to the management and protection of cultural heritage beyond the stipulations of the 2001 UNESCO Convention, specifically the Convention’s preference for in situ preservation as a first option and the ban it places on commercial exploitation (Pearson, 2019). The domestic legal framework is the fundamental base of implementation. Without lawful intervention and strict enforcement from governments is no meaningful change at site preservation in cultural heritage (Cheng, 2017). Coastal states performing UCH sovereignty in inland water with jurisdiction face foreign countries claim UCH ownership. The scenario involves international negotiation with state jurisdiction and coastal states negotiate in site preservation with foreign countries. Such as transnational governance approaches might enhance the protection of UCH. New solutions are needed to perform global regional-level regimes, and community-centered collaborative governance to provide additional protections for UCH (J. Martin, 2019). A broader discussion on legislative reforms to future UCH management, better engagement at the global and regional negotiating table supports adopting a unified and consistent policy aiming at any remaining UCH preservation (J. B. Martin & Gane, 2020).

Underwater shipwreck value accumulated with marine resources and naturally formulated an ecosystem since it was sunk until discovered. The site locates at the seabed in inland waters under state jurisdiction. The foreign country should apply for an investigation of heritage and commence operation until approval from the state administration (Ministry of Culture, 2015). Allocating resources and risk assessment is an important infrastructure for cultural preservation. The holistic framework of trans-boundary ameliorates the performance of underwater ecological conservation. The archaeology is a tool of peacemaking when cultural heritage meets social activism, politics, and community identity. Using social media builds a community at underwater tourism between myth and reality (Melotti, 2017). The involvement of countries needs to identify common protection approaches, standards, and actions to exchange practices. Reconciling private and public interests to protect UCH should be governed by international law (Kupusović et al., 2019). Developing a perspective aims to ensure the protection of UCH sites. Cooperation actions include: (i) the identification of UCH sites; (ii) common legal protection; (iii) sharing practices about monitoring, protection, and mitigation measures for endangered UCH.
5. Conclusion

Domestic regulation and international conventions of any heritage activities would be based principle of in situ preservation on UNESCO. A valuable discovery of historical culture, shipwreck heritage as time capsule since it was sunk until discovered. The coastal states claim UCH jurisdiction in situ protection and foreign countries demand sovereignty to evolve an international political event. Consequently, UCH becomes a political tool. The paper identifies significant issues about UCH to provide SOP, One-Stop service, and finds a way for international disputes. Results showed 13 issues with no significant difference and conversion into seven groups with a significant difference. The top three groups, MSP, Digital Technology, Excavation Equipment identification contribute to better UCH investigation, and finding transnational collaborative governance offers better preservation. Finally, suggestion MSP activating idle assets construct UCH research center through digital technology with excavation equipment and link AI, IoT to improve UCH investigation and international collaboration.

Declarations

Conflict of Interest

No conflict of interest exists.

The author confirms that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

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Intellectual Property

The author confirms that has given due consideration to the protection of intellectual property associated with this work and that there is no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property.

Ethical Approval and Consent to participate

“Not applicable”

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“Not applicable”

Availability of supporting data
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50. Marine Spatial Planning Links Digital Technology and Excavation Equipment for Underwater Cultural Heritage Investigation and Preservation.

Tables

| Table 1: Primary Data of Six Members for Underwater Cultural Heritage (UCH) |
|-----------------------------|----------|----------|----------|-----------------------------|
| No  | Age  | Education    | Married | Gender | Career, Expertise or Interest |
|-----|------|--------------|---------|--------|------------------------------|
| 1   | 40-59| Master’s Degree | No      | Male   | Environment                  |
| 2   | 40-59| Master’s Degree | Yes     | Male   | Non-Environment              |
| 3   | 40-59| Master’s Degree | Yes     | Male   | Environment                  |
| 4   | 18-39| Master’s Degree | No      | Female | Environment                  |
| 5   | 18-39| Master’s Degree | No      | Male   | Non-Environment              |
| 6   | 18-39| Master’s Degree | No      | Female | Non-Environment              |
### Summary of 13 Issues

| Mean                | 4.615385 |
|---------------------|----------|
| Standard Error      | 0.330859 |
| Median              | 4        |
| Mode                | 4        |
| Standard Deviation (SD) | 1.192928 |
| Variance            | 1.423077 |
| Kurtosis            | -0.24482 |
| Skewness            | 0.547864 |
| Range               | 4        |
| Minimum             | 3        |
| Maximum             | 7        |
| Sum                 | 60       |
| Number              | 13       |

### Table 4: The seven groups covered from 13 issues. The Chi-Squared test results of seven groups were significant difference. The top three groups are Digital Technology and Education Group that equal importance.

| Group | Mean | Standard Deviation | Chi-Square | P-Value | df | P-Value | df |
|-------|------|--------------------|------------|---------|----|---------|----|
| G1    | 4    | 1.192928           | 0.32       | 0.57    | 1  | 0.43    | 1  |
| G2    | 4.5  | 1.423077           | 1.25       | 0.26    | 1  | 0.26    | 1  |
| G3    | 3.8  | 0.24482            | 3.14       | 0.07    | 1  | 0.07    | 1  |
| G4    | 3.5  | 0.547864           | 6.23       | 0.01    | 1  | 0.01    | 1  |
| G5    | 3.5  | 1.192928           | 4.23       | 0.04    | 1  | 0.04    | 1  |
| G6    | 3.5  | 0.24482            | 3.14       | 0.07    | 1  | 0.07    | 1  |
| G7    | 3.5  | 0.547864           | 6.23       | 0.01    | 1  | 0.01    | 1  |

**Notes:**
- Group 1: Digital Technology, Group 2: Education, Group 3: Communication, Group 4: Information Systems, Group 5: Human Resources, Group 6: Financial, Group 7: Prevention.
- Chi-Square value 12.80, Critical Value 12.592, p-value 0.005.

Chi-Square: 12.80, p-value 0.005, df = 6.
### Table 5: Summary of Seven Groups

|                        |               |
|------------------------|---------------|
| **Mean**               | 8.571429      |
| **Standard Error**     | 1.616244      |
| **Median**             | 7             |
| **Mode**               | 13            |
| **Standard Deviation (SD)** | 4.27618     |
| **Variance**           | 18.28571      |
| **Kurtosis**           | -2.50093      |
| **Skewness**           | 0.145062      |
| **Range**              | 9             |
| **Minimum**            | 4             |
| **Maximum**            | 13            |
| **Sum**                | 60            |
| **Number**             | 7             |

### Figures

1. **One Stop**
   - Legal or Institutional Rule: One Stop Window. Measure list with score
   - Monitor performance with website on progress in schedule

2. **Report**
   - Fishman or patrol found possible heritage to report One Stop Window for authentication
   - Provide website for update tracing

3. **Authority Implementation**
   - Once received report from ONE STOP window service, authority establishes team of project right away.
   - Authority prohibits any intrusive action in scene, protection in situ
   - Comprehensively collect data of heritage in scene, literature review, journal, file, website and magazine

4. **Analyze Authentication**
   - If score below 70. Hand over to local government in arrangement with regular written report.
   - If score above 70. Keep going data collection, comparative analysis and comprehensive integration with assistance from digital technology.
   - If is valuable. Keep going data collection, analysis, integration and action

5. **Project Team**
   - The member of team will cover diverse aspect from professor in theory and associate experts with practice
   - Technical network trans-boundary on support establishes subdivision for each task.
   - Depend on adjustment of real demand, take useful movement and implement adaptive approach for dealing with change.

6. **Monitor and Feedback Mechanism**
   - Implement Precautionary Measure
   - List item, progress schedule for performance monitor
   - Feedback amendment and adjust modification on direction with speed

### Figure 1

The Standard Operation Procedure
Figure 1

The Standard Operation Procedure

Figure 2

The 13 issues of UCH showed no significant difference and were grouped from a total of 18 topics
Figure 2

The 13 issues of UCH showed no significant difference and were grouped from a total of 18 topics.

Figure 3

Conducting the Chi-Square Test of the 7 groups showed a significant difference.
Figure 3

Conducting the Chi-Square Test of the 7 groups showed a significant difference